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BATHYMETRICAL SURVEY  
OF THE  
FRESH WATER LOCHS  
OF  
SCOTLAND

UNDER THE DIRECTION OF  
SIR JOHN MURRAY, K.C.B., F.R.S.  
AND  
LAURENCE PULLAR, F.R.S.E.

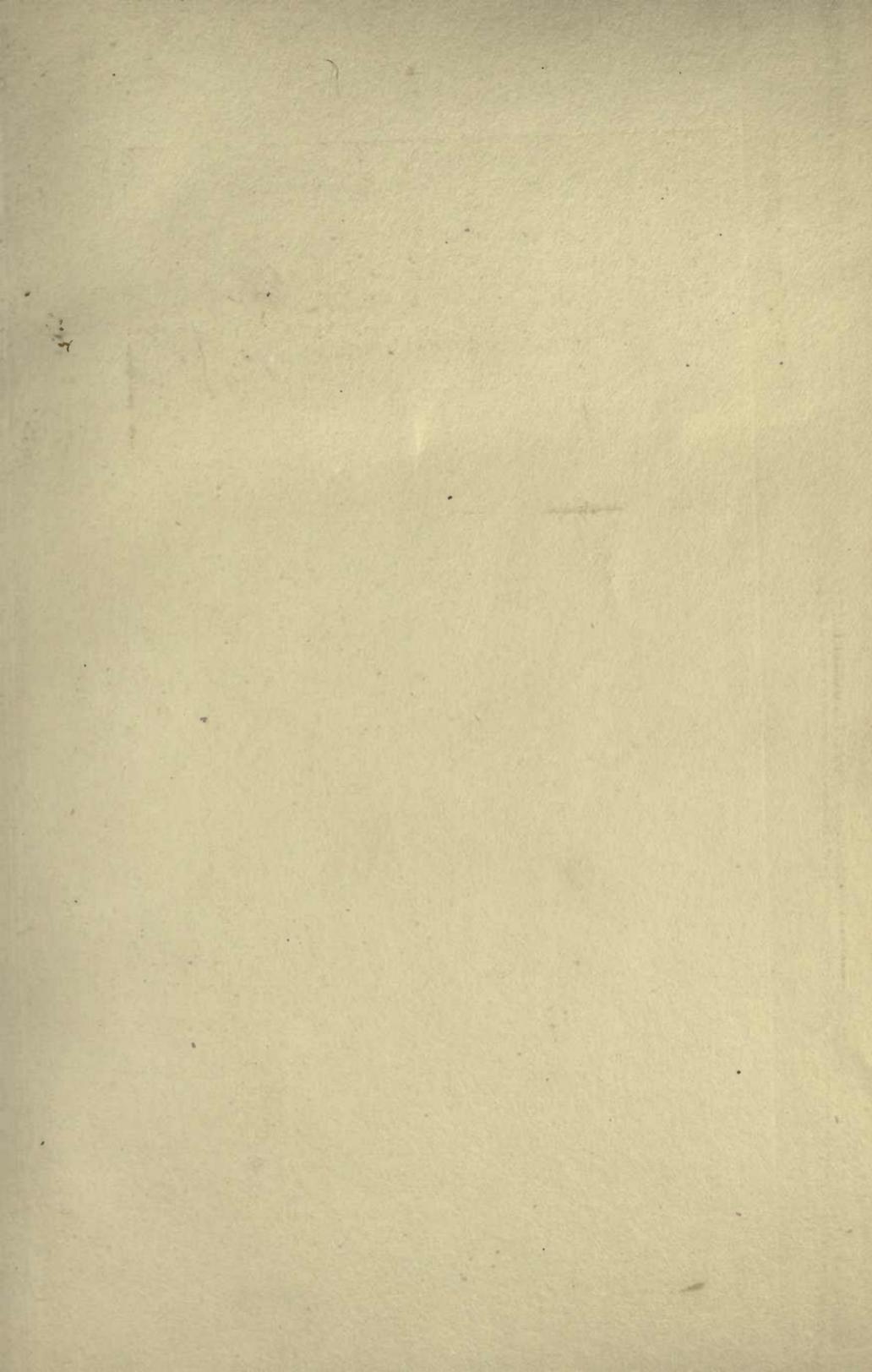
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OF THE  
SCOTTISH FRESH-WATER LOCHS

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Report on the Scientific Results

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OF THE  
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SIR JOHN MURRAY  
K.C.B., F.R.S., D.Sc., ETC.

AND

LAURENCE PULLAR  
F.R.S.E., F.R.G.S.

DURING THE YEARS 1897 TO 1909

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Report on the Scientific Results

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*VOLUME II*

UNIV. OF  
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EDINBURGH  
CHALLENGER OFFICE

1910

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AND

LAURENCE TELLER

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Report on the Scientific Results

VOLUME IV

DEPT. OF  
AGRICULTURE  
EDINBURGH

HALLINGER OFFICE  
EDINBURGH

1910

Dedicated

TO THE MEMORY OF

FREDERICK PATTISON PULLAR

WHO WAS DROWNED

WHILE ATTEMPTING TO SAVE THE LIVES OF OTHERS

ON 15TH FEBRUARY 1901

AT THE AGE OF TWENTY-FIVE YEARS

---

*He took an active part in the initiation  
of this systematic survey of the  
Scottish Fresh-water Lochs*

216510



## PREFACE

THIS publication consists of six volumes, two of text and four of maps, and gives an account of the work done, of the observations recorded, and of most of the results obtained, during an investigation into the bathymetry of the fresh-water lochs or lakes of Scotland between the years 1897 and 1909.

Although the determination of the depths of the lakes, and of the general form of the basins in which they lie, made up the principal work of the Survey, still a very large number of observations were carried out in other branches of the science of limnography. Many of these observations and the results were published from time to time, as the work proceeded, in scientific journals, while others now appear in print for the first time.

Volume I. consists for the most part of new matter. It includes numerous articles dealing with the general results of the researches from the topographical, geological, physical, chemical, and biological points of view, a comparison of Scottish lakes with lakes in other parts of the world, and various theoretical considerations. These articles have been written chiefly by gentlemen who have taken an active part in the field-work of the Survey. This volume also contains an extensive bibliography of books and special papers referring to lakes.

Volume II. contains the special descriptions of the lakes, the maps of which appear in Volumes III., IV., V., and VI. Throughout the text will be found numerous index-maps, showing the drainage areas of the districts in which the lochs are situated, together with other illustrations.

The bathymetrical maps have all appeared during the past eight years in the *Journal of the Royal Geographical Society* or in an extra publication of the same Society; and some of the maps have also been published in the

Magazine of the Royal Scottish Geographical Society. These maps consist of two series. In the first series (Volumes III. and IV.), the contours of depth in the lakes are shown in shades of blue, and the contours of the height of the surrounding land are shown in brown shades of colour; in the second series (Volumes V. and VI.), the contours of depth are shown in shades of blue, the brown shades on the land being omitted.

In addition to the bathymetrical maps, there are also a few maps showing the surface geology, the rainfall, and other physical features of some of the districts.

These maps have all been prepared and printed by Dr J. G. Bartholomew, and we desire to express our indebtedness to him for the care with which these have been produced, and for his assistance and advice in many directions. We are also indebted to Messrs G. Cornwall & Sons, Aberdeen, for their assistance and advice with regard to the binding of the maps, and to Messrs Neill & Co., Edinburgh, for their advice in connection with the letterpress.

We feel confident that the whole investigation has resulted in very substantial contributions to knowledge. Some of the observations—those regarding the temperature seiche, and the variation of the viscosity of the water with temperature, for example—throw much light on obscure oceanographical problems. Most of the observations could, with advantage, have been carried further, by means of improved instruments and methods suggested during the progress of the work, but it was found necessary to terminate the survey, at least in the meantime, and to review what had been accomplished. We are conscious of many shortcomings.

In conclusion, we tender our best thanks to all who have assisted us in carrying these investigations to a successful conclusion.

JOHN MURRAY.

LAURENCE PULLAR.

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In addition to the maps showing the depths of the lochs, the following maps are included in Vol. III. :—

- Plate I. Head-waters of the Forth—Orography and drainage areas.  
Plate II. " " " —Surface geology.  
Plate III. " " " —Mean annual rainfall.  
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Plate XLII. Assynt District—Surface geology.  
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# STATISTICAL TABLES OF THE SCOTTISH FRESH-WATER LOCHS

*(Surveyed during the years 1897 to 1909)*

DURING the course of the Lake Survey work 562 of the Scottish fresh-water lochs were surveyed. These include all the principal lochs of the country, and a very large number of the smaller and less important ones. As a matter of fact, all lochs were surveyed on which boats could be found at the time the work was being carried out. To have included all the smaller highland and less accessible lochs and tarns would have very greatly increased the expense and the time involved. To transport a boat to many of the remote lochs in the Highlands would have entailed much labour and difficulty, not to speak of the objections of proprietors, keepers, and others, who do not wish to have grouse moors and deer forests disturbed at a time of the year when the lochs are most accessible.

The general results of the survey work are, however, in no way affected by these smaller lochs having been excluded, for a great many lochs have been surveyed in all districts of the country.

The following tables are intended to summarise the results which are given in detail in Volume II. of this Report.

Table I. shows the lakes arranged according to their lengths.

Table II. shows the lakes arranged according to their superficial areas.

Table III. shows the lakes arranged according to their maximum depths.

Table IV. shows the lakes arranged according to their mean depths.

Table V. shows the lakes arranged according to the volume of water in each.

Table VI. shows :—

- (a) The number of lakes surveyed in the various river basins ;
- (b) The number of soundings taken in the lakes of the various river basins ;

- (c) The volume of water in the lakes of the various river basins in millions of cubic feet ;
- (d) The superficial area of the lakes in the various river basins ;
- (e) The extent of the drainage area in the various river basins, together with the ratio of the drainage area to the superficial area of the lakes.

The information in Table VI. is extracted from the tables given in greater detail in the descriptions which will be found in Volume II. of this Report.

From this table it will be seen that 562 lochs have been surveyed, and that the number of soundings recorded on the maps of these lochs is 59,195. The actual number taken exceeds 60,000. The aggregate area of the water-surface is over 340 square miles, and therefore the average number of soundings per square mile of surface is 174.

The aggregate volume of water contained in these 562 lochs is estimated at about 1,015,814 millions of cubic feet, or nearly 7 cubic miles. The area drained by the lochs is about 6669 square miles, or about  $19\frac{1}{2}$  times the area of the lochs.

TABLE I

FRESH-WATER LOCHS OF SCOTLAND (SOUNDED BY THE LAKE SURVEY)  
ARRANGED ACCORDING TO LENGTH

Loch.	Length. Miles.	Loch.	Length. Miles.
1. Awe (Etive)	25.47	55. Beoraid	3.43
2. Ness	24.23	56. Dùn na Seilcheig	3.41
3. Lomond	22.64	57. Eilt	3.37
4. Shiel	17.40	58. na Meide	3.33
5. Shin	17.22	59. Avich	3.30
6. Tay	14.55	60. Stack	3.27
7. Ericht	14.50	61. Affric	3.20
8. Maree	13.46	62. Ossian	3.20
9. Arkaig	12.00	63. Skinaskink	3.16
10. Morar	11.68	64. Cliff	3.16
11. Lochy	9.78	65. Coir' an Fhearna	3.15
12. Rannoch	9.70	66. Bà (Mull)	3.04
13. Katrine	8.00	67. Obisary	3.03
14. Langavat (Lewis)	7.86	68. Merkland	3.02
15. Laggan	7.04	69. St Mary's	3.02
16. Quoich	6.95	70. nan Cuinne	3.00
17. Fannich	6.92	71. Watten	3.00
18. Earn	6.46	72. Trealaval	2.90
19. Assynt	6.36	73. Càrn	2.76
20. Naver	6.18	74. Loyne (East)	2.75
21. Hope	6.13	75. Tummel	2.75
22. Eck	6.02	76. Suainaval	2.68
23. Fionn (Gruinard)	5.76	77. a' Bhraoin	2.66
24. Doon	5.64	78. Beinn a' Mheadhoìn	2.64
25. Laidon	5.30	79. nan Eun (N. Uist)	2.63
26. Treig	5.10	80. Fadagao	2.60
27. Luichart	5.05	81. Garry (Tay)	2.55
28. Garry (Ness)	4.90	82. Strom	2.54
29. Mhor	4.84	83. Tulla	2.50
30. Harray	4.84	84. Talla	2.47
31. Ken	4.62	85. Fionn (Kirkaig)	2.40
32. Frisa	4.50	86. nan Geirgann (Mill)	2.39
33. Scadavay (East)	4.50	87. Calder	2.32
34. Laoghal	4.46	88. Morie	2.30
35. Clunie (Ness)	4.28	89. Ard	2.30
36. Mullardoch	4.16	90. Grunavat	2.26
37. More (Laxford)	4.11	91. Ruthven	2.26
38. Monar	4.10	92. Muick	2.22
39. Veyatie	4.05	93. Langavat (Benbecula)	2.20
40. Glass	4.03	94. Lochindorb	2.18
41. Expansions of River Dee	4.02	95. Bà (Tay)	2.15
42. Oich	4.02	96. Bad a' Ghail	2.13
43. Vennachar	4.00	97. Boardhouse	2.03
44. Lubnaig	4.00	98. Grennoch	2.02
45. Damh (Torridon)	3.93	99. Dhùghail (Carron)	2.02
46. Lurgain	3.87	100. Skebacleit	2.00
47. Scadavay (West)	3.80	101. Swannay	2.00
48. Stenness	3.79	102. Eilde Mòr	1.98
49. na Sheallag	3.74	103. Migdale	1.92
50. Fada (Ewe)	3.74	104. na Salach Uidhre	1.90
51. Leven	3.65	105. Urigill	1.86
52. Brora	3.53	106. Beannachan	1.85
53. Voil	3.50	107. Arianas	1.85
54. a' Chroisg	3.47	108. Achall	1.83

TABLE I—*continued*

Loch.	Length. Miles.	Loch.	Length. Miles.
109. na h-Earba (West)	1·80	169. Shurrery	1·28
110. Fada (N. Uist)	1·80	170. Harperrig	1·27
111. Woodhall	1·79	171. Buidhe (Fleet)	1·27
112. a' Bhealaich (Gairloch)	1·78	172. na h-Earba (East)	1·27
113. Thom	1·78	173. Hunder	1·26
114. Lyon	1·74	174. Kirbister	1·26
115. Freuchie	1·74	175. Bunacharan	1·26
116. na h-Oidhche	1·73	176. an t-Seilich	1·26
117. Castle Semple	1·72	177. Martnaham	1·26
118. Eye	1·72	178. Achray	1·25
119. an Daimh (Shin)	1·71	179. Rescobie	1·24
120. Baddanloch	1·70	180. Beannach (Inver)	1·24
121. Chon (Forth)	1·70	181. Urrahag	1·24
122. Nell	1·68	182. Loch	1·23
123. Trool	1·68	183. Droma	1·23
124. Heouravay	1·68	184. Dubh (Gruinard)	1·23
125. Leum a' Chlamhain	1·62	185. Muckle Water	1·21
126. Fiodhaig	1·61	186. an Gead	1·21
127. Heilen	1·60	187. Sloy	1·21
128. Olavat	1·60	188. Lowes (Tay)	1·20
129. Fad	1·60	189. Castle (Bladenoch)	1·20
130. Menteith	1·60	190. Inbhir	1·20
131. Ashie	1·60	191. Maberry	1·19
132. a' Bhealaich (Naver)	1·60	192. Dee	1·18
133. a' Bhaid-Luachraich	1·57	193. a' Bharpa	1·18
134. Creagach	1·57	194. Garbhaig	1·18
135. Owskeich	1·56	195. an Duin (Spey)	1·18
136. Gladhouse	1·56	196. Tralaig	1·16
137. an Dithreibh	1·55	197. an Stromore	1·15
138. Scamadale	1·54	198. na Leitreach	1·14
139. an Ruathair	1·54	199. Oban nam Fiadh	1·13
140. Garve	1·54	200. Sgamhain	1·12
141. a' Chlàir (Helmsdale)	1·53	201. Calavie	1·12
142. Fada (Gruinard)	1·52	202. Killin	1·12
143. Mochrum	1·50	203. nam Breac	1·12
144. a' Ghriama	1·50	204. an Eilein (Spey)	1·10
145. Threipmuir	1·50	205. Milton	1·10
146. Girlsta	1·48	206. Meiklie	1·10
147. Finlas	1·46	207. Auchenreoch	1·08
148. Poulary	1·46	208. Forfar	1·07
149. an Tomain	1·45	209. Crogavat	1·06
150. Caravat	1·45	210. Kinord	1·06
151. Lungard	1·44	211. Benachally	1·05
152. Dilate	1·43	212. a' Bhaillidh	1·04
153. an Dùin (N. Uist)	1·40	213. Turret	1·04
154. Cròcach	1·40	214. More Barvas	1·04
155. Gorm Loch Mòr	1·39	215. Gartmorn	1·04
156. Clair (Ewe)	1·38	216. Insh	1·03
157. Lintrathen	1·38	217. Moy	1·03
158. Black (Ryan)	1·36	218. Borralan	1·03
159. Strandavat	1·36	219. Pattack	1·03
160. a' Chuilinn (Conon)	1·35	220. Morlich	1·02
161. Iubhair	1·35	221. Tingwall	1·02
162. Kernsary	1·35	222. an Staca	1·02
163. Coulin (Ewe)	1·33	223. ic Colla	1·00
164. Kilbirnie	1·32	224. na Craobhaig	1·00
165. Spiggie	1·30	225. Vatandip	1·00
166. Hundland	1·30	226. Gainmheich (South)	1·00
167. Knockie	1·30	227. Wester	1·00
168. Loyne (West)	1·28	228. Drunkie	1·00

TABLE I—continued

Loch.	Length. Miles.	Loch.	Length. Miles.
229. Arklet . . . . .	1·00	289. na Creige Duibhe . . . . .	0·80
230. Doine . . . . .	1·00	290. na Moracha . . . . .	0·80
231. an Lagain . . . . .	1·00	291. Kindar . . . . .	0·80
232. Skaill . . . . .	0·98	292. Builg . . . . .	0·80
233. Skene (Dee) . . . . .	0·98	293. Kirk Dam . . . . .	0·80
234. na Beinne Bàine . . . . .	0·97	294. Crò Criosdaig . . . . .	0·80
235. Bodavat . . . . .	0·96	295. Eela . . . . .	0·79
236. Chìl na Sìthe . . . . .	0·96	296. Chaluum . . . . .	0·78
237. Daimh (Tay) . . . . .	0·96	297. Skiach . . . . .	0·78
238. Ailsh . . . . .	0·95	298. Hempriggs . . . . .	0·77
239. Cuil Airidh a' Flod . . . . .	0·94	299. Lochrutton . . . . .	0·77
240. Alvie . . . . .	0·94	300. Airidh na Lic . . . . .	0·76
241. Gryfe . . . . .	0·94	301. Raoinavat . . . . .	0·76
242. na Cuaich . . . . .	0·94	302. Gelly . . . . .	0·76
243. Con (Tay) . . . . .	0·94	303. Lundie (Garry) . . . . .	0·76
244. Dungeon . . . . .	0·93	304. na Mòine Buige . . . . .	0·76
245. Skealtar . . . . .	0·93	305. Araich-Lin . . . . .	0·75
246. Clousta . . . . .	0·92	306. an Laig Aird . . . . .	0·74
247. Dubh (Gairloch) . . . . .	0·92	307. Davan . . . . .	0·74
248. Nant . . . . .	0·90	308. nam Breac Dearga . . . . .	0·74
249. Tollie . . . . .	0·90	309. Muckle Lunga . . . . .	0·74
250. Hermidale . . . . .	0·90	310. nan Deaspoint . . . . .	0·74
251. Huna . . . . .	0·90	311. Bran . . . . .	0·74
252. Bradan . . . . .	0·90	312. Howie . . . . .	0·74
253. Fitty . . . . .	0·90	313. a' Ghobhainn . . . . .	0·73
254. Peppermill . . . . .	0·90	314. Druim Suardalain . . . . .	0·73
255. North-house . . . . .	0·90	315. na Lairige . . . . .	0·73
256. Ochiltree . . . . .	0·89	316. Stacsavat . . . . .	0·72
257. White (Ryan) . . . . .	0·88	317. an Drainc . . . . .	0·72
258. Ceò-Glas . . . . .	0·88	318. Skeen (Annan) . . . . .	0·72
259. Allt an Fhearna . . . . .	0·88	319. Sguod . . . . .	0·72
260. Eigheach . . . . .	0·88	320. Broom . . . . .	0·72
261. Achilty . . . . .	0·87	321. Skerrow . . . . .	0·70
262. Tankerness . . . . .	0·86	322. na Bi . . . . .	0·70
263. More (Thurso) . . . . .	0·86	323. Eileach Mhìe' ille Rìabhaich . . . . .	0·70
264. a' Bhaid Daraich . . . . .	0·86	324. Tearnait . . . . .	0·70
265. Crombie Den . . . . .	0·86	325. Syre . . . . .	0·70
266. Lùnn dà-Bhrà . . . . .	0·86	326. Caol na Doire . . . . .	0·70
267. Drumellie . . . . .	0·86	327. Long . . . . .	0·70
268. a' Mhuillin . . . . .	0·84	328. nan Lann . . . . .	0·70
269. Vaara . . . . .	0·84	329. Carlingwark . . . . .	0·70
270. Achanalt . . . . .	0·84	330. Benisval . . . . .	0·70
271. Callater . . . . .	0·84	331. Bad an Sgalaig . . . . .	0·69
272. Lewes (Tweed) . . . . .	0·84	332. Spynie . . . . .	0·69
273. Oban a' Chlachain . . . . .	0·84	333. Tarff . . . . .	0·69
274. Ussie . . . . .	0·84	334. Tormasad . . . . .	0·69
275. Lindores . . . . .	0·84	335. Seil . . . . .	0·68
276. Scarmclate . . . . .	0·84	336. Ghuiragarstidh . . . . .	0·68
277. Truid air Sgithiche . . . . .	0·84	337. Baile a' Ghobhainn . . . . .	0·68
278. a' Bhuird . . . . .	0·84	338. Crunachan . . . . .	0·68
279. na Moine . . . . .	0·83	339. Rosebery . . . . .	0·68
280. Castle (Annan) . . . . .	0·83	340. Drummond . . . . .	0·68
281. Braigh Horrisdale . . . . .	0·82	341. Kennard . . . . .	0·68
282. Ghuilbinn . . . . .	0·82	342. Deoravat . . . . .	0·68
283. na h-Achlaise . . . . .	0·82	343. Clings . . . . .	0·68
284. St John's . . . . .	0·82	344. na h-Airidh Sléibhe . . . . .	0·68
285. Awe (Inver) . . . . .	0·82	345. Dornal . . . . .	0·68
286. Giorra . . . . .	0·82	346. Bogton . . . . .	0·66
287. an Tuire . . . . .	0·81	347. Portmore . . . . .	0·66
288. Linlithgow . . . . .	0·80	348. an Eilein (Gairloch) . . . . .	0·66

TABLE I—*continued*

Loch.	Length. Miles.	Loch.	Length. Miles.
349. a' Bhealaich (Alsh) . . . . .	0'66	409. Whinyeon . . . . .	0'56
350. Stormont . . . . .	0'66	410. a' Chonnachair . . . . .	0'56
351. Morsgail . . . . .	0'66	411. an Nostarie . . . . .	0'56
352. Dibadale . . . . .	0'66	412. Whitefield . . . . .	0'56
353. an t-Slagain . . . . .	0'65	413. na Ceithir Eileana . . . . .	0'56
354. Ordie . . . . .	0'64	414. Sròn Smeur . . . . .	0'56
355. Gleann a' Bhearraidh . . . . .	0'64	415. Gown (South) . . . . .	0'55
356. Grass . . . . .	0'64	416. Moraig . . . . .	0'55
357. Raonasgail . . . . .	0'64	417. Monzievaird . . . . .	0'55
358. Sealbhag . . . . .	0'64	418. Coire nam Meann . . . . .	0'54
359. Bosquoy . . . . .	0'64	419. Kilconquhar . . . . .	0'54
360. Valtos . . . . .	0'64	420. na Stainge . . . . .	0'54
361. Beannach (Gruinard) . . . . .	0'63	421. a' Mhiotailt . . . . .	0'54
362. Arthur . . . . .	0'63	422. Bruadale . . . . .	0'54
363. Edgelaw . . . . .	0'62	423. Asta . . . . .	0'53
364. Bad a' Chrotha . . . . .	0'62	424. Uanagan . . . . .	0'52
365. Roer . . . . .	0'62	425. Burga . . . . .	0'52
366. Craggie . . . . .	0'62	426. Allan . . . . .	0'52
367. na Dèighe fo Dheas . . . . .	0'62	427. an Losgainn Mòr . . . . .	0'52
368. Allt na h-Airbhe . . . . .	0'62	428. Kemp . . . . .	0'52
369. Doire nam Mart . . . . .	0'62	429. Monk Myre . . . . .	0'52
370. an Laghair . . . . .	0'62	430. nan Druinnean . . . . .	0'52
371. Dochart . . . . .	0'62	431. Lochinvar . . . . .	0'52
372. Fiart . . . . .	0'62	432. Flugarth . . . . .	0'52
373. an Tachdaidh . . . . .	0'62	433. a' Buaille . . . . .	0'52
374. Clunie (Tay) . . . . .	0'62	434. na Coinnich . . . . .	0'51
375. Urr . . . . .	0'62	435. an Leòid . . . . .	0'50
376. Dochard . . . . .	0'62	436. an t-Seagain . . . . .	0'50
377. Scaslavat . . . . .	0'62	437. Aithness . . . . .	0'50
378. a' Chlachain (Lewis) . . . . .	0'62	438. Balgavies . . . . .	0'50
379. Black (Etive) (East) . . . . .	0'62	439. Burntisland . . . . .	0'50
380. nam Faoileag . . . . .	0'62	440. Harperleas . . . . .	0'50
381. Leitir Easaich . . . . .	0'61	441. Eldrig . . . . .	0'50
382. a' Choire . . . . .	0'61	442. Littlester . . . . .	0'50
383. Harelaw . . . . .	0'60	443. Kilcheran . . . . .	0'50
384. an Droighinn . . . . .	0'60	444. na Doire Daraich . . . . .	0'50
385. Leodsay . . . . .	0'60	445. Tarruinn an Eithir . . . . .	0'50
386. Isbister . . . . .	0'60	446. na Sreinge . . . . .	0'50
387. Burreland . . . . .	0'60	447. Mhic' ille Riabhaich . . . . .	0'49
388. Sabiston . . . . .	0'60	448. Hosta . . . . .	0'49
389. Snarravoe . . . . .	0'60	449. Breaclaich . . . . .	0'49
390. Ederline . . . . .	0'60	450. Peerie . . . . .	0'48
391. Airdh na Ceardaich . . . . .	0'60	451. a' Chlachain (Nairn) . . . . .	0'48
392. Dhomhnuill Bhig . . . . .	0'60	452. nan Eun (Ness) . . . . .	0'48
393. an Iasgaich . . . . .	0'59	453. Monikie (South) . . . . .	0'48
394. Lochaber . . . . .	0'59	454. Punds . . . . .	0'48
395. Derculich . . . . .	0'59	455. na Craige . . . . .	0'48
396. Bhradain . . . . .	0'58	456. a' Ghlinne Dorcha . . . . .	0'47
397. nan Gabhar . . . . .	0'58	457. Moor Dam . . . . .	0'47
398. Phitiùlais . . . . .	0'58	458. Lundie (Clunie) . . . . .	0'46
399. Craighush . . . . .	0'58	459. Shechernich . . . . .	0'46
400. Butterstone . . . . .	0'58	460. Liath . . . . .	0'46
401. Veiragvat . . . . .	0'58	461. Essan . . . . .	0'46
402. Derclach . . . . .	0'58	462. Fithie . . . . .	0'46
403. Soulseat . . . . .	0'58	463. a' Phearsain . . . . .	0'46
404. Gown (North) . . . . .	0'57	464. nan Eun (Tay) . . . . .	0'45
405. Black (Etive) (West) . . . . .	0'56	465. a' Vullan . . . . .	0'45
406. Black (Etive) (Mid) . . . . .	0'56	466. Rae . . . . .	0'44
407. White of Myrton . . . . .	0'56	467. Holl . . . . .	0'44
408. Dhùgaill (Torridon) . . . . .	0'56	468. an Dùna . . . . .	0'44

TABLE I—continued

Loch.	Length. Miles.	Loch.	Length. Miles.
469. Brow . . . . .	0·44	517. Brough . . . . .	0·32
470. Lochnaw . . . . .	0·44	518. Geal . . . . .	0·32
471. Dallas . . . . .	0·43	519. Kilchoan (Upper) . . . . .	0·32
472. Mill . . . . .	0·43	520. a' Chaoruinn . . . . .	0·32
473. Dubh (Ailort) . . . . .	0·43	521. Sior . . . . .	0·32
474. Muck . . . . .	0·42	522. na Garbh-Abhuinn Ard . . . . .	0·32
475. Clickhimin . . . . .	0·42	523. Kinghorn . . . . .	0·31
476. Harrow . . . . .	0·42	524. a' Chladaich . . . . .	0·31
477. Kirk . . . . .	0·42	525. nan Losganan . . . . .	0·30
478. Monikie (North) . . . . .	0·42	526. Hightae Mill . . . . .	0·30
479. Gamhna . . . . .	0·42	527. Dubh-Mòr . . . . .	0·30
480. Lochenbreck . . . . .	0·42	528. Beag . . . . .	0·30
481. na h-Ealaidh . . . . .	0·42	529. Sand . . . . .	0·29
482. na Claise Fearna . . . . .	0·42	530. Duartmore . . . . .	0·29
483. nan Geireann . . . . .	0·41	531. Clubbi Shuns . . . . .	0·29
484. Lure . . . . .	0·40	532. Hostigates . . . . .	0·28
485. Sandy . . . . .	0·40	533. Scoly . . . . .	0·28
486. nan Garbh Chlachain . . . . .	0·40	534. nan Ràth . . . . .	0·28
487. Bhac . . . . .	0·38	535. Black (Tay) . . . . .	0·28
488. Brouster . . . . .	0·38	536. Drumlamford . . . . .	0·28
489. Fleet . . . . .	0·38	537. nan Ailscof . . . . .	0·27
490. Hoglinns . . . . .	0·38	538. na Creige Léithe . . . . .	0·27
491. Collaster . . . . .	0·38	539. Cults . . . . .	0·26
492. na Beiste . . . . .	0·37	540. Skae . . . . .	0·26
493. Màma . . . . .	0·37	541. Cornish . . . . .	0·26
494. Fyntalloch . . . . .	0·37	542. Kirriereoch . . . . .	0·26
495. Auchenchapel . . . . .	0·37	543. Eion Mhic Alastair . . . . .	0·25
496. Birka . . . . .	0·36	544. na Beithe . . . . .	0·25
497. Aboyne . . . . .	0·36	545. an Dubh (Lochy) . . . . .	0·24
498. na Garbh-Abhuinn . . . . .	0·36	546. an Tairbeirt Stuadaich . . . . .	0·23
499. Hoil . . . . .	0·36	547. Magillie . . . . .	0·22
500. Blairs . . . . .	0·36	548. Tùtach . . . . .	0·22
501. Gainmheich (North) . . . . .	0·36	549. Crann . . . . .	0·22
502. a' Bhainne . . . . .	0·36	550. Setter . . . . .	0·22
503. Kilchoan (Lower) . . . . .	0·36	551. Pitlyal . . . . .	0·21
504. Tilt . . . . .	0·35	552. na Gealaich . . . . .	0·21
505. Anna . . . . .	0·35	553. Choire na Cloich . . . . .	0·20
506. Aslaich . . . . .	0·35	554. Dubh (Forth) . . . . .	0·20
507. Fingask . . . . .	0·35	555. Loch on Eilean Subhainn (Maree) . . . . .	0·18
508. Dubh (Etive) . . . . .	0·35	556. Dubh (Ness) . . . . .	0·18
509. Maol a' Choire . . . . .	0·34	557. na h-Eaglais . . . . .	0·16
510. Laide . . . . .	0·34	558. Uaine . . . . .	0·14
511. White (Tay) . . . . .	0·34	559. St Margaret's . . . . .	0·13
512. Duddingston . . . . .	0·34	560. Dhu (Portnochachan) . . . . .	0·12
513. Kinellan . . . . .	0·33	561. Allt na Mult . . . . .	0·12
514. Fender . . . . .	0·33	562. Rainbow . . . . .	0·10
515. Ree . . . . .	0·32		
516. Buidhe (Tay) . . . . .	0·32		

TABLE II

FRESH-WATER LOCHS OF SCOTLAND (SOUNDED BY THE LAKE SURVEY)  
ARRANGED ACCORDING TO SUPERFICIAL AREA

Loch.	Area. Square Miles.	Loch.	Area. Square Miles.
1. Lomond . . . . .	27.45	54. nan Cuinne . . . . .	1.15
2. Ness . . . . .	21.78	55. Coir' an Fhearna . . . . .	1.15
3. Awe (Etive) . . . . .	14.85	56. Tulla . . . . .	1.10
4. Maree . . . . .	11.03	57. Clunie (Ness) . . . . .	1.10
5. Morar . . . . .	10.30	58. Ossian . . . . .	1.03
6. Tay . . . . .	10.19	59. Bad a' Ghail . . . . .	1.02
7. Shin . . . . .	8.70	60. Menteith . . . . .	1.02
8. Shiel . . . . .	7.56	61. Càrn . . . . .	1.01
9. Rannoch . . . . .	7.37	62. a' Chroisg . . . . .	1.00
10. Ericht . . . . .	7.21	63. Stack . . . . .	0.99
11. Arkaig . . . . .	6.24	64. St Mary's . . . . .	0.99
12. Lochy . . . . .	5.91	65. Baddanloch . . . . .	0.99
13. Leven . . . . .	5.30	66. Tummel . . . . .	0.98
14. Katrine . . . . .	4.78	67. Lubnaig . . . . .	0.96
15. Earn . . . . .	3.91	68. Ard . . . . .	0.94
16. Harray . . . . .	3.78	69. Swannay . . . . .	0.94
17. Fannich . . . . .	3.60	70. Suainaval . . . . .	0.94
18. Fionn (Gruinard) . . . . .	3.52	71. Veyatie . . . . .	0.93
19. Langavat (Lewis) . . . . .	3.45	72. Morie . . . . .	0.92
20. Assynt . . . . .	3.10	73. Bà (Tay) . . . . .	0.92
21. Laggan . . . . .	2.97	74. Boardhouse . . . . .	0.89
22. Quoich . . . . .	2.86	75. Brora . . . . .	0.88
23. Laoghal . . . . .	2.55	76. Voil . . . . .	0.88
24. Stenness . . . . .	2.46	77. na Meide . . . . .	0.87
25. Treig . . . . .	2.41	78. Muick . . . . .	0.85
26. Hope . . . . .	2.35	79. Lochindorb . . . . .	0.84
27. Naver . . . . .	2.26	80. an Ruathair . . . . .	0.82
28. Skinaskink . . . . .	2.09	81. Affric . . . . .	0.82
29. Doon . . . . .	2.04	82. Beinn a' Mheadhoim . . . . .	0.79
30. Dùn na Seilcheig . . . . .	1.95	83. Urigill . . . . .	0.78
31. Glass . . . . .	1.86	84. Oich . . . . .	0.76
32. Laidon . . . . .	1.80	85. an Dithreibh . . . . .	0.74
33. Luichart . . . . .	1.76	86. Fada (N. Uist) . . . . .	0.70
34. Garry (Ness) . . . . .	1.75	87. Merkland . . . . .	0.69
35. Eck . . . . .	1.70	88. nan Geireann (Mill) . . . . .	0.68
36. Frisa . . . . .	1.69	89. Expansions of River Dee . . . . .	0.67
37. Mhor . . . . .	1.69	90. a' Bhraoin . . . . .	0.66
38. Vennachar . . . . .	1.61	91. Arienas . . . . .	0.66
39. More (Laxford) . . . . .	1.46	92. Eilt . . . . .	0.66
40. Watten . . . . .	1.45	93. Owskeich . . . . .	0.65
41. Fada (Ewe) . . . . .	1.44	94. Lintrathen . . . . .	0.62
42. na Sheallag . . . . .	1.37	95. Garry (Tay) . . . . .	0.61
43. Ken . . . . .	1.36	96. Trealaval . . . . .	0.61
44. Damh (Torridon) . . . . .	1.33	97. Grunavat . . . . .	0.60
45. Calder . . . . .	1.32	98. Gladhouse . . . . .	0.59
46. Lurgain . . . . .	1.26	99. Garve . . . . .	0.59
47. Bà (Mull) . . . . .	1.21	100. Fiodhaig . . . . .	0.58
48. Avich . . . . .	1.21	101. Caravat . . . . .	0.58
49. Scadavay (West) . . . . .	1.20	102. Ruthven . . . . .	0.57
50. Mullardoch . . . . .	1.18	103. Beoraid . . . . .	0.55
51. Monar . . . . .	1.17	104. Leum a' Chlamhain . . . . .	0.55
52. Obisary . . . . .	1.17	105. na h-Oidhche . . . . .	0.54
53. a' Chlàir (Helmsdale) . . . . .	1.17	106. Freuchie . . . . .	0.54

TABLE II—continued

Loch.	Area. Square Miles.	Loch.	Area. Square Miles.
107. Achall . . . . .	0·52	166. Heilen . . . . .	0·30
108. nan Eun (N. Uist) . . . . .	0·52	167. Skebacleit . . . . .	0·30
109. Ashie . . . . .	0·52	168. na h-Achlaise . . . . .	0·29
110. Thom . . . . .	0·52	169. Kinord . . . . .	0·29
111. Strom . . . . .	0·52	170. a' Bhaillidh . . . . .	0·29
112. a' Bhaid-Luachraich . . . . .	0·51	171. Hunder . . . . .	0·29
113. Nell . . . . .	0·50	172. Truid air Sgithiche . . . . .	0·29
114. Fadagoa . . . . .	0·48	173. Moy . . . . .	0·29
115. Talla . . . . .	0·47	174. Gorm Loch Mòr . . . . .	0·29
116. Morlich . . . . .	0·47	175. More (Thurso) . . . . .	0·28
117. Scadavay (East) . . . . .	0·46	176. Fad . . . . .	0·28
118. Creagach . . . . .	0·46	177. Knockie . . . . .	0·28
119. Skene (Dee) . . . . .	0·46	178. Drumellie . . . . .	0·27
120. Grennoch . . . . .	0·45	179. Pattack . . . . .	0·27
121. Insh . . . . .	0·44	180. an Dainh (Shin) . . . . .	0·27
122. a' Bhealaich (Gairloch) . . . . .	0·44	181. Maberry . . . . .	0·27
123. Dhùghaill (Carron) . . . . .	0·44	182. Benisval . . . . .	0·27
124. Chon (Forth) . . . . .	0·43	183. Clubbi Shuns . . . . .	0·27
125. Loyne (East) . . . . .	0·43	184. a' Bhealaich (Naver) . . . . .	0·27
126. Hundland . . . . .	0·43	185. Turret . . . . .	0·26
127. Beannachan . . . . .	0·42	186. Calavie . . . . .	0·26
128. na h-Earba (West) . . . . .	0·41	187. Woodhall . . . . .	0·26
129. Migdale . . . . .	0·41	188. an Staca . . . . .	0·26
130. a' Ghriama . . . . .	0·40	189. Tollie . . . . .	0·26
131. Cliff . . . . .	0·40	190. Benachally . . . . .	0·25
132. Dee . . . . .	0·40	191. Cròcach . . . . .	0·25
133. an t-Seilich . . . . .	0·39	192. Achanalt . . . . .	0·25
134. Kilbirnie . . . . .	0·39	193. Bunacharan . . . . .	0·25
135. Ailsh . . . . .	0·38	194. Rescobie . . . . .	0·25
136. Eilde Mòr . . . . .	0·38	195. Skail . . . . .	0·24
137. na Sàlach Uidhre . . . . .	0·38	196. Clair (Ewe) . . . . .	0·24
138. Lyon . . . . .	0·37	197. na Beinne Bàine . . . . .	0·24
139. More Barvas . . . . .	0·37	198. Milton . . . . .	0·24
140. Castle (Bladenoch) . . . . .	0·36	199. Ochiltree . . . . .	0·24
141. Shurrery . . . . .	0·36	200. an Stromore . . . . .	0·24
142. Mochrum . . . . .	0·36	201. Loyne (West) . . . . .	0·24
143. Harperrig . . . . .	0·35	202. Fada (Gruinard) . . . . .	0·23
144. Seamadale . . . . .	0·35	203. Davan . . . . .	0·23
145. Gurlsta . . . . .	0·35	204. Ghuilbinn . . . . .	0·23
146. Kirbister . . . . .	0·35	205. na h-Earba (East) . . . . .	0·23
147. Lowes (Tay) . . . . .	0·34	206. Garbhaig . . . . .	0·23
148. Lungard . . . . .	0·34	207. Gelly . . . . .	0·23
149. Hempriggs . . . . .	0·34	208. Achilty . . . . .	0·23
150. Spiggie . . . . .	0·34	209. White (Ryan) . . . . .	0·23
151. Arklet . . . . .	0·33	210. Black (Ryan) . . . . .	0·23
152. Fionn (Kirkaig) . . . . .	0·33	211. Tankerness . . . . .	0·23
153. Eye . . . . .	0·33	212. Inbhir . . . . .	0·23
154. Allt an Fhearna . . . . .	0·33	213. Tralaig . . . . .	0·23
155. Urrahag . . . . .	0·33	214. Trool . . . . .	0·23
156. Castle Semple . . . . .	0·32	215. Alvie . . . . .	0·22
157. Achray . . . . .	0·32	216. Olavat . . . . .	0·22
158. Dubh (Gruinard) . . . . .	0·32	217. Drunkie . . . . .	0·22
159. Meiklie . . . . .	0·31	218. Gartmorn . . . . .	0·22
160. Kernsary . . . . .	0·31	219. Sgamhain . . . . .	0·22
161. Ussie . . . . .	0·31	220. Fitty . . . . .	0·22
162. Scarmclate . . . . .	0·30	221. Finlas . . . . .	0·22
163. Castle (Annan) . . . . .	0·30	222. Dilate . . . . .	0·22
164. St John's . . . . .	0·30	223. nam Breac . . . . .	0·22
165. Threipmuir . . . . .	0·30	224. Nant . . . . .	0·22

TABLE II—*continued*

Loch.	Area. Square Miles.	Loch.	Area. Square Miles.
225. Bad an Sgalaig . . . . .	0·22	284. a' Ghobhainn . . . . .	0·15
226. Eela . . . . .	0·22	285. an Tomain . . . . .	0·15
227. Doine . . . . .	0·21	286. Dubh (Gairloch) . . . . .	0·15
228. Kindar . . . . .	0·21	287. na Moracha . . . . .	0·15
229. Iubhair . . . . .	0·21	288. an Drainc . . . . .	0·15
230. Huna . . . . .	0·21	289. Chaluim . . . . .	0·15
231. Gainmheich (South) . . . . .	0·21	290. Roer . . . . .	0·15
232. Tarff . . . . .	0·21	291. Lowes (Tweed) . . . . .	0·15
233. Clunie (Tay) . . . . .	0·21	292. Giorra . . . . .	0·14
234. Strandavat . . . . .	0·21	293. Peppermill . . . . .	0·14
235. Vaara . . . . .	0·21	294. Drummond . . . . .	0·14
236. Buidhe (Fleet) . . . . .	0·21	295. Oban nam Fiadh . . . . .	0·14
237. Killin . . . . .	0·20	296. an Nostarie . . . . .	0·14
238. Lochrutton . . . . .	0·20	297. an Tachdaidh . . . . .	0·14
239. an Eilein (Spey) . . . . .	0·20	298. an Eilein (Gairloch) . . . . .	0·14
240. Skealtar . . . . .	0·20	299. Braigh Horrisdale . . . . .	0·14
241. na Craobhaig . . . . .	0·20	300. na Moine . . . . .	0·14
242. Muckle Water . . . . .	0·19	301. Poulary . . . . .	0·14
243. Coire nam Meann . . . . .	0·19	302. Dungeon . . . . .	0·14
244. Langavat (Benbecula) . . . . .	0·19	303. Clings . . . . .	0·14
245. an Dùin (N. Uist) . . . . .	0·19	304. Bodavat . . . . .	0·14
246. Skerrow . . . . .	0·19	305. Stacsavat . . . . .	0·14
247. a' Bharpa . . . . .	0·19	306. Broom . . . . .	0·13
248. Araich-Lin . . . . .	0·18	307. Bradan . . . . .	0·13
249. na Cuaich . . . . .	0·18	308. Isbister . . . . .	0·13
250. Ordie . . . . .	0·18	309. Loch . . . . .	0·13
251. Gryfe . . . . .	0·18	310. Heouravay . . . . .	0·13
252. Coulin (Ewe) . . . . .	0·18	311. Awe (Inver) . . . . .	0·13
253. a' Chuilinn (Conon) . . . . .	0·18	312. Auchenreoch . . . . .	0·13
254. Droma . . . . .	0·18	313. Allt na h-Airbhe . . . . .	0·13
255. Borralan . . . . .	0·18	314. Crogavat . . . . .	0·13
256. Martuaham . . . . .	0·18	315. a' Choire . . . . .	0·13
257. Beannach (Inver) . . . . .	0·18	316. ic Colla . . . . .	0·13
258. Daimh (Tay) . . . . .	0·17	317. an Laghair . . . . .	0·13
259. Tearnait . . . . .	0·17	318. a' Bhuird . . . . .	0·13
260. Wester . . . . .	0·17	319. Dochard . . . . .	0·13
261. an Gead . . . . .	0·17	320. na Leitreach . . . . .	0·13
262. Syre . . . . .	0·17	321. Crò Criosdaig . . . . .	0·13
263. Clousta . . . . .	0·17	322. Kennard . . . . .	0·12
264. Butterstone . . . . .	0·17	323. Burga . . . . .	0·12
265. Sguod . . . . .	0·17	324. Caol na Doire . . . . .	0·12
266. a' Bhaid Daraich . . . . .	0·17	325. Builg . . . . .	0·12
267. Lindores . . . . .	0·17	326. Stormont . . . . .	0·12
268. Lundie (Garry) . . . . .	0·17	327. Arthur . . . . .	0·12
269. Dornal . . . . .	0·17	328. an t-Slagain . . . . .	0·12
270. Urr . . . . .	0·17	329. a' Bhealaich (Alsh) . . . . .	0·12
271. Tingwall . . . . .	0·17	330. Beannach (Gruinard) . . . . .	0·12
272. Derculich . . . . .	0·16	331. Sabiston . . . . .	0·12
273. an Duin (Spey) . . . . .	0·16	332. Druim Suardalain . . . . .	0·12
274. Long . . . . .	0·16	333. Deoravat . . . . .	0·12
275. Forfar . . . . .	0·16	334. Monkie (South) . . . . .	0·12
276. Linlithgow . . . . .	0·16	335. Craiglush . . . . .	0·11
277. Portmore . . . . .	0·16	336. Doire nam Mart . . . . .	0·11
278. Whinyeon . . . . .	0·16	337. Crunachan . . . . .	0·11
279. Carlingwark . . . . .	0·16	338. Callater . . . . .	0·11
280. a' Mhuilinn . . . . .	0·16	339. Sealbhag . . . . .	0·11
281. nam Faoileag . . . . .	0·16	340. Skeen (Annan) . . . . .	0·11
282. Skiach . . . . .	0·15	341. an Dùna . . . . .	0·11
283. Kilconquhar . . . . .	0·15	342. na h-Airidh Sléibhe . . . . .	0·11

TABLE II—continued

Loch.	Area. Square Miles.	Loch.	Area. Square Miles.
343. Ederline . . . . .	0·11	402. Veiragvat . . . . .	0·08
344. an Lagain . . . . .	0·11	403. Burrealand . . . . .	0·08
345. Lochinvar . . . . .	0·11	404. Valtos . . . . .	0·08
346. Kemp . . . . .	0·11	405. an Droighinn . . . . .	0·08
347. Souleat . . . . .	0·11	406. Rosebery . . . . .	0·08
348. an Leòid . . . . .	0·11	407. Balgavies . . . . .	0·08
349. Raoinavat . . . . .	0·11	408. Clickhimin . . . . .	0·07
350. Bosquoy . . . . .	0·10	409. Dochart . . . . .	0·07
351. Con (Tay) . . . . .	0·10	410. Holl . . . . .	0·07
352. Hosta . . . . .	0·10	411. Breaclaich . . . . .	0·07
353. na h-Ealaidh . . . . .	0·10	412. Burntisland . . . . .	0·07
354. na Ceithir Eileana . . . . .	0·10	413. na Lairige . . . . .	0·07
355. Morsgail . . . . .	0·10	414. Oban a' Chlachain . . . . .	0·07
356. Liath . . . . .	0·10	415. Shechernich . . . . .	0·07
357. an Laig Aird . . . . .	0·10	416. na Doire Daraich . . . . .	0·07
358. Phitiùlais . . . . .	0·10	417. Sandy . . . . .	0·07
359. Raonasgail . . . . .	0·10	418. nan Gabhar . . . . .	0·07
360. Littlester . . . . .	0·10	419. Bad a' Chrotha . . . . .	0·07
361. Bruadale . . . . .	0·10	420. a' Chlachain (Lewis) . . . . .	0·07
362. Vatandip . . . . .	0·10	421. Craggie . . . . .	0·07
363. Lunn dà-Bhàr . . . . .	0·10	422. Whitefield . . . . .	0·07
364. a' Phearsain . . . . .	0·10	423. Eldrig . . . . .	0·07
365. Sloy . . . . .	0·10	424. Monikie (North) . . . . .	0·07
366. Cuil Airidh a' Flod . . . . .	0·10	425. Gown (North) . . . . .	0·07
367. nan Lann . . . . .	0·10	426. Lochnaw . . . . .	0·07
368. Eigheach . . . . .	0·09	427. Dibadale . . . . .	0·07
369. Spynie . . . . .	0·09	428. Fleet . . . . .	0·07
370. Ghuiragarstidh . . . . .	0·09	429. Airidh na Lie . . . . .	0·07
371. nam Breac Dearga . . . . .	0·09	430. Brow . . . . .	0·07
372. na Mòine Buige . . . . .	0·09	431. Dhomhuill Bhig . . . . .	0·07
373. Cuil na Sìthe . . . . .	0·09	432. Howie . . . . .	0·07
374. a' Chlachain (Nairn) . . . . .	0·09	433. Hoglins . . . . .	0·06
375. Gown (South) . . . . .	0·09	434. Auchen Chapel . . . . .	0·06
376. Bogton . . . . .	0·09	435. Dallas . . . . .	0·06
377. na Sreinge . . . . .	0·09	436. Monzievaird . . . . .	0·06
378. Punds . . . . .	0·09	437. Aboyne . . . . .	0·06
379. North-house . . . . .	0·09	438. Hoil . . . . .	0·06
380. Kirk Dam . . . . .	0·09	439. Harperleas . . . . .	0·06
381. nan Deaspoint . . . . .	0·09	440. Moraig . . . . .	0·06
382. Muckle Lunga . . . . .	0·09	441. Fingask . . . . .	0·06
383. Aithness . . . . .	0·09	442. an Iasgaich . . . . .	0·06
384. na Dèighe fo Dheas . . . . .	0·08	443. nan Eun (Tay) . . . . .	0·06
385. Sròn Smeur . . . . .	0·08	444. Tarruinn an Eithir . . . . .	0·06
386. Hermidale . . . . .	0·08	445. na Creige Duibhe . . . . .	0·06
387. na Stainge . . . . .	0·08	446. a' Chonnachair . . . . .	0·06
388. a' Bhradaìn . . . . .	0·08	447. Mhic' ille Riabhaich . . . . .	0·06
389. Moor Dam . . . . .	0·08	448. Laide . . . . .	0·06
390. Leitir Easaich . . . . .	0·08	449. Dhùgaill (Torridon) . . . . .	0·06
391. Lochaber . . . . .	0·08	450. Flugarth . . . . .	0·06
392. a' Mhiotailt . . . . .	0·08	451. Black (Etive) (East) . . . . .	0·06
393. an Tuirc . . . . .	0·08	452. Harrow . . . . .	0·06
394. a' Ghlinne Dorcha . . . . .	0·08	453. Derclach . . . . .	0·06
395. Seil . . . . .	0·08	454. Crombie Den . . . . .	0·06
396. White of Myrton . . . . .	0·08	455. Peerie . . . . .	0·06
397. Ceò-Glas . . . . .	0·08	456. Airidh na Ceardaich . . . . .	0·06
398. Leodsay . . . . .	0·08	457. Gainmheich (North) . . . . .	0·06
399. Scaslavat . . . . .	0·08	458. na Bi . . . . .	0·06
400. Tormasad . . . . .	0·08	459. nan Druinnean . . . . .	0·06
401. Snarravoe . . . . .	0·08	460. Lochenbreck . . . . .	0·06

TABLE II—continued

Loch.	Area. Square Miles.	Loch.	Area. Square Miles.
461. Black (Etive) (Mid) . . . . .	0·05	512. Tilt . . . . .	0·03
462. " " (West) . . . . .	0·05	513. Allan . . . . .	0·03
463. Buidhe (Tay) . . . . .	0·05	514. Maol a' Choire . . . . .	0·03
464. Kinghorn . . . . .	0·05	515. Tùtach . . . . .	0·03
465. Essan . . . . .	0·05	516. Màna . . . . .	0·03
466. Kirk . . . . .	0·05	517. Kirriereoch . . . . .	0·03
467. Bhac . . . . .	0·05	518. Brough . . . . .	0·03
468. Mill . . . . .	0·05	519. Kilchoan (Lower) . . . . .	0·03
469. Rae . . . . .	0·05	520. a' Chaoruinn . . . . .	0·03
470. nan Garbh Chlachain . . . . .	0·05	521. Hightae Mill . . . . .	0·03
471. Dubh (Ailort) . . . . .	0·05	522. Fithie . . . . .	0·03
472. na Coinnich . . . . .	0·05	523. Sior . . . . .	0·03
473. Eileach Mhic' ille Riabhaich . . . . .	0·05	524. na Beithe . . . . .	0·03
474. na Garbh-Abhuinn . . . . .	0·05	525. a' Buaille . . . . .	0·03
475. na Claise Fearna . . . . .	0·05	526. Cults . . . . .	0·03
476. Baile a' Ghobhainn . . . . .	0·05	527. na Garbh-Abhuinn Ard . . . . .	0·03
477. Asta . . . . .	0·05	528. Skae . . . . .	0·03
478. a' Bhainne . . . . .	0·05	529. Aslaich . . . . .	0·03
479. Harelaw . . . . .	0·05	530. Dubh (Etive) . . . . .	0·03
480. Birka . . . . .	0·05	531. Hostigates . . . . .	0·03
481. nan Eun (Ness) . . . . .	0·05	532. Duddingston . . . . .	0·03
482. an Losgann Mòr . . . . .	0·05	533. Pitlyal . . . . .	0·02
483. Dubh-Mor . . . . .	0·05	534. Sand . . . . .	0·02
484. Gleann a' Bhearraidh . . . . .	0·05	535. White (Tay) . . . . .	0·02
485. Fiart . . . . .	0·05	536. an t-Seagain . . . . .	0·02
486. Edgelaw . . . . .	0·05	537. Dubh (Forth) . . . . .	0·02
487. Grass . . . . .	0·05	538. a' Chladaich . . . . .	0·02
488. Lure . . . . .	0·05	539. Seoly . . . . .	0·02
489. na Craige . . . . .	0·04	540. Crann . . . . .	0·02
490. Blairs . . . . .	0·04	541. Duartmore . . . . .	0·02
491. Fender . . . . .	0·04	542. Kinellan . . . . .	0·02
492. Anna . . . . .	0·04	543. na Gealaich . . . . .	0·02
493. Monk Myre . . . . .	0·04	544. Cornish . . . . .	0·02
494. Eion Mhic Alastair . . . . .	0·04	545. nan Ràth . . . . .	0·02
495. na Beiste . . . . .	0·04	546. Setter . . . . .	0·02
496. nan Geireann . . . . .	0·04	547. Magillie . . . . .	0·02
497. Beag . . . . .	0·04	548. na h' Eaglais . . . . .	0·02
498. Kilcheran . . . . .	0·04	549. Black (Tay) . . . . .	0·01
499. Luandie (Clunie) . . . . .	0·04	550. nan Auncot . . . . .	0·01
500. a' Vullan . . . . .	0·04	551. Uaine . . . . .	0·01
501. Gamhna . . . . .	0·04	552. an Tairbeirt Stuaighaich . . . . .	0·01
502. Uanagan . . . . .	0·04	553. Loch on Eilean Subhainn . . . . .	0·01
503. Collaster . . . . .	0·04	554. na Creige Léithe . . . . .	0·01
504. Drumlamford . . . . .	0·04	555. an Dubh (Lochy) . . . . .	0·01
505. Fyntalloch . . . . .	0·04	556. Rainbow . . . . .	0·01
506. Kilchoan (Upper) . . . . .	0·04	557. Dubh (Ness) . . . . .	0·01
507. Ree . . . . .	0·04	558. Choire na Cloich . . . . .	0·01
508. Muck . . . . .	0·04	559. nan Losganan . . . . .	0·01
509. Geal . . . . .	0·04	560. St Margaret's . . . . .	0·01
510. Browster . . . . .	0·04	561. Dhu (Portsonachan) . . . . .	0·003
511. Bran . . . . .	0·04	562. Allt na Mult . . . . .	0·003

TABLE III

FRESH-WATER LOCHS OF SCOTLAND (SOUNDED BY THE LAKE SURVEY)  
ARRANGED ACCORDING TO MAXIMUM DEPTH

Loch.	Max. Depth. Feet.	Loch.	Max. Depth. Feet.
1. Morar . . . . .	1017	54. Scamadale . . . . .	145
2. Ness . . . . .	754	55. Fionn (Gruinard) . . . . .	144
3. Lomond . . . . .	623	56. Bà (Mull) . . . . .	144
4. Lochy . . . . .	531	57. a' Bhaid-Luachraich . . . . .	143
5. Ericht . . . . .	512	58. Eck . . . . .	139
6. Tay . . . . .	508	59. Ossian . . . . .	132
7. Katrine . . . . .	495	60. Lungard . . . . .	129
8. Rannoch . . . . .	440	61. Tummel . . . . .	128
9. Treig . . . . .	436	62. Laidon . . . . .	128
10. Shiel . . . . .	420	63. Veyatie . . . . .	126
11. Maree . . . . .	367	64. Clunie (Ness) . . . . .	123
12. Glass . . . . .	365	65. Càrn . . . . .	122
13. Arkaig . . . . .	359	66. na h-Oidhe . . . . .	121
14. More (Laxford). . . . .	316	67. a' Bhaid Daraich . . . . .	121
15. Awe (Etive) . . . . .	307	68. Gainmheich (South) . . . . .	120
16. Earn . . . . .	287	69. Eilt . . . . .	119
17. Assynt . . . . .	282	70. Achilty . . . . .	119
18. Fannich . . . . .	282	71. Tralaig . . . . .	117
19. Quoich . . . . .	281	72. Arienas . . . . .	116
20. Morie . . . . .	270	73. Nell . . . . .	115
21. Monar . . . . .	260	74. Dubh-Mòr . . . . .	114
22. Muick . . . . .	256	75. na h-Airidh Sléibhe . . . . .	113
23. Fada (Ewe) . . . . .	248	76. Garry (Tay) . . . . .	113
24. Affric . . . . .	221	77. Bunacharan . . . . .	113
25. Suainaval . . . . .	219	78. Vennachar . . . . .	111
26. na Sheallag . . . . .	217	79. nan Lann . . . . .	109
27. Laoghal . . . . .	217	80. Dhùgail (Torridon) . . . . .	108
28. Skinaskink . . . . .	216	81. Stack . . . . .	108
29. Garry (Ness) . . . . .	213	82. Naver . . . . .	108
30. Damh (Torridon) . . . . .	206	83. Ard . . . . .	107
31. Dùn na Seilcheig . . . . .	205	84. Garve . . . . .	105
32. Frisa . . . . .	205	85. an Duin (Spey) . . . . .	102
33. Mullardoch . . . . .	197	86. Lyon . . . . .	100
34. Avich . . . . .	188	87. an Laghair . . . . .	100
35. Hope . . . . .	187	88. Eilde Mòr . . . . .	100
36. Bad a' Ghaill . . . . .	180	89. Doon . . . . .	100
37. Dhùghaill (Carron) . . . . .	179	90. Insh . . . . .	100
38. Beannachan . . . . .	176	91. Voil . . . . .	98
39. Laggan . . . . .	174	92. Langavat (Lewis) . . . . .	98
40. a' Chroisg . . . . .	168	93. an t-Seilich . . . . .	98
41. Beinn a' Mheadhoin . . . . .	167	94. Achray . . . . .	97
42. Luichart . . . . .	164	95. Drunkie . . . . .	97
43. Shin . . . . .	162	96. Daimh (Tay) . . . . .	95
44. Beoraid . . . . .	159	97. Benisval . . . . .	95
45. an Dithreibh . . . . .	157	98. Raonasgail . . . . .	95
46. Lurgain . . . . .	156	99. Dungeon . . . . .	94
47. Oich . . . . .	154	100. a' Mhuilinn . . . . .	94
48. Dubh (Ailort) . . . . .	153	101. Garbhaig . . . . .	93
49. St Mary's . . . . .	153	102. na Creige Duibhe . . . . .	93
50. Owskeich . . . . .	153	103. Clair (Ewe) . . . . .	93
51. Coir' an Fhearna . . . . .	151	104. Kernsary . . . . .	93
52. Obisary . . . . .	151	105. Nant . . . . .	92
53. Lubnaig . . . . .	146	106. a' Bhealaich (Gairloch) . . . . .	92

TABLE III—*continued*

Loch.	Max. Depth. Feet.	Loch.	Max. Depth. Feet.
107. Gorm Loch Mòr . . . . .	91	166. an Eilein (Spey) . . . . .	66
108. Seil . . . . .	91	167. Brora . . . . .	66
109. Mhor . . . . .	91	168. Doine . . . . .	65
110. Fionn (Kirkaig) . . . . .	90	169. Iubhair . . . . .	65
111. Grunavat . . . . .	90	170. Benachally . . . . .	64
112. Tarff . . . . .	89	171. Bad an Sgalaidh . . . . .	64
113. Dubh (Gruinard) . . . . .	88	172. a' Ghriama . . . . .	64
114. na Leitreach . . . . .	88	173. Loch on Eilean Subhainn . . . . .	64
115. Baile a' Ghobhainn . . . . .	88	174. na Meide . . . . .	63
116. Tollie . . . . .	86	175. Ken . . . . .	62
117. Builg . . . . .	86	176. Freuchie . . . . .	62
118. Calder . . . . .	85	177. an Tachdaidh . . . . .	62
119. na Cuaich . . . . .	85	178. Raoinavat . . . . .	61
120. Merkland . . . . .	85	179. Dibadale . . . . .	61
121. a' Ghlinne Dorcha . . . . .	85	180. Tingwall . . . . .	60
122. Creagach . . . . .	84	181. Hunder . . . . .	60
123. Tulla . . . . .	84	182. a' Choire . . . . .	60
124. Calavie . . . . .	84	183. na Moine Buige . . . . .	60
125. Leven . . . . .	83	184. Kilcheran . . . . .	60
126. Scaslavat . . . . .	82	185. Allt na h-Airbhe . . . . .	60
127. na h-Earba (West) . . . . .	81	186. Gainmheich (North) . . . . .	59
128. Loch . . . . .	81	187. nan Drummnean . . . . .	59
129. a' Chlachain (Nairn) . . . . .	80	188. Lowes (Tweed) . . . . .	58
130. a' Bhealaich (Naver) . . . . .	80	189. Lochrutton . . . . .	58
131. Turret . . . . .	79	190. Ederline . . . . .	58
132. an Lebid . . . . .	79	191. na Beithe . . . . .	58
133. Fender . . . . .	78	192. Fiart . . . . .	58
134. Menteith . . . . .	77	193. Drumellie . . . . .	58
135. Edgelaw . . . . .	77	194. Pattack . . . . .	58
136. Chon (Forth) . . . . .	75	195. Aithness . . . . .	57
137. Knoekie . . . . .	75	196. Ashie . . . . .	57
138. Eion Mhic Alastair . . . . .	74	197. Hoglinns . . . . .	57
139. Pithiulais . . . . .	74	198. an Losgainn Mòr . . . . .	57
140. Girlsta . . . . .	74	199. Clousta . . . . .	57
141. Caravat . . . . .	74	200. Fleet . . . . .	56
142. a' Bhraoin . . . . .	73	201. nan Deaspoint . . . . .	56
143. Talla . . . . .	73	202. Sealbhag . . . . .	56
144. Clings . . . . .	73	203. Fada (Gruinard) . . . . .	56
145. Sgamhain . . . . .	72	204. Skiach . . . . .	55
146. Kennard . . . . .	72	205. Trool . . . . .	55
147. Fiodhaig . . . . .	71	206. an t-Slagain . . . . .	55
148. Cròcach . . . . .	71	207. Liath . . . . .	55
149. nam Breac . . . . .	71	208. Rosebery . . . . .	55
150. Kilchoan (Upper) . . . . .	70	209. Mill . . . . .	55
151. Leitir Easaich . . . . .	70	210. an Drainc . . . . .	55
152. Alvie . . . . .	70	211. Caol na Doire . . . . .	55
153. nam Breac Dearga . . . . .	70	212. Dilate . . . . .	55
154. Achall . . . . .	70	213. Lochaber . . . . .	55
155. Lintathen . . . . .	70	214. Crogavat . . . . .	55
156. Derculich . . . . .	70	215. Gladhouse . . . . .	55
157. Clunie (Tay) . . . . .	69	216. Eela . . . . .	55
158. a' Mhiotailt . . . . .	69	217. Lundie (Garry) . . . . .	54
159. na h-Earba (East) . . . . .	69	218. Harelaw . . . . .	54
160. Ordie . . . . .	69	219. Crombie Den . . . . .	53
161. Grennoch . . . . .	68	220. Lowes (Tay) . . . . .	53
162. Dubh (Gairloch) . . . . .	68	221. a' Phearsain . . . . .	53
163. Arklet . . . . .	67	222. Gown (South) . . . . .	52
164. Killin . . . . .	67	223. an Daimh (Shin) . . . . .	52
165. na Beinne Bàine . . . . .	67	224. Braigh Horrisdale . . . . .	51

TABLE III—continued

Loch.	Max. Depth. Feet.	Loch.	Max. Depth. Feet.
225. Kemp . . . . .	51	284. Kindar . . . . .	41
226. Leum a' Chlamhain . . . . .	51	285. Gambna . . . . .	41
227. an Staca . . . . .	51	286. Spiggie . . . . .	41
228. Lochindorb . . . . .	51	287. White of Myrton . . . . .	40
229. Moy . . . . .	50	288. Craggie . . . . .	40
230. Bran . . . . .	50	289. Finlas . . . . .	40
231. Black (Ryan) . . . . .	50	290. an Dubh (Lochy) . . . . .	40
232. Inbhir . . . . .	50	291. Stacsavat . . . . .	40
233. Arthur . . . . .	50	292. Urigill . . . . .	40
234. na Craobhaig . . . . .	50	293. Monzievaired . . . . .	39
235. Scadavay (East) . . . . .	50	294. na Lairige . . . . .	39
236. nan Eun (Tay). . . . .	50	295. Fadagaa . . . . .	39
237. Giorra . . . . .	49	296. an Tuirc . . . . .	39
238. Migdale . . . . .	49	297. nan Abscot . . . . .	39
239. Woodhall . . . . .	49	298. Howie . . . . .	39
240. Ghuilbinn . . . . .	49	299. Burntisland . . . . .	39
241. Morlich . . . . .	49	300. Tearnait . . . . .	39
242. Coulin (Ewe) . . . . .	49	301. na Claise Fearna . . . . .	38
243. Gleann a' Bhearraidh . . . . .	48	302. White (Ryan) . . . . .	38
244. Doire nam Mart . . . . .	48	303. Fad . . . . .	38
245. an Droighinn . . . . .	48	304. Beannach (Inver) . . . . .	38
246. Fingask . . . . .	48	305. Holl . . . . .	38
247. Poulary . . . . .	47	306. Kinghorn . . . . .	38
248. Bodavat . . . . .	46	307. a' Bharpa . . . . .	37
249. Hoil . . . . .	46	308. Ghiuragarstidh . . . . .	37
250. Birka . . . . .	45	309. Scadavay (West) . . . . .	37
251. Fada (N. Uist) . . . . .	45	310. Dee . . . . .	36
252. Meiklie . . . . .	45	311. Allt an Fhearna . . . . .	36
253. Kilchoan (Lower) . . . . .	45	312. Buidhe (Fleet) . . . . .	36
254. Ree . . . . .	44	313. Black (Etive) (East). . . . .	36
255. a' Bhealaich (Alsh) . . . . .	44	314. Skeen (Annan) . . . . .	36
256. Mاما . . . . .	44	315. a' Bhuid . . . . .	36
257. Expansions of River Dee . . . . .	44	316. Skae . . . . .	35
258. Craighush . . . . .	44	317. Trealaval . . . . .	35
259. an Tomain . . . . .	44	318. an Dùin (N. Uist) . . . . .	35
260. Skebacleit . . . . .	44	319. na Beiste . . . . .	35
261. Uanagan . . . . .	43	320. Loyne (East) . . . . .	35
262. na Sreinge . . . . .	43	321. Ussie . . . . .	35
263. a' Chuiliun (Conon) . . . . .	43	322. an Nostarie . . . . .	35
264. na h-Eaglais . . . . .	43	323. Langavat (Benbecula) . . . . .	34
265. Dochar . . . . .	42	324. Gryfe . . . . .	34
266. Ruthven . . . . .	42	325. an Eilein (Gairloch) . . . . .	34
267. Urr . . . . .	42	326. Ochiltree . . . . .	34
268. Skealtar . . . . .	42	327. Anchenreoch . . . . .	34
269. Thom . . . . .	42	328. na Déighe fo Dheas . . . . .	34
270. Baddanloch . . . . .	42	329. ic Colla . . . . .	34
271. an Laig Aird . . . . .	42	330. Coire nam Meann . . . . .	33
272. Soulseat . . . . .	42	331. Sròn Smeur . . . . .	33
273. Bhac . . . . .	42	332. Eileach Mhic' ille Riabhaich . . . . .	33
274. na Ceithir Eileana . . . . .	42	333. Skerrow . . . . .	33
275. Long . . . . .	42	334. Whinyeon . . . . .	33
276. Breaclaich . . . . .	41	335. Urrahag . . . . .	33
277. Harperleas . . . . .	41	336. Roer . . . . .	32
278. Portmore . . . . .	41	337. White (Tay) . . . . .	32
279. Bhradain . . . . .	41	338. a' Chláir (Helmsdale) . . . . .	32
280. Heouravay . . . . .	41	339. Deoravat . . . . .	32
281. Dubh (Forth) . . . . .	41	340. Ceò-Glas . . . . .	32
282. Hermidale . . . . .	41	341. Hosta . . . . .	31
283. Hostigates . . . . .	41	342. Sloy . . . . .	31

TABLE III—*continued*

Loch.	Max. Depth. Feet.	Loch.	Max. Depth. Feet.
343. Drnim Suardalain . . . . .	31	402. Bad a' Chrotha . . . . .	23
344. nan Eun (N. Uist) . . . . .	31	403. a' Buaille . . . . .	23
345. Morsgail . . . . .	31	404. Muck . . . . .	23
346. Balgavies . . . . .	31	405. Airidh na Ceardaich . . . . .	22
347. Burga . . . . .	30	406. an Stromore . . . . .	22
348. Chaluum . . . . .	30	407. Monikie (North) . . . . .	22
349. an Gead . . . . .	30	408. Duartmore . . . . .	22
350. Bà (Tay) . . . . .	30	409. nam Faoileag . . . . .	22
351. Callater . . . . .	30	410. Black (Etive) (West) . . . . .	22
352. Harperrig . . . . .	30	411. Crò Criosdaig . . . . .	21
353. Punds . . . . .	30	412. nan Eun (Ness) . . . . .	21
354. Kilbirmie . . . . .	30	413. Borralan . . . . .	21
355. Forfar . . . . .	29	414. Cliff . . . . .	21
356. Harrow . . . . .	29	415. Gartmorn . . . . .	21
357. Martnaham . . . . .	29	416. a' Chaoruinn . . . . .	20
358. Allan . . . . .	29	417. Leodsay . . . . .	20
359. an Dùna . . . . .	29	418. na Moraicha . . . . .	20
360. Snarravoe . . . . .	29	419. Choire na Cloich . . . . .	20
361. na Sàlach Uidhre . . . . .	29	420. na Garbh-Abhuinn . . . . .	20
362. Beag . . . . .	29	421. a' Bhaillidh . . . . .	20
363. Cults . . . . .	28	422. Muckle Water . . . . .	20
364. a' Bhainne . . . . .	28	423. Airidh na Lic . . . . .	19
365. na h-Achlaise . . . . .	28	424. Pitlyal . . . . .	19
366. Eigheach . . . . .	28	425. Oban a' Chlachain . . . . .	19
367. nan Cuinne . . . . .	28	426. Loyne (West) . . . . .	19
368. Clubbi Shuns . . . . .	28	427. Essan . . . . .	18
369. a' Ghobhainn . . . . .	28	428. Dubh (Ness) . . . . .	18
370. Black (Etive) (Mid) . . . . .	27	429. an Lagain . . . . .	18
371. Valtos . . . . .	27	430. nan Geireann (Mill) . . . . .	18
372. nan Geireann . . . . .	27	431. an t-Seasgann . . . . .	18
373. Beannach (Gruinard) . . . . .	27	432. Castle (Annan) . . . . .	18
374. a' Chonnachair . . . . .	27	433. Carlingwark . . . . .	17
375. nan Ràth . . . . .	27	434. Peppermill . . . . .	17
376. Anna . . . . .	27	435. Gown (North) . . . . .	17
377. a' Vullan . . . . .	27	436. Stenness . . . . .	17
378. Linlithgow . . . . .	27	437. Auchen Chapel . . . . .	17
379. Muckle Lunga . . . . .	27	438. Crann . . . . .	17
380. an Ruathair . . . . .	26	439. Threipmuir . . . . .	17
381. Aslaich . . . . .	26	440. Vatandip . . . . .	17
382. Rainbow . . . . .	26	441. Swannay . . . . .	16
383. Monikie (South) . . . . .	26	442. Rae . . . . .	16
384. Drumlamford . . . . .	26	443. Fitty . . . . .	16
385. na Gealaich . . . . .	25	444. Droma . . . . .	16
386. na Coinnich . . . . .	25	445. Tùtach . . . . .	16
387. Lùnn dà-Bhrà . . . . .	25	446. Kinellan . . . . .	16
388. nan Garbh Chlachain . . . . .	25	447. an Iasgaich . . . . .	16
389. Vaara . . . . .	25	448. Fithie . . . . .	16
390. Veiragvat . . . . .	25	449. Lochenbreck . . . . .	15
391. Kirk . . . . .	25	450. Milton . . . . .	15
392. Huna . . . . .	25	451. Fyntalloch . . . . .	15
393. Crunachan . . . . .	25	452. Kirriereoch . . . . .	15
394. Butterstone . . . . .	25	453. Moraig . . . . .	14
395. Lundie (Clunie) . . . . .	25	454. Whitefield . . . . .	14
396. Strandavat . . . . .	25	455. Sguod . . . . .	14
397. Ailsh . . . . .	24	456. Cùil na Síthe . . . . .	14
398. an Tairbeirt Stuaधाich . . . . .	24	457. Harray . . . . .	14
399. Taruinn an Eithir . . . . .	23	458. Maberry . . . . .	14
400. Rescobie . . . . .	23	459. na Stainge . . . . .	14
401. Geal . . . . .	23	460. Magillie . . . . .	14

TABLE III—continued

Loch.	Max. Depth. Feet.	Loch.	Max. Depth. Feet.
461. na Creige Léithe . . . . .	14	512. Hempriggs . . . . .	8
462. na Craige . . . . .	13	513. Dallas . . . . .	8
463. Hightae Mill . . . . .	13	514. na h-Ealaidh . . . . .	8
464. Asta . . . . .	13	515. na Moine . . . . .	8
465. North-house . . . . .	13	516. Flugarth . . . . .	8
466. Mochrum . . . . .	13	517. Black (Tay) . . . . .	7
467. Strom . . . . .	13	518. More (Thurso) . . . . .	7
468. Watten . . . . .	12	519. Dhomhnuill Bhig . . . . .	7
469. Truid air Sgithiche . . . . .	12	520. Cornish . . . . .	7
470. Olavat . . . . .	12	521. Eye . . . . .	7
471. Mhic' ille Riabhaich . . . . .	12	522. Hundland . . . . .	7
472. Syre . . . . .	12	523. Shurrery . . . . .	7
473. Derclach . . . . .	12	524. nan Losganan . . . . .	7
474. Kinord . . . . .	12	525. Araich-Lin . . . . .	7
475. Monk Myre . . . . .	12	526. St John's . . . . .	7
476. Scoly . . . . .	12	527. Sandy . . . . .	7
477. Drummond . . . . .	12	528. Awe (Inver) . . . . .	7
478. Castle (Bladenoch) . . . . .	11	529. na Garbh-Abhuinn Ard . . . . .	7
479. a' Chlachain (Lewis) . . . . .	11	530. Tankerness . . . . .	7
480. Brouster . . . . .	11	531. Lure . . . . .	7
481. Dochart . . . . .	11	532. na Bi . . . . .	6
482. Aboyne . . . . .	11	533. Moor Dam . . . . .	6
483. Dornal . . . . .	10	534. Kilconquhar . . . . .	6
484. Uaine . . . . .	10	535. Grass . . . . .	6
485. Oban nam Fiadh . . . . .	10	536. Skene (Dee) . . . . .	6
486. Dhu (Portsonachan) . . . . .	10	537. Spynie . . . . .	6
487. Eldrig . . . . .	10	538. Lochnaw . . . . .	6
488. Lindores . . . . .	10	539. Kirbister . . . . .	6
489. Peerie . . . . .	10	540. Bruadale . . . . .	6
490. Dubh (Etive) . . . . .	10	541. Brow . . . . .	6
491. Burriland . . . . .	10	542. Tilt . . . . .	5
492. Duddingston . . . . .	10	543. Blairs . . . . .	5
493. Clickhimin . . . . .	10	544. Scarmclate . . . . .	5
494. Tormasad . . . . .	10	545. Castle Semple . . . . .	5
495. Lochinvar . . . . .	10	546. Heilen . . . . .	5
496. Collaster . . . . .	10	547. Bosquoy . . . . .	5
497. Broom . . . . .	9	548. nan Gabhar . . . . .	5
498. Boardhouse . . . . .	9	549. St Margaret's . . . . .	5
499. na Doire Daraich . . . . .	9	550. Kirk Dam . . . . .	5
500. Davan . . . . .	9	551. Bogton . . . . .	4
501. Littlester . . . . .	9	552. Skaill . . . . .	4
502. a' Chladaich . . . . .	9	553. Sand . . . . .	4
503. Con (Tay) . . . . .	9	554. Brough . . . . .	4
504. Cuil Airidh a' Flod . . . . .	9	555. Sior . . . . .	4
505. Laide . . . . .	9	556. Stormont . . . . .	3
506. Gelly . . . . .	9	557. Allt na Mult . . . . .	3
507. Achanalt . . . . .	9	558. Sabiston . . . . .	3
508. Shechernich . . . . .	8	559. Wester . . . . .	3
509. More Barvas . . . . .	8	560. Ishister . . . . .	3
510. Maol a' Choire . . . . .	8	561. Buidhe (Tay) . . . . .	3
511. Bradan . . . . .	8	562. Setter . . . . .	2

TABLE IV

FRESH-WATER LOCHS OF SCOTLAND (SOUNDED BY THE LAKE SURVEY)  
ARRANGED ACCORDING TO MEAN DEPTH

Loch.	Mean Depth. Feet.	Loch.	Mean Depth. Feet.
1. Ness . . . . .	433·02	53. a' Bhaid Daraich . . . . .	55·60
2. Morar . . . . .	284·00	54. na h-Oidheche . . . . .	53·95
3. Lochy . . . . .	228·95	55. Achilty . . . . .	51·78
4. Treig . . . . .	207·37	56. Shin . . . . .	51·04
5. Katrine . . . . .	199·19	57. Dubh-Mòr . . . . .	50·93
6. Tay . . . . .	199·08	58. Eck . . . . .	50·16
7. Ericht . . . . .	189·21	59. Bunacharan . . . . .	50·11
8. Rannoch . . . . .	167·46	60. Clunie (Ness) . . . . .	49·98
9. Glass . . . . .	159·07	61. Garry (Tay) . . . . .	49·91
10. Arkaig . . . . .	152·71	62. Tummel . . . . .	48·03
11. Earn . . . . .	137·83	63. Bà (Mull) . . . . .	47·42
12. Shiel . . . . .	132·73	64. Eilde Mòr . . . . .	47·01
13. More (Laxford) . . . . .	125·83	65. Owskeich . . . . .	46·90
14. Maree . . . . .	125·30	66. Lyon . . . . .	44·87
15. Morie . . . . .	125·20	67. na h-Airidh Sléibhe . . . . .	44·43
16. Lomond . . . . .	121·29	68. Ard . . . . .	43·86
17. Muick . . . . .	116·30	69. Garve . . . . .	43·60
18. Fannich . . . . .	108·76	70. Lubnaig . . . . .	42·77
19. Suainaval . . . . .	108·60	71. Ossian . . . . .	42·75
20. Awe (Etive) . . . . .	104·95	72. na Cuaich . . . . .	42·48
21. Quoich . . . . .	104·60	73. Vennachar . . . . .	42·41
22. na Sheallag . . . . .	103·47	74. Dubh (Gruinard) . . . . .	42·33
23. Fada (Ewe) . . . . .	102·20	75. Clair (Ewe) . . . . .	42·10
24. Assynt . . . . .	101·10	76. Gainmheich (South) . . . . .	41·80
25. Avich . . . . .	98·42	77. Oich . . . . .	41·78
26. Monar . . . . .	98·33	78. an t-Seilich . . . . .	41·30
27. Affric . . . . .	93·64	79. Tralaig . . . . .	41·03
28. Dhn na Seilchrig . . . . .	84·00	80. Veyatie . . . . .	41·00
29. Garry (Ness) . . . . .	78·00	81. Voil . . . . .	40·94
30. Mullardoch . . . . .	77·52	82. na Leitreach . . . . .	40·29
31. Frisa . . . . .	76·40	83. Eion Mhic Alastair . . . . .	39·73
32. a' Chroisg . . . . .	73·78	84. Daimh (Tay) . . . . .	39·12
33. St Mary's . . . . .	72·93	85. Naver . . . . .	39·06
34. Beoraid . . . . .	72·34	86. Baile a' Ghobhainn . . . . .	38·77
35. Beannachan . . . . .	70·42	87. Dhùgaill (Torridon) . . . . .	38·27
36. Scamadale . . . . .	69·58	88. Kernsary . . . . .	38·17
37. Laggan . . . . .	67·68	89. Tulla . . . . .	38·08
38. Luichart . . . . .	66·84	90. Calavie . . . . .	37·91
39. Dhùghaill (Carron) . . . . .	66·65	91. Càrn . . . . .	37·70
40. an Dithreibh . . . . .	65·93	92. Insh . . . . .	37·31
41. Beinn a' Mheadhoin . . . . .	65·36	93. an Laghair . . . . .	37·23
42. Laoghal . . . . .	65·21	94. Eilt . . . . .	37·12
43. Lungard . . . . .	63·68	95. nan Lann . . . . .	37·03
44. Dubh (Ailort) . . . . .	62·70	96. Nell . . . . .	36·80
45. Bad a' Ghail . . . . .	61·90	97. Seil . . . . .	36·73
46. Hope . . . . .	61·47	98. a' Bhraoin . . . . .	36·60
47. Lurgain . . . . .	60·90	99. Lowes (Tweed) . . . . .	36·55
48. Skinaskink . . . . .	60·40	100. Drunkie . . . . .	36·05
49. Damh (Torridon) . . . . .	58·91	101. Achray . . . . .	36·01
50. Coir' an Fheàrna . . . . .	58·79	102. Stack . . . . .	35·91
51. Fionn (Gruinard) . . . . .	57·79	103. an Leòid . . . . .	35·75
52. Arienas . . . . .	56·60	104. na h-Earba (West) . . . . .	35·62

TABLE IV—continued

Loch.	Mean Depth. Feet.	Loch.	Mean Depth. Feet.
105. Garbhaig . . . . .	35·41	163. Benachally . . . . .	25·06
106. Laidon . . . . .	35·19	164. Iubhair . . . . .	24·96
107. Talla . . . . .	34·70	165. Langavat (Lewis) . . . . .	24·79
108. Benisval . . . . .	34·68	166. Derculich . . . . .	24·72
109. Scaslavat . . . . .	34·65	167. Crogavat . . . . .	24·66
110. a' Mhuilinn . . . . .	34·15	168. na Mòine Buige . . . . .	24·62
111. a' Bhaid-Luachraich . . . . .	34·02	169. Gainmheich (North) . . . . .	24·50
112. Creagach . . . . .	33·17	170. nam Breac Dearga . . . . .	24·43
113. Doine . . . . .	33·13	171. Knockie . . . . .	24·40
114. Tollie . . . . .	33·13	172. Nant . . . . .	24·31
115. a' Bhealaich (Gairloch) . . . . .	32·74	173. Gorm Loch Mòr . . . . .	24·30
116. na Creige Duibhe . . . . .	32·49	174. Arklet . . . . .	24·19
117. Raonasgail . . . . .	32·37	175. Killin . . . . .	24·15
118. Kennard . . . . .	32·27	176. Mhor . . . . .	24·11
119. Turret . . . . .	31·79	177. Tarff . . . . .	23·89
120. Fender . . . . .	31·77	178. Dilate . . . . .	23·50
121. Dubh (Gairloch) . . . . .	31·74	179. Lintrathen . . . . .	23·42
122. Girlsta . . . . .	31·41	180. Black (Ryan) . . . . .	23·37
123. a' Bhealaich (Naver) . . . . .	31·20	181. Ederline . . . . .	23·15
124. na h-Earba (East) . . . . .	31·11	182. Phitiùlais . . . . .	23·15
125. Edgelaw . . . . .	31·10	183. Fiart . . . . .	23·13
126. an Duin (Spey) . . . . .	30·38	184. Caol na Doire . . . . .	23·04
127. a' Mhiotailt . . . . .	30·30	185. na h-Eaglais . . . . .	22·84
128. Allt na h-Airbhe . . . . .	30·17	186. Fingask . . . . .	22·83
129. Merkland . . . . .	30·14	187. Freuchie . . . . .	22·83
130. a' Chlachain (Nairn) . . . . .	29·84	188. Harelaw . . . . .	22·83
131. Loch on Eilean Subhainn . . . . .	29·70	189. Brora . . . . .	22·68
132. Kilchoan (Upper) . . . . .	29·54	190. Dungeon . . . . .	22·64
133. Chon (Forth) . . . . .	29·38	191. Liath . . . . .	22·36
134. Loch . . . . .	29·22	192. Meiklie . . . . .	22·10
135. Drumellie . . . . .	29·18	193. Fleet . . . . .	21·81
136. Clunie (Tay) . . . . .	29·12	194. Giorra . . . . .	21·70
137. Grunavat . . . . .	28·36	195. nan Eun (Tay) . . . . .	21·64
138. na Beinne Bàine . . . . .	28·33	196. Doire nam Mart . . . . .	21·33
139. a' Ghriama . . . . .	28·03	197. Ashie . . . . .	21·26
140. nam Breac . . . . .	27·94	198. Migdale . . . . .	21·18
141. Achall . . . . .	27·83	199. Kilcheran . . . . .	21·11
142. Dibadale . . . . .	27·77	200. Ken . . . . .	21·00
143. Bulg . . . . .	27·75	201. Calder . . . . .	20·87
144. na Beithe . . . . .	27·72	202. nan Deaspoirt . . . . .	20·82
145. a' Ghlinne Dorcha . . . . .	27·65	203. Grennoch . . . . .	20·82
146. a' Choire . . . . .	27·55	204. Dubh (Forth) . . . . .	20·70
147. an Daimh (Shin) . . . . .	27·17	205. Sealbhag . . . . .	20·66
148. Alvie . . . . .	27·02	206. na Meide . . . . .	20·61
149. Sgamhain . . . . .	26·77	207. Lochaber . . . . .	20·57
150. Doon . . . . .	26·71	208. Raoinavat . . . . .	20·56
151. Clings . . . . .	26·55	209. Fionn . . . . .	20·40
152. Ordie . . . . .	26·32	210. Lowes (Tay) . . . . .	20·40
153. Kemp . . . . .	26·23	211. Kilchoan (Lower) . . . . .	20·30
154. Hoglinns . . . . .	26·09	212. Leitir Easaich . . . . .	19·90
155. an Drainc . . . . .	25·86	213. Menteith . . . . .	19·77
156. Fiodhaig . . . . .	25·79	214. Woodhall . . . . .	19·67
157. Arthur . . . . .	25·77	215. Leum a' Chlamhain . . . . .	19·54
158. Obisary . . . . .	25·70	216. a' Phearsain . . . . .	19·44
159. an Eilein (Spey) . . . . .	25·47	217. Moy . . . . .	19·31
160. Mill . . . . .	25·33	218. Thom . . . . .	19·25
161. Bad an Sgalaig . . . . .	25·26	219. Hoil . . . . .	19·09
162. Rosebery . . . . .	25·20	220. Tingwall . . . . .	18·88

TABLE IV—continued

Loch.	Mean Depth. Feet.	Loch.	Mean Depth. Feet.
221. Aithness . . . . .	18·84	279. Eileach Mhic' ille Riabhaich	14·13
222. an Losgairn Mòr . . . . .	18·65	280. Braeclaich . . . . .	14·09
223. Trool . . . . .	18·39	281. White (Ryan) . . . . .	14·09
224. Coulin (Ewe) . . . . .	18·29	282. Pattack . . . . .	14·07
225. Braigh Horrisdale . . . . .	18·10	283. Expansions of River Dee . . . . .	13·90
226. Skiach . . . . .	18·09	284. na Ceithir Eileana . . . . .	13·81
227. Hunder . . . . .	18·08	285. White of Myrton . . . . .	13·70
228. Harperleas . . . . .	17·88	286. a' Chlàir (Helmsdale) . . . . .	13·65
229. an Tachdaidh . . . . .	17·88	287. Monikie (South) . . . . .	13·47
230. Skeen (Annan) . . . . .	17·87	288. Vaara . . . . .	13·44
231. Crombie Den . . . . .	17·64	289. Black (Etive) (East) . . . . .	13·39
232. na Spreinge . . . . .	17·53	290. an Ruathair . . . . .	13·34
233. Stacsavat . . . . .	17·43	291. Ghuilbinn . . . . .	13·32
234. Gryfe . . . . .	17·35	292. na Claise Fèarna . . . . .	13·23
235. Baddanloch . . . . .	17·33	293. Beannach (Inver) . . . . .	13·20
236. Fada (Gruinard) . . . . .	17·15	294. an Dùna . . . . .	13·12
237. Fad . . . . .	17·13	295. Urigill . . . . .	13·10
238. Holl . . . . .	17·04	296. Lochrutton . . . . .	13·03
239. Cròcach . . . . .	16·80	297. White (Tay) . . . . .	12·95
240. Uanagan . . . . .	16·80	298. Gleann a' Bhearraidh . . . . .	12·79
241. nan Àiscot . . . . .	16·79	299. Anna . . . . .	12·74
242. Portmore . . . . .	16·79	300. Burga . . . . .	12·65
243. na Craobhaig . . . . .	16·63	301. Bran . . . . .	12·63
244. Eela . . . . .	16·59	302. Skerrow . . . . .	12·63
245. Caravat . . . . .	16·57	303. Bodavat . . . . .	12·61
246. a' Bhealaich (Alsh) . . . . .	16·53	304. a' Ghobhainn . . . . .	12·59
247. Bhac . . . . .	16·50	305. Monikie (North) . . . . .	12·58
248. an Tomain . . . . .	16·47	306. Snarravoe . . . . .	12·55
249. Gladhouse . . . . .	16·46	307. Hermidale . . . . .	12·49
250. an t-Slagain . . . . .	16·42	308. Hosta . . . . .	12·47
251. Lundie (Garry) . . . . .	16·28	309. a' Bharpa . . . . .	12·43
252. Hostigates . . . . .	16·26	310. Lochindorb . . . . .	12·42
253. Tearnait . . . . .	16·16	311. nan Cuinne . . . . .	12·38
254. Craiglush . . . . .	16·13	312. Morsgail . . . . .	12·33
255. Skealtar . . . . .	15·90	313. a' Vullan . . . . .	12·27
256. Gown (South) . . . . .	15·88	314. Whinyeon . . . . .	12·22
257. Howie . . . . .	15·69	315. Urr . . . . .	12·06
258. nan Druinnean . . . . .	15·61	316. Callater . . . . .	11·99
259. an Staca . . . . .	15·52	317. Burntisland . . . . .	11·85
260. an Dubh (Lochy) . . . . .	15·50	318. Dochard . . . . .	11·84
261. Kinghorn . . . . .	15·33	319. Birka . . . . .	11·81
262. Craggie . . . . .	15·31	320. Beag . . . . .	11·80
263. Clousta . . . . .	15·27	321. Buidhe (Fleet) . . . . .	11·72
264. Skebacleit . . . . .	15·21	322. Fadagoa . . . . .	11·70
265. Soulseat . . . . .	15·19	323. Auchenreoch . . . . .	11·69
266. an Laig Aird . . . . .	15·12	324. Harrow . . . . .	11·61
267. Ree . . . . .	14·96	325. Coire nam Meann . . . . .	11·60
268. Leven . . . . .	14·87	326. Deoravat . . . . .	11·60
269. Bhradain . . . . .	14·83	327. Spiggie . . . . .	11·59
270. an Droighinn . . . . .	14·78	328. Urrahag . . . . .	11·49
271. Monzievaird . . . . .	14·70	329. Forfar . . . . .	11·43
272. Morlich . . . . .	14·62	330. an Gead . . . . .	11·29
273. an Eilein (Gairloch) . . . . .	14·39	331. Butterstone . . . . .	11·29
274. Rainbow . . . . .	14·33	332. Black (Etive) (Mid) . . . . .	11·27
275. Allt an Fhèarna . . . . .	14·31	333. Ruthven . . . . .	11·27
276. Màma . . . . .	14·29	334. Muckle Water . . . . .	11·08
277. Dee . . . . .	14·25	335. na Lairige . . . . .	10·97
278. Kindar . . . . .	14·22	336. Harperrig . . . . .	10·96

TABLE IV—*continued*

Loch.	Mean Depth. Feet.	Loch.	Mean Depth. Feet.
337. an Nostarie . . . . .	10·95	395. Peppermill . . . . .	8·60
338. Aslaich . . . . .	10·91	396. Castle (Annan) . . . . .	8·58
339. Drumlamford . . . . .	10·82	397. nan Geireann . . . . .	8·47
340. ic Colla . . . . .	10·77	398. Lunn dà-Bhrà . . . . .	8·44
341. Gartmorn . . . . .	10·75	399. Watten . . . . .	8·42
342. Cliff . . . . .	10·65	400. Pitlyal . . . . .	8·32
343. an Tuirc . . . . .	10·60	401. Ailsh . . . . .	8·30
344. na Beiste . . . . .	10·56	402. Auchenchapel . . . . .	8·26
345. na Déighe fo Dheas . . . . .	10·54	403. nan Ràth . . . . .	8·23
346. a' Tairbeirt Stuaadhaich . . . . .	10·50	404. Huna . . . . .	8·22
347. Stennes . . . . .	10·43	405. Langavat (Benbecula) . . . . .	8·12
348. a' Bhuid . . . . .	10·42	406. Sloy . . . . .	8·12
349. Allan . . . . .	10·40	407. Bà (Tay) . . . . .	8·10
350. Geal . . . . .	10·38	408. Whitefield . . . . .	8·01
351. Loyne (East) . . . . .	10·32	409. Ussie . . . . .	7·98
352. Sròn Smeur . . . . .	10·31	410. Chalum . . . . .	7·92
353. Druim Suardalain . . . . .	10·30	411. Threipmuir . . . . .	7·90
354. Fada (N. Uist) . . . . .	10·25	412. Inbhir . . . . .	7·85
355. a' Chuilinn (Conon) . . . . .	10·22	413. nan Eun (N. Uist) . . . . .	7·84
356. Punds . . . . .	10·20	414. Lundie (Clunie) . . . . .	7·80
357. Roer . . . . .	10·16	415. Crunachan . . . . .	7·79
358. Ceò-Glas . . . . .	10·14	416. Ochiltree . . . . .	7·68
359. Rescobie . . . . .	9·99	417. Lochenbreck . . . . .	7·61
360. Kirk . . . . .	9·96	418. a' Bhaillidh . . . . .	7·60
361. na Gealaich . . . . .	9·94	419. an Lagain . . . . .	7·57
362. Long . . . . .	9·92	420. Linlithgow . . . . .	7·55
363. nan Eun (Ness) . . . . .	9·90	421. Fyntalloch . . . . .	7·48
364. Poulary . . . . .	9·90	422. na Craige . . . . .	7·42
365. Vatandip . . . . .	9·85	423. Chìl na Sìthe . . . . .	7·42
366. Balgavies . . . . .	9·76	424. Derclach . . . . .	7·42
367. Oban a' Chlachain . . . . .	9·75	425. Fithie . . . . .	7·42
368. Kilbirnie . . . . .	9·72	426. Fitty . . . . .	7·40
369. a' Bhainne . . . . .	9·69	427. Valtos . . . . .	7·40
370. Finlas . . . . .	9·69	428. Leodsay . . . . .	7·38
371. Martnaham . . . . .	9·61	429. Heouravay . . . . .	7·37
372. Borralan . . . . .	9·60	430. Black (Etive) (West) . . . . .	7·34
373. na h-Achlaise . . . . .	9·58	431. Maberry . . . . .	7·32
374. Gamhna . . . . .	9·56	432. Hightae Mill . . . . .	7·31
375. Skae . . . . .	9·52	433. nan Garbh Chlachain . . . . .	7·28
376. Choire na Cloich . . . . .	9·44	434. Kinellan . . . . .	7·14
377. a' Chaoruinn . . . . .	9·37	435. Muck . . . . .	7·12
378. na Moracha . . . . .	9·26	436. Dubh (Ness) . . . . .	7·00
379. Swannay . . . . .	9·22	437. na Creige Léithe . . . . .	7·00
380. Trealaval . . . . .	9·22	438. Strom . . . . .	7·00
381. Airidh na Lic . . . . .	9·21	439. Kirriereoch . . . . .	6·98
382. Cults . . . . .	9·16	440. Sguod . . . . .	6·91
383. Scadavay (West) . . . . .	9·16	441. Muckle Lunga . . . . .	6·88
384. Ghiuragarstidh . . . . .	9·08	442. Gown (North) . . . . .	6·87
385. Harray . . . . .	9·02	443. Carlingwark . . . . .	6·86
386. an Stromore . . . . .	9·01	444. a' Buaille . . . . .	6·82
387. a' Chonnachair . . . . .	8·88	445. Essan . . . . .	6·82
388. Clubbi Shuns . . . . .	8·85	446. Crann . . . . .	6·79
389. Crò Criosdaig . . . . .	8·80	447. Mochrum . . . . .	6·75
390. nam Faoilèag . . . . .	8·69	448. Milton . . . . .	6·67
391. Veiragvat . . . . .	8·68	449. North-house . . . . .	6·60
392. Scadavay (East) . . . . .	8·67	450. Rae . . . . .	6·59
393. na Coinnich . . . . .	8·62	451. Castle (Bladenoch) . . . . .	6·56
394. Strandavat . . . . .	8·61	452. na Sàlach Uidhre . . . . .	6·54

TABLE IV—*continued*

Loch.	Mean Depth. Feet.	Loch.	Mean Depth. Feet.
453. Beannach (Gruinard)	6·45	508. Achanalt	4·50
454. Lochinvar	6·41	509. a' Chladaich	4·50
455. nan Geireann (Mill)	6·37	510. Cuil Airidh a' Flod	4·50
456. Tarruin an Eithir	6·37	511. St John's	4·50
457. Peerie	6·34	512. Bruadale	4·46
458. an Dùin (N. Uist)	6·27	513. Araich-Lin	4·45
459. Droma	6·27	514. Bradan	4·40
460. Eigheach	6·09	515. Shurrery	4·37
461. Bad a' Chrotha	6·08	516. Tankerness	4·35
462. Boardhouse	6·06	517. More Barvas	4·33
463. Aboyne	6·03	518. Hundland	4·32
464. Loyne (West)	5·93	519. Lochnaw	4·32
465. Duartmore	5·90	520. Oban nam Fiadh	4·23
466. Collaster	5·88	521. Olavat	4·20
467. Airidh na Ceardaich	5·86	522. More (Thurso)	4·18
468. Truid air Sgithiche	5·83	523. Kirbister	4·15
469. an t-Seasgain	5·72	524. Eye	4·06
470. Seoly	5·72	525. Shechernich	4·01
471. Eldrig	5·70	526. Davan	3·98
472. Clickhimin	5·60	527. Dhomhnuill Bhig	3·90
473. Tormasad.	5·60	528. Lure	3·90
474. Brouster	5·57	529. Kilconquhar	3·90
475. an Iasgaich	5·55	530. Cornish	3·80
476. Moraig	5·54	531. na Doire Daraich	3·60
477. a' Chlachain (Lewis)	5·52	532. Dallas	3·50
478. Syre	5·48	533. nan Losganan	3·50
479. Magillie	5·37	534. Uaine	3·50
480. Dornal	5·36	535. Con (Tay)	3·47
481. Mhic' ille Riabhaich.	5·35	536. na Bi	3·30
482. Flugarth	5·23	537. Moor Dam	3·27
483. Hempriggs	5·22	538. na Garbh-Abhuinn Ard	3·02
484. Laide	5·16	539. Grass	2·99
485. Duddingston	5·14	540. Dubh (Etive)	2·76
486. Asta	5·11	541. Spynie	2·71
487. Maol a' Choire	5·10	542. Blairs	2·55
488. na Stainge	5·10	543. Brow	2·50
489. Drummond	5·09	544. Bosquoy	2·50
490. Monk Myre	5·08	545. Castle Semple	2·50
491. Lindores	5·06	546. Heilen	2·50
492. Gelly	5·03	547. nan Gabhar	2·50
493. Kinord	5·03	548. St Margaret's	2·50
494. Dochart	5·02	549. Scarmclate	2·50
495. Broom	5·02	550. Tilt	2·50
496. Dhu (Portsonachan)	5·00	551. Bogton	2·00
497. Kirk Dam	5·00	552. Brough	2·00
498. Tùtach	4·88	553. Sand	2·00
499. Awe (Inver)	4·80	554. Sior.	2·00
500. Sandy	4·76	555. Skaill	2·00
501. Black (Tay)	4·73	556. Allt na Mult	1·50
502. Skene (Dee)	4·69	557. Buidhe (Tay)	1·50
503. Burrealand	4·67	558. Isbister	1·50
504. na h-Ealaidh	4·66	559. Sabiston	1·50
505. na Garbh-Abhuinn	4·65	560. Stormont.	1·50
506. na Moine	4·61	561. Wester	1·50
507. Littlester.	4·55	562. Setter	1·00

TABLE V

FRESH-WATER LOCHS OF SCOTLAND (SOUNDED BY THE LAKE SURVEY)  
ARRANGED ACCORDING TO VOLUME OF WATER

Loch.	Volume in Million Cubic Feet.	Loch.	Volume in Million Cubic Feet.
1. Ness	263,162	53. Doon	1,517
2. Lomond	92,805	54. Beinn a' Mheadhoin	1,435
3. Morar	81,482	55. an Dithreibh	1,366
4. Tay	56,550	56. Tummel	1,317
5. Awe (Etive)	43,451	57. Ossian	1,224
6. Maree	38,539	58. Tulla	1,167
7. Ericht	38,027	59. Beoraid	1,156
8. Lochy	37,726	60. Ard	1,150
9. Rannoch	34,387	61. Lubnaig	1,144
10. Shiel	27,986	62. Mhor	1,134
11. Katrine	27,274	63. Càrn	1,063
12. Arkaig	26,573	64. Veyatie	1,062
13. Earn	14,421	65. Arienas	1,035
14. Treig	13,907	66. Voil	1,000
15. Shin	12,380	67. Stack	988
16. Fannich	10,920	68. Harray	951
17. Assynt	8,731	69. Oich	890
18. Quoich	8,345	70. Garry (Tay)	846
19. Glass	8,265	71. Owskeich	846
20. Fionn (Gruinard)	5,667	72. Obisary	837
21. Laggan	5,601	73. Dhùghaill (Carron)	823
22. More (Laxford)	4,928	74. Beannachan	819
23. Laoghal	4,628	75. na h-Oidheche	816
24. Dùn na Seilcheig	4,599	76. Ken	792
25. Fada (Ewe)	4,091	77. Calder	767
26. Hope	4,032	78. Garve	721
27. na Sheallag	3,948	79. Stenness	716
28. Garry (Ness)	3,794	80. Eilt	686
29. Frisa	3,603	81. Scamadale	685
30. Skinaskink	3,518	82. a' Bhraoin	669
31. Avich	3,327	83. Lungard	599
32. Luichart	3,288	84. Merkland	577
33. Monar	3,213	85. Menteith	562
34. Morie	3,201	86. Brora	553
35. Suainaval	2,843	87. Nell	515
36. Muick	2,771	88. na Meide	498
37. Mullardoch	2,553	89. Eilde Mòr	493
38. Naver	2,461	90. a' Bhaid-Luachraich	486
39. Langavat (Lewis)	2,388	91. Baddanloch	479
40. Eck	2,381	92. Grunavat	478
41. Leven	2,195	93. Lyon	461
42. Damh (Torridon)	2,183	94. Insh	454
43. Afric	2,146	95. an t-Seilich	448
44. Lurgain	2,140	96. a' Chlàir (Helmsdale)	446
45. a' Chroisg	2,057	97. Talla	443
46. St Mary's	2,018	98. Creagach	429
47. Vennachar	1,903	99. Fiodhaig	415
48. Coir' an Fheàrna	1,886	100. na h-Earba (West)	408
49. Bad a' Ghaill	1,768	101. Lintrathen	405
50. Laidon	1,762	102. Achall	401
51. Bà (Mull)	1,602	103. a' Bhealaich (Gairloch)	398
52. Clunie (Ness)	1,533	104. nan Cuinne	396

TABLE V—*continued*

Loch.	Volume in Million Cubic Feet.	Loch.	Volume in Million Cubic Feet.
105. Dubh (Gruinard)	374	162. Lowes (Tweed)	157
106. Chon (Forth)	358	163. Moy	157
107. Freuchie	347	164. Fadagoa	156
108. Bunacharan	343	165. Trealaval	156
109. Watten	341	166. Bad an Sgalaig	151
110. Kernsary	333	167. a' Mhullinn	150
111. Achilty	332	168. Boardhouse	150
112. Achray	321	169. Black (Ryan)	149
113. a' Ghriama	314	170. Cròcach	148
114. Ashie	309	171. Nant	148
115. Girlsta	308	172. Iubhair	147
116. Scadavay (West)	306	173. na Leitreach	147
117. an Ruathair	304	174. Hunder	146
118. Leum a' Chlamhain	298	175. Dilate	145
119. Lochindorb	291	176. an Eilein (Spey)	144
120. Clair (Ewe)	287	177. Woodhall	144
121. Urigill	285	178. Killin	137
122. Thom	277	179. Dubh (Gairloch)	136
123. Calavie	276	180. Tarff	136
124. a' Bhaid Daraich	270	181. an Laghair	135
125. Caravat	270	182. an Duin (Spey)	134
126. Gladhouse	269	183. Ordie	133
127. Tralaig	267	184. Allt an Fhèarna	132
128. Grennoch	263	185. Fad	132
129. Expansions of River Dee	261	186. na h-Airidh Sléibhe	131
130. Benisval	260	187. Skebacleit	128
131. Gainmheich (South)	246	188. Loyne (East)	123
132. Tollie	244	189. nan Geireann (Mill)	121
133. Migdale	242	190. Cliff	118
134. Swannay	242	191. Trool	116
135. a' Bhealaich (Naver)	238	192. an Leòid	114
136. Garbhaig	228	193. nan Eun (N. Uist)	114
137. Turret	222	194. Scadavay (East)	112
138. Arklet	222	195. Spiggie	111
139. Drumellie	222	196. Allt na h-Airbhe	110
140. Drunkie	217	197. an Staca	110
141. na Cuaich	214	198. Fada (Gruinard)	109
142. Bà (Tay)	206	199. an Drainc	108
143. an Daimh (Shin)	205	200. Derculich	108
144. Fada (N. Uist)	199	201. Harperrig	108
145. Doine	196	202. Kennard	108
146. Gorm Loch Mòr	196	203. Pattack	106
147. Knoekie	194	204. Kilbirnie	105
148. Lowes (Tay)	194	205. nan Lann	105
149. Meiklie	193	206. Urrahag	105
150. Morlich	192	207. a' Choire	103
151. na h-Earba (East)	191	208. Eela	103
152. Daimh (Tay)	190	209. Loch	103
153. na Beinne Bàine	190	210. Clings	101
154. Fionn (Kirkaig)	186	211. Strom	101
155. Ruthven	180	212. Raonasgail	94
156. Benachally	178	213. Builg	93
157. nam Breac	172	214. na Craobhaig	93
158. Clunie (Tay)	170	215. White (Ryan)	92
159. Sgamhain	165	216. Coulin (Ewe)	90
160. Alvie	163	217. Crogavat	90
161. Dee	157	218. Skealtar	90

TABLE V—continued

Loch.	Volume in Million Cubic Feet.	Loch.	Volume in Million Cubic Feet.
219. Ailsh . . . . .	88	276. Muckle Water . . . . .	57
220. Dubh (Ailort) . . . . .	87	277. a' Bhealaich (Aish) . . . . .	56
221. Dungeon . . . . .	87	278. Maberry . . . . .	56
222. Gryfe . . . . .	87	279. Whinyeon . . . . .	56
223. Tingwall . . . . .	87	280. Urr . . . . .	56
224. Ghuilbinn . . . . .	85	281. an t-Slagain . . . . .	55
225. Giorra . . . . .	84	282. Baile a' Ghobhainn . . . . .	55
226. Arthur . . . . .	83	283. a' Ghobhainn . . . . .	54
227. Kindar . . . . .	83	284. an Gead . . . . .	54
228. Vaara . . . . .	80	285. Butterstone . . . . .	53
229. Seil . . . . .	79	286. Skeen (Annan) . . . . .	53
230. a' Chlachain (Nairn) . . . . .	78	287. a' Phearsain . . . . .	52
231. Lundie (Garry) . . . . .	78	288. na Creige Duibhe . . . . .	52
232. Caol na Doire . . . . .	77	289. Oehiltree . . . . .	52
233. Kemp . . . . .	77	290. Dibadale . . . . .	51
234. Skiach . . . . .	77	291. Forfar . . . . .	51
235. na h-Achlaise . . . . .	76	292. Hundland . . . . .	51
236. Portmore . . . . .	76	293. a' Chuilinn (Conon) . . . . .	50
237. Teárnait . . . . .	75	294. Bodavat . . . . .	50
238. Lochrutton . . . . .	73	295. Inbhir . . . . .	50
239. Seaslavat . . . . .	73	296. nan Deaspoirt . . . . .	50
240. an Tachdaidh . . . . .	72	297. Borralan . . . . .	49
241. Castle (Annan) . . . . .	72	298. Craiglush . . . . .	49
242. Clousta . . . . .	71	299. Hempriggs . . . . .	49
243. Ederline . . . . .	70	300. Strandavat . . . . .	49
244. na Sàlach Uidhre . . . . .	70	301. Huna . . . . .	48
245. a' Mhiotailt . . . . .	69	302. Edgelaw . . . . .	47
246. an Tomain . . . . .	69	303. Lochaber . . . . .	47
247. Rescobie . . . . .	69	304. Martnaham . . . . .	47
248. Buidhe (Fleet) . . . . .	68	305. Soulseat . . . . .	47
249. Mochrum . . . . .	68	306. Truid air Sgithiche . . . . .	47
250. Skerrow . . . . .	68	307. Aithness . . . . .	46
251. Ussie . . . . .	68	308. Fitty . . . . .	46
252. Beannach (Inver) . . . . .	67	309. Eion Mhic Alastair . . . . .	45
253. Doire nam Mart . . . . .	67	310. Leitir Easaich . . . . .	45
254. Phitiùlais . . . . .	67	311. Milton . . . . .	45
255. a' Bharpa . . . . .	66	312. More Barvas . . . . .	45
256. Dubh-Mòr . . . . .	66	313. an Laig Aird . . . . .	44
257. Stacsavat . . . . .	66	314. an Nostarie . . . . .	44
258. Threipmuir . . . . .	66	315. Auchenreoch . . . . .	44
259. Castle (Bladenoch) . . . . .	65	316. Dochard . . . . .	44
260. Gartmorn . . . . .	65	317. Hoglinns . . . . .	44
261. Raoinavat . . . . .	65	318. Langavat (Benbecula) . . . . .	44
262. Dhùgail (Torridon) . . . . .	63	319. Burga . . . . .	43
263. Braigh Horrisdale . . . . .	62	320. Gainmheich (North) . . . . .	43
264. Liath . . . . .	62	321. Monikie (South) . . . . .	43
265. a' Bhaillidh . . . . .	61	322. na Sreinge . . . . .	43
266. an Stromore . . . . .	61	323. Roer . . . . .	43
267. Sealbhag . . . . .	61	324. Shurrery . . . . .	43
268. a' Ghlinne-Dorcha . . . . .	60	325. an Dùna . . . . .	41
269. Coire nam Meann . . . . .	60	326. Fleet . . . . .	41
270. nam Breac Dearga . . . . .	60	327. Kinord . . . . .	41
271. Skene (Dee) . . . . .	60	328. Kirbister . . . . .	41
272. na Mòine Buige . . . . .	59	329. Loyne (West) . . . . .	40
273. an Eilein (Gairloch) . . . . .	58	330. na Moracha . . . . .	39
274. Finlas . . . . .	58	331. Poulary . . . . .	39
275. Rosebery . . . . .	58	332. Callater . . . . .	38

TABLE V—*continued*

Loch.	Volume in Million Cubic Feet.	Loch.	Volume in Million Cubic Feet.
333. Deoravat . . . . .	38	390. Monzievaird . . . . .	24
334. Gown (South) . . . . .	38	391. na Déighe fo Dheas . . . . .	24
335. ic Colla . . . . .	38	392. an Lagain . . . . .	23
336. na Ceithir Eileana . . . . .	38	393. Araich-Lin . . . . .	23
337. nam Faoileag . . . . .	38	394. Crunachan . . . . .	23
338. St John's . . . . .	38	395. Ghuiragarstidh . . . . .	23
339. a' Bhuid . . . . .	37	396. Lhùn dà-Bhrà . . . . .	23
340. Eye . . . . .	37	397. na Beithe . . . . .	23
341. Hosta . . . . .	36	398. na Lairige . . . . .	23
342. Mill . . . . .	36	399. Sloy . . . . .	23
343. Druim Suardalain . . . . .	35	400. Sròn Smeur . . . . .	23
344. Morsgail . . . . .	35	401. Balgavies . . . . .	22
345. an Dùin (N. Uist) . . . . .	34	402. Beannach (Gruinard) . . . . .	22
346. Bhradain . . . . .	34	403. Bhac . . . . .	22
347. Fiart . . . . .	34	404. Burntisland . . . . .	22
348. Linlithgow . . . . .	34	405. Castle Semple . . . . .	22
349. nan Eun (Tay) . . . . .	34	406. Black (Etive) (East) . . . . .	21
350. Peppermill . . . . .	34	407. Heilen . . . . .	21
351. Chalum . . . . .	33	408. Scarmclate . . . . .	21
352. Holl . . . . .	33	409. Drummond . . . . .	20
353. an Droighinn . . . . .	32	410. Kinghorn . . . . .	20
354. Droma . . . . .	32	411. na Claise Fearnna . . . . .	20
355. Fingask . . . . .	32	412. Oban a' Chlachain . . . . .	20
356. Gelly . . . . .	32	413. Veiragvat . . . . .	20
357. Long . . . . .	32	414. Airidh na Lic . . . . .	19
358. More (Thurso) . . . . .	32	415. Broom . . . . .	19
359. Sguod . . . . .	32	416. Chùl na Sìthe . . . . .	19
360. Achanalt . . . . .	31	417. Eileach Mhic'ille Riabhaich . . . . .	19
361. Carlingwark . . . . .	31	418. Harrow . . . . .	19
362. Crò Crìosdaig . . . . .	31	419. Lochinvar . . . . .	19
363. Crombie Den . . . . .	31	420. Awe (Inver) . . . . .	18
364. Fender . . . . .	31	421. na Moine . . . . .	18
365. Harperleas . . . . .	31	422. Uanagan . . . . .	18
366. Howie . . . . .	31	423. Black (Etive) (Mid) . . . . .	17
367. White of Myrton . . . . .	30	424. Muckle Lunga . . . . .	17
368. Craggie . . . . .	30	425. Oban nam Fiadh . . . . .	17
369. Harelaw . . . . .	30	426. Ree . . . . .	17
370. Hermidale . . . . .	29	427. Whitefield . . . . .	16
371. Hoil . . . . .	29	428. Bradan . . . . .	16
372. Kilchoan (Upper) . . . . .	29	429. Eigheach . . . . .	16
373. Tankerness . . . . .	28	430. Gleann a' Bhearraidh . . . . .	16
374. an Losgainn Mòr . . . . .	27	431. Kilehoan (Lower) . . . . .	16
375. Breaclaich . . . . .	27	432. Kileconquhar . . . . .	16
376. Snarravoe . . . . .	27	433. Leodsay . . . . .	16
377. Vatandip . . . . .	27	434. North-house . . . . .	16
378. Dornal . . . . .	26	435. Valtos . . . . .	16
379. Heuravay . . . . .	26	436. a' Chonnachair . . . . .	15
380. Kilcheran . . . . .	26	437. a' Vullan . . . . .	15
381. Monikie (North) . . . . .	26	438. Birka . . . . .	15
382. nan Druimnean . . . . .	26	439. Kirk . . . . .	15
383. Olavat . . . . .	26	440. nan Eun (Ness) . . . . .	15
384. Punds . . . . .	26	441. a' Bhainne . . . . .	14
385. an Tuirc . . . . .	25	442. Gown (North) . . . . .	14
386. Davan . . . . .	25	443. Anna . . . . .	13
387. Syre . . . . .	25	444. Beag . . . . .	13
388. Ceò-Glas . . . . .	24	445. Bran . . . . .	13
389. Lindores . . . . .	24	446. Bruadale . . . . .	13

TABLE V—*continued*

Loch.	Volume in Million Cubic Feet.	Loch.	Volume in Million Cubic Feet.
447. Drumlamford . . . . .	13	505. na Doire Daraich . . . . .	7
448. Hostigates . . . . .	13	506. na Gealaich . . . . .	7
449. Littlester . . . . .	13	507. Shechernich . . . . .	7
450. Lochenbreck . . . . .	13	508. Spynie . . . . .	7
451. na h-Ealaidh . . . . .	13	509. Wester . . . . .	7
452. Skail . . . . .	13	510. a' Buaille . . . . .	6
453. Auchenchapel . . . . .	13	511. an Dubh (Lochy) . . . . .	6
454. Bad a' Chrotha . . . . .	12	512. Dallas . . . . .	6
455. Cuil Airidh a' Flod . . . . .	12	513. Hightae Mill . . . . .	6
456. Derclach . . . . .	12	514. na Bi . . . . .	6
457. Geal . . . . .	12	515. na Garbh-Abhuinn . . . . .	6
458. Kirk Dam . . . . .	12	516. nan Aùscot . . . . .	6
459. na Coinnich . . . . .	12	517. Monk Myre . . . . .	6
460. Tormasad . . . . .	12	518. Loch on Eilean Subhainn . . . . .	6
461. a' Chlachain (Lewis) . . . . .	11	519. Bogton . . . . .	5
462. Burriland . . . . .	11	520. Brouster . . . . .	5
463. Clickhimin . . . . .	11	521. Brow . . . . .	5
464. Eldrig . . . . .	11	522. Isbister . . . . .	5
465. Màma . . . . .	11	523. Kinellan . . . . .	5
466. na Beiste . . . . .	11	524. Kirrieroch . . . . .	5
467. na Stainge . . . . .	11	525. Lure . . . . .	5
468. nan Garbh Chlachain . . . . .	11	526. nan Gabhar . . . . .	5
469. Peerie . . . . .	11	527. nan Càth . . . . .	5
470. Aboyne . . . . .	10	528. Pitlyal . . . . .	5
471. Allan . . . . .	10	529. Sabiston . . . . .	5
472. Aslaich . . . . .	10	530. Stormont . . . . .	5
473. Black (Etive) (West) . . . . .	10	531. an t-Seasgain . . . . .	4
474. Con (Tay) . . . . .	10	532. Crann . . . . .	4
475. Dochart . . . . .	10	533. Duddingston . . . . .	4
476. Essan . . . . .	10	534. Grass . . . . .	4
477. Gamhna . . . . .	10	535. Maol a' Choire . . . . .	4
478. na h-Eaglais . . . . .	10	536. Tùtach . . . . .	4
479. nan Geireann . . . . .	10	537. Blairs . . . . .	3
480. Tarruinn an Eithir . . . . .	10	538. Cornish . . . . .	3
481. Airidh na Ceardaich . . . . .	9	539. Dnartmore . . . . .	3
482. an Iasgaich . . . . .	9	540. Magillie . . . . .	3
483. Laide . . . . .	9	541. na Garbh-Abhuinn Ard . . . . .	3
484. Lochnaw . . . . .	9	542. Scoly . . . . .	3
485. Lundie (Clunie) . . . . .	9	543. a' Chladaich . . . . .	2
486. Moraig . . . . .	9	544. an Tairbeirt Stuadahaich . . . . .	2
487. Muck . . . . .	9	545. Black (Tay) . . . . .	2
488. Rae . . . . .	9	546. Brough . . . . .	2
489. Sandy . . . . .	9	547. Buidhe (Tay) . . . . .	2
490. Flugarth . . . . .	8	548. Choire na Cloich . . . . .	2
491. Fyntalloch . . . . .	8	549. Dubh (Etive) . . . . .	2
492. Mhic' ille Riabhaich . . . . .	8	550. Dubh (Ness) . . . . .	2
493. na Craige . . . . .	8	551. na Creige Leithe . . . . .	2
494. Skae . . . . .	8	552. Rainbow . . . . .	2
495. White (Tay) . . . . .	8	553. Sior . . . . .	2
496. a' Chaoruinn . . . . .	7	554. Tilt . . . . .	2
497. Asta . . . . .	7	555. nan Losganan . . . . .	1
498. Bosnoy . . . . .	7	556. Sand . . . . .	1
499. Clubbi Shuns . . . . .	7	557. Uaine . . . . .	0·7
500. Collaster . . . . .	7	558. Dubh (Forth) . . . . .	0·6
501. Cults . . . . .	7	559. Setter . . . . .	0·6
502. Dhomhnuill Bhig . . . . .	7	560. Dhu (Portsonachan) . . . . .	0·5
503. Fithie . . . . .	7	561. St Margaret's . . . . .	0·4
504. Moor Dam . . . . .	7	562. Allt na Mult . . . . .	0·1

TABLE VI

FRESH-WATER LOCHS OF SCOTLAND (SOUNDED BY THE LAKE SURVEY)  
SHOWING SUMMARY OF PHYSICAL RESULTS

Basins.	Number of Lochs.	Number of Soundings.	Volume in Million Cubic Feet.	Area of Lochs in Square Miles.	Drainage Area.	
					Total in Square Miles.	Ratio to Area of Lochs.
Forth . . . . .	13	3,825	36,543	17·02	227·66	13·38
Tay . . . . .	59	6,851	151,353	39·81	1099·52	27·62
Inver, Roe, Kirkaig, Polly, Garvie . . . . .	21	2,540	20,355	12·64	150·44	11·9
Morar . . . . .	3	1,284	82,686	10·99	65·63	6·0
Ewe . . . . .	14	2,473	44,530	14·80	185·51	12·5
Shiel, Ailort, nan Uamh . . . . .	6	1,191	28,967	8·58	99·97	11·65
Conon . . . . .	16	2,188	29,850	11·65	366·33	31·5
Shin . . . . .	11	1,564	14,538	12·11	239·69	19·8
Naver, Borgie, Kinloch, Hope . . . . .	11	1,409	15,615	11·06	239·46	21·7
Beaully . . . . .	13	841	11,227	5·76	215·26	37·4
Lochy . . . . .	12	2,570	85,855	19·88	293·42	14·8
Ness . . . . .	33	4,385	280,923	34·25	689·14	20·1
Brora, Helmsdale . . . . .	11	700	2,756	6·68	202·89	30·4
Wick, Wester, Heilen, Dunnet, Thurso, Forss Laxford, Scourie, Badcall, Duartmore . . . . .	10	994	6,679	3·35	59·20	17·7
Broom, Gruinard . . . . .	11	1,141	11,312	7·10	111·50	15·7
Gairloch, Torridon, Carron Alsh, Aline, Leven . . . . .	12	1,098	4,921	3·90	98·46	25·2
Oban, Feochan, Seil, Mel-fort . . . . .	13	855	1,328	1·66	34·03	20·5
Bute, Eachaig . . . . .	3	372	2,525	2·07	44·89	21·7
Doon, Girvan, Stinchar, Ryan, Galdenoch . . . . .	13	1,028	1,935	3·40	75·16	22·1
Luce, Bladenoch, Cree . . . . .	15	594	427	2·12	35·43	16·7
Fleet, Dee . . . . .	13	954	1,951	4·02	298·89	74·4
Urr, Nith, Annan . . . . .	14	599	652	1·79	24·77	13·7
Tweed, Monikie, Lunan, Dee, Slains . . . . .	16	879	5,762	4·24	121·19	28·6
Spey . . . . .	13	663	2,053	2·63	350·50	133·3
Lossie, Findhorn, Nairn . . . . .	10	655	5,179	3·50	42·41	12·1
Lismore, Mull, Benbecula . . . . .	11	728	5,475	3·75	35·54	9·5
North Uist . . . . .	40	3,751	3,026	8·66	45·29	5·2
Lewis . . . . .	30	2,896	7,409	9·64	151·98	15·8
Orkney . . . . .	14	932	2,321	9·98	90·36	9·1
Shetland . . . . .	31	1,707	1,416	5·36	51·89	9·7
Forth (Reservoirs) . . . . .	20	1,065	998	3·07	43·69	14·2
Etive . . . . .	21	2,619	48,451	18·19	307·55	16·9
Clyde . . . . .	7	2,487	93,331	29·00	314·40	10·8
Tay, Linnhe . . . . .	3	106	79	0·23	3·51	15·3
	562	59,195	1,015,814 =6·9 cubic miles	340·22	6669·06	19·6

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<sup>1</sup> The spelling of the names of the lochs is uniform with that used in the 6-inch Ordnance Survey maps.

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## LOCHS OF THE FORTH BASIN.

WITHIN this basin the following lochs were sounded by Sir John Murray and the late Mr. Fred. P. Pullar, viz., Lochs Katrine, Arklet, Achray, Vennachar, Drunkie, Voil, Doine, Lubnaig, Chon, Dubh, Ard, Menteith, and Leven. The eight first-mentioned lochs belong to the catchment-basin of the river Teith, and have a special interest from being directly or indirectly connected with the excellent water-supply to the city of Glasgow.\* Loch Arklet belongs to the catchment-basin of Loch Lomond, but the Corporation of Glasgow has power to divert its waters into the catchment-basin of Loch Katrine.

*Loch Katrine* (see Plate IV.).—Loch Katrine is one of the best known and most beautiful of the Scottish lochs. The celebrated

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\* In the year 1855 the Corporation of Glasgow was empowered by Act of Parliament to raise Loch Katrine 4 feet above, and to draw it down 3 feet below, the previous summer level, thus giving a total available depth of 7 feet for the supply of water to the city, the quantity of water to be drawn from the loch being restricted to fifty million gallons in twenty-four hours. For the purpose of providing compensation water to the riparian owners on the river Teith, power was also given to raise Loch Vennachar 5 feet 9 inches above its previous summer level, and to draw it down 6 feet, and also to raise Loch Drunkie 25 feet. An aqueduct was built from the southern shore of Loch Katrine to Glasgow, 8 feet wide and 8 feet high throughout, with a semicircular top, and having a fall towards Glasgow of 10 inches per mile. At first only a portion of the available fifty million gallons per day was conveyed to Glasgow, but by the end of 1881, the whole of the works necessary to complete the original design were finished. In the year 1884 it was found necessary to provide a larger quantity of water in order to keep pace with the growth of the city, and it was then found that the roughness of the rock sides of the aqueduct had a very retarding influence upon the velocity of the water, and that the aqueduct could not be made to discharge more than forty-two million gallons per day. Power was subsequently obtained from Parliament to build a second aqueduct, to raise Loch Katrine an additional 5 feet, and to convert Loch Arklet, which flows into Loch Lomond, into a reservoir by raising it 25 feet in level. These works are now in progress, and when completed are estimated to give a supply of seventy-five millions of gallons of water per day to the city of Glasgow. Should a still greater supply be necessary in the future, it is believed this can be obtained by connecting Loch Doine with Loch Katrine by a tunnel through the intervening hills, and by constructing an embankment at the bottom of Loch Doine to raise the water-level 30 feet, and another at the bottom of Loch Voil to raise the water-level of that loch 10 feet, and if still more water were wanted, Loch Lubnaig could furnish it (see papers by James M. Gale, Esq., M. INST. C.E., in the *Trans. Inst. Engineers in Scotland*, vols. vii., xii., xxvi., and xxxviii., and his Report on the proposed extension of the Glasgow Corporation Water Works, dated May 17, 1884).

woodland scenery of the Trossachs and Ellen's isle are situated at its south-eastern end, while splendid moorland scenery prevails at the north-western end. It has a total length of about 8 miles, with a maximum width of almost exactly 1 mile between the mouths of Letter burn and Strone burn on the northern shore to a small bay on the opposite shore. The mean breadth, obtained by dividing the area of the loch by its length, is 0·6 mile, or 1056 yards, being  $7\frac{1}{2}$  per cent. of the length.

The waters of the loch cover an area of 3059 acres (or  $4\frac{3}{4}$  square miles), and it drains an area about eight times greater, or about 24,900



FIG. 1.—LOCH KATRINE AND ELLEN'S ISLE.

(Photograph by J. Valentine.)

acres (nearly  $37\frac{1}{2}$  square miles).\* The total number of soundings taken in Loch Katrine was 775, an average of 163 per square mile, and the average depth of these was  $142\frac{1}{2}$  feet, the greatest depth observed being 495 feet ( $82\frac{1}{2}$  fathoms).† The positions of the majority of the soundings are shown on Plate IV.

\* When the waters of Loch Arklet are diverted into Loch Katrine this drainage area will, of course, be extended.

† As long ago as September, 1812, and September, 1814, Mr. James Jardine, c.e., recorded observations on the depth and temperature of Loch Katrine (see Buchan, *Proc. Roy. Soc. Edin.*, vol. vii. p. 791, 1872). The maximum depth recorded by him is 480 feet (80 fathoms), whereas, as stated above, we found a depth of 495 feet. His temperature observations are given in the table of serial temperatures, and discussed along with the recent observations. We believe that Mr. J. Y. Buchanan took soundings and temperatures in Loch Katrine some years ago, but, as far as we are aware, they were never published, and are therefore not available for discussion (see also Art. "Lake" in *Encycl. Brit.*, 9th edit.).

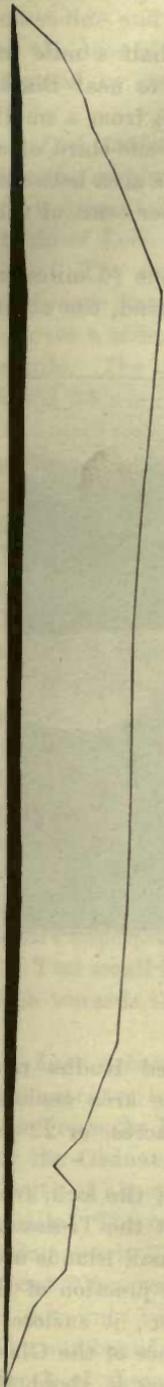


FIG. 2.—LONGITUDINAL SECTION OF LOCH KATRINE, ALONG THE AXIS OF MAXIMUM DEPTH. THE BLACK PORTION SHOWS THE TRUE SLOPES; THE OUTLINE SHOWS THE SLOPES EXAGGERATED TEN TIMES.

The bulk of water contained in the loch is estimated at 27,274,000,000 cubic feet, or about one-fifth of a cubic mile, and the mean depth (supposing the loch to be of uniform depth over its present area) at 199 feet (33 fathoms), the mean depth being over 40 per cent. of the maximum depth. The length of the loch is 85 times the maximum depth, and 211 times the mean depth.

The surface of the loch is, according to the Ordnance Survey maps, at an elevation of 364 feet above sea-level, so that our survey shows that a considerable portion of the bottom of the loch (equal to about 645 acres, or over one square mile) lies below sea-level, the deepest part being 131 feet (or 22 fathoms) below the level of the sea. The area below the level of the sea is indicated by a red line on Plate IV. In this respect Loch Katrine differs from the other lochs referred to in this paper, for in none of them is the depth sufficiently great to bring any portion of their bottoms below the level of the sea.

The soundings show that Loch Katrine practically forms a single basin, not being divided, like Loch Lomond and Loch Lubnaig, for instance, into separate basins by any important ridges or rises on the bottom. The deepest part is in the centre of the loch, a long narrow depression, with depths exceeding 400 feet, extending for over 4 miles from opposite Coilachra to opposite Ruinn Dubh-aird, with a maximum width of over a quarter of a mile; this 400-foot depression has an area of about 515 acres, or 17 per cent. of the entire superficial area of the loch. The deepest sounding (495 feet) is situated at the very eastern extremity of the 400-foot depression.

The 300-foot depression is over 5 miles in length, with a maximum breadth of one-third of a mile; it extends from off Coilachra to near Ellen's isle. The area enclosed between the 300-foot and



FIG. 3.—CROSS-SECTION OF LOCH KATRINE. THE BLACK PORTION SHOWS THE TRUE SLOPES; THE OUTLINE SHOWS THE SLOPES EXAGGERATED TEN TIMES.

400-foot contour-lines is about 415 acres, or 13 per cent. of the entire area of the loch.

The 200-foot depression is  $5\frac{1}{2}$  miles in length and half a mile in maximum breadth, extending from south of Ellen's isle to near Black island, where it is separated (by a sounding of 198 feet) from a small isolated area, lying between Coilachra and Black island, one-third of a mile in length by nearly one-eighth of a mile broad. The area between the 200- and 300-foot contours is about 510 acres, or 17 per cent. of the area of the loch.

There are two 100-foot depressions, the principal one (6 miles in length) stretching from close to Ellen's isle to Black island, the other

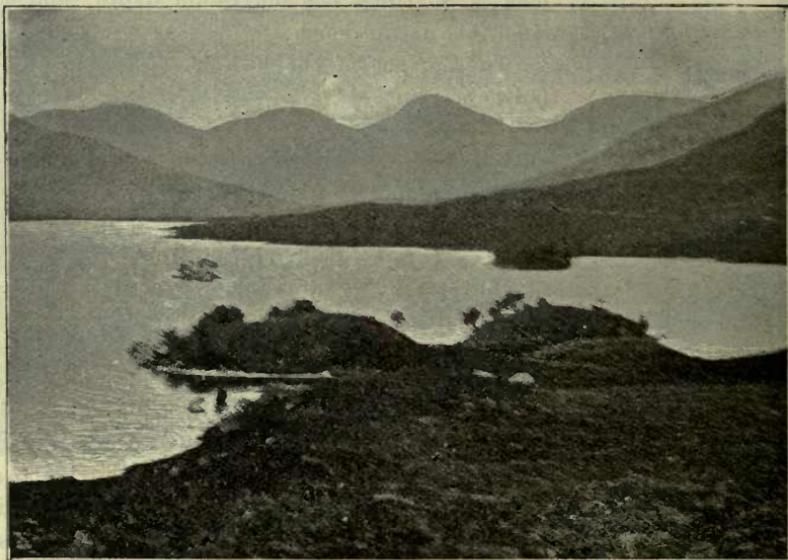


FIG. 4.—LOCH ARKLET, LOOKING WEST.

(Photograph by G. W. Wilson.)

extending from Black island towards the point called Rudha nam Moine, with a total length of over half a mile. The area enclosed between the 100- and 200-foot contours is about 670 acres, or 22 per cent. of the area of the loch.

The 50-foot line follows pretty closely the contour of the loch, from Rudha nam Moine into the eastern arms of the loch at the Trossachs, running outside of Black island, Ellen's isle, and the small islands near the shore all round, with a small isolated patch at the junction of the Trossachs arm with the arm leading to Achray Water; it encloses a small shallow, with a beacon on it, opposite the entrance of the Glasahoil. The area between the 50- and 100-foot contours is about 400

acres, or 13 per cent. of the area of the loch, while the area between the coast-line and the 50-foot contour is nearly 550 acres, or 18 per cent. of the area of the loch, so that 82 per cent. of the floor of the loch is covered by over 50 feet of water.

*Loch Arklet* (see Plate IV.).—Loch Arklet drains into Loch Lomond, but the corporation of the city of Glasgow have power, by the erection of a dam at its west end, to divert the waters into the catchment-basin of Loch Katrine, in order to increase the supply of water to the city. The surface of this little moorland loch is, according to the Ordnance Survey maps, 455 feet above sea-level. It has a total length of over a mile, and a maximum width near the east end of nearly half a mile. The mean breadth is about one-third of a mile, or 587 yards, being 33 per cent. of the length. Its waters cover an area of about 210 acres (0·3 square mile), and it drains an area about sixteen times greater, or about 3400 acres ( $5\frac{1}{3}$  square miles). The number of soundings taken in Loch Arklet was 135, the average depth of these being 21 feet, and the greatest depth observed being 67 feet (11 fathoms). The mass of water in the loch is estimated at 222,000,000 cubic feet, and the mean depth at 24 feet, or 36 per cent. of the maximum depth. The length of the loch is 79 times the maximum depth, and 218 times the mean depth.

The wide eastern portion of Loch Arklet is shallower than the narrower western portion. The 50-foot depression extends little more than halfway towards the eastern end of the loch, and is slightly under half a mile in length, the greatest depth (67 feet) being approximately near the centre of the depression, and nearer the western than the eastern end. The area of over 50 feet in depth is estimated at about 19 acres, or 9 per cent. of the area of the loch, while the area between the 50-foot line and the shore is about 191 acres, or 91 per cent. of the entire superficial area.

Two small islands appear on the chart in the shallower part of the loch towards the north-eastern end.

*Loch Achray* (see Plate V.).—This pretty little lake is situated at the entrance to the Trossachs, and immediately before the windows of the Trossachs Hotel. Loch Achray, the surface of which is, according to the Ordnance Survey maps, 276 feet above sea-level, has a total length of about  $1\frac{1}{4}$  miles, with a maximum width of nearly one-third of a mile. The mean breadth is about a quarter of a mile, or 458 yards, being nearly 21 per cent. of the length. Its waters cover an area of about 205 acres (one-third of a square mile), and the area draining into it is twenty-two times greater, or about 4500 acres (7 square miles). The number of soundings taken in Loch Achray was 171, and the average depth of these was  $36\frac{1}{2}$  feet, the maximum depth recorded being 97

feet (16 fathoms). The bulk of water contained in the loch is estimated at 321,000,000 cubic feet, and the mean depth at 36 feet (6 fathoms), or 37 per cent. of the maximum depth. The length of the loch is 68 times the maximum depth, and 183 times the mean depth.

The 50-foot depression is over two-thirds of a mile in extreme length, with a maximum width of about one-fifth of a mile, lying uniformly near the centre of the loch, and covers an area of about 64 acres, or 31 per cent. of the superficies of the loch. Within this area there is a depression occupying about 32 acres where the depths exceed 90 feet, the greatest registered depth (97 feet) being recorded in two places approximately in the centre of the loch. At the west end of the loch,



FIG. 5.—LOCH ACHRAY, LOOKING WEST TOWARDS BEN VENUE.

(*Photograph by J. Valentine.*)

not far from the hotel pier, a detached sounding of 50 feet is recorded ; off the mouth of the Achray water there are some shallow patches, and a shallow in the centre of the loch towards the west end, on which there are 2 to 3 feet of water, is marked by a beacon. The area less than 50 feet in depth is estimated at about 141 acres, or 69 per cent. of the total area of the loch. The eastern end of the loch is relatively shallow ; at one place there is a depression with 27 feet surrounded by shallower water, and at another place there is what appears to be a submerged crannog covered by only 1 or 2 feet of water.

*Loch Vennachar* (see Plate V.).—Loch Vennachar, the surface of

which is, according to the Ordnance Survey maps, 270 feet above sea-level, has a total length of about 4 miles, with a maximum width of less than three-quarters of a mile. The mean breadth is about two-fifths of a mile, or 704 yards, being 10 per cent. of the length. Its waters cover an area of about 1030 acres (or over  $1\frac{1}{2}$  square miles), and it drains an area nearly eighteen times greater, or about 18,300 acres ( $28\frac{1}{2}$  square miles). The total number of soundings taken in Loch Vennachar was 423, an average of 263 per square mile, the average depth of these being 41 feet, and the greatest depth observed being 111 feet ( $18\frac{1}{2}$  fathoms), so that it may be regarded as a relatively shallow loch. The bulk of water contained in the loch is estimated at 1,903,000,000 cubic feet, and the mean depth at  $42\frac{1}{2}$  feet (7 fathoms), being 38 per cent. of the maximum depth. The length of the loch is 190 times the maximum depth, and 498 times the mean depth.

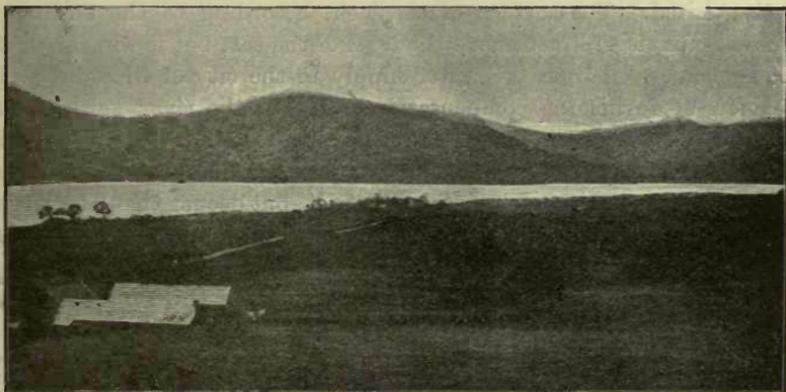


FIG. 6.—LOCH VENNACHAR, LOOKING SOUTH-WEST.

(*Photograph by G. W. Wilson.*)

It will be observed from an examination of the map that the loch is deeper in the eastern than in the western portion, the western end being shallow and covered with weeds, so that one must proceed nearly a mile from the west end of the loch before encountering depths of 50 feet, and this is merely a small patch separated from the principal 50-foot depression by a distance of nearly two-thirds of a mile. In August the water in the loch is at its lowest, and the weeds at the west end most abundant. The principal 50-foot depression is about 2 miles in length, with a mean breadth of about one-third of a mile and a maximum breadth of nearly half a mile. It includes two 100-foot depressions: the first one is very irregular in shape, situated approximately in the centre of the loch, and contains the greatest observed length (111 feet), which lies towards the northern shore; the second one occupies the central portion of the large 50-foot depression, the greatest depth observed

therein being 106 feet. Towards the eastern end of the large 50-foot depression is a small shallow patch in the centre of the loch opposite Portnellan, in which a depth of 36 feet was found.

At the extreme eastern end are situated the sluices and weir, over which the compensation water passes into the river Teith; at some distance from the sluices the depth of water flowing over a weir is recorded twice a day.

The area between the shore and the 50-foot contour is estimated at about 635 acres, or 62 per cent. of the entire superficial area of the loch, while the area between the 50- and 100-foot lines is estimated at about 324 acres, or 31 per cent., and the area with depths over 100 feet is estimated at about 71 acres, or 7 per cent. of the area of the loch.

*Loch Drunkie* (see Plate V.).—This picturesque and irregular Highland loch is shut in on all sides by high hills, is difficult of access, and rarely visited. The surface of the loch, according to the Ordnance Survey maps, is 416 feet above the level of the sea, but it was raised 25 feet in connection with the water-supply to the city of Glasgow, with the view of furnishing compensation water to the river Teith. The soundings shown on the map give the depth in the loch in April, 1899.

Loch Drunkie is remarkable in many respects. It is the smallest of the five lochs in the Loch Katrine district, but deeper than the larger Loch Arklet situated at a similar high elevation, and quite as deep as the neighbouring Loch Achray situated at a lower elevation. In form it is peculiar, consisting of a quadrangular portion throwing out three arms of various sizes in different directions. The largest arm runs in a north-easterly direction, the extremity approaching within a quarter of a mile of the southern shores of Loch Vennachar; this arm contains the greatest depths observed in the loch, and near its extremity the Ordnance Survey map indicates a small island which was not seen. The second arm in point of size runs directly west, and contains a maximum depth of 80 feet. The smallest arm runs in a south-westerly direction, deepening gradually though irregularly from 6 feet at the extremity to 15 feet near the junction with the quadrangular body of the loch.

The maximum length of the loch (between the extremities of the north-eastern and south-western arms) is over one mile; from the extremity of the western arm to the opposite (eastern) shore of the loch is a little less. The maximum width of the quadrangular body of the loch is over a quarter of a mile. The mean breadth is 0·21 mile, being 21 per cent. of the length. The waters of the loch cover an area of about 138 acres (0·22 square mile), and drain an area ten times greater, or over 1400 acres (2·2 square miles). The number of soundings taken in Loch Drunkie was 155, the average depth of these being 38½ feet, the greatest depth observed (exactly the same as in the case of Loch

Achray) being 97 feet (16 fathoms). The bulk of water contained in the loch is estimated at 217,000,000 cubic feet, and the mean depth at 36 feet (or 6 fathoms), being 37 per cent. of the maximum depth. The length of the loch is 54 times the maximum depth, and 147 times the mean depth.

There are two depressions with depths over 50 feet: one at the extremity of the western arm, about a quarter of a mile in length, and the other filling up the greater part of the body of the loch, and extending some distance up the north-eastern arm, being over one-third of a mile in length and about one-quarter of a mile in maximum width. The area over 50 feet in depth is estimated at 43 acres, or 31 per cent.



FIG. 7.—LOCHS VOIL AND DOINE, LOOKING WEST FROM ROB ROY'S GRAVE, BALQUHIDDER.

(Photograph by J. Valentine.)

of the total area of the loch, while the area between the shore and the 50-foot contour is estimated at 95 acres, or 69 per cent. of the area of the loch.

*Lochs Voil and Doine.*—These two lochs, the surfaces of which, according to the Ordnance Survey maps, are situated at an elevation of 414 feet above sea-level, formed at no very distant date a continuous loch, which has been divided into two portions principally by the deposition of material brought down Monachyle glen by the river; this is supported by the fact that deep water extends close up to the dividing promontory of land on both sides. The former continuous loch must

have been over  $4\frac{1}{2}$  miles in length. As the level of these two lochs is 50 feet higher than the level of Loch Katrine, it has been suggested by Mr. Gale that the water-supply to the city of Glasgow could, if necessary, be increased by connecting these lochs to Loch Katrine by a conduit through the intervening hills.

*Loch Voil* (see Plate VII.).—Loch Voil has a total length of over  $3\frac{1}{2}$  miles, with a maximum width (near the western end) of about one-third of a mile. The mean breadth is about a quarter of a mile, or 422 yards, being 7 per cent. of the length. The waters of Loch Voil cover an area of about 561 acres (0·88 square mile), and those of Loch Doine about 135 acres (0·21 square mile), or together over one square mile, while they drain an area thirty-five times greater, or about 24,600 acres (nearly  $38\frac{1}{2}$  square miles).

The total number of soundings taken in Loch Voil is 279, the average depth of these being  $39\frac{1}{2}$  feet, and the greatest depth 98 feet (or  $16\frac{3}{4}$  fathoms). The bulk of water contained in the loch is estimated at 1,000,000,000 cubic feet, and the mean depth at 41 feet (or nearly 7 fathoms), being 42 per cent. of the maximum depth. The length of the loch is 189 times the maximum depth, and 451 times the mean depth.

Loch Voil becomes narrower and shallower towards the eastern end; one must proceed about a mile and a half (or over one-third of the length of the loch) from the eastern end before encountering depths of 50 feet, while deeper water is found towards the western end. The 50-foot depression extends from quite close to the western end for a distance of 2 miles towards the eastern end of the loch, with a maximum width of about a quarter of a mile. Towards the western end of the loch is a considerable area (over half a mile in length by a sixth of a mile in maximum breadth) having depths greater than 90 feet. In this all the deepest soundings are situated (the greatest depth, 98 feet, having been observed in two places). From this depression the bottom of the loch apparently rises very gradually towards the eastern end.

The area over 50 feet in depth is estimated at about 230 acres, or 41 per cent. of the entire area of the loch, while the area between the shore and the 50-foot line is estimated at about 331 acres, or 59 per cent. of the total extent of the loch.

*Loch Doine* (see Plate VII.).—Loch Doine has a total length of nearly one mile, with a maximum width of over a quarter of a mile; the mean breadth is about 0·21 mile, or 370 yards, being 21 per cent. of the length. The total number of soundings taken in Loch Doine was 90, the average depth of these being  $34\frac{3}{4}$  feet, the greatest depth being 65 feet (11 fathoms). The bulk of water contained in the loch is estimated at 196,000,000 cubic feet, and the mean depth at 33 feet ( $5\frac{1}{2}$  fathoms). The length of the loch is 81 times the maximum depth, and 160 times the mean depth.

In Loch Doine the deeper water occupies approximately the centre of the loch, the deepest soundings (65 feet) being found, however, nearer the eastern than the western end of the loch. The 50-foot depression covers over one-third of the area of the loch, being about three-quarters of a mile in length with a maximum width of over one-eighth of a mile. It seems doubtful whether this 50-foot depression is not really separated into a larger and smaller portion, for the narrow neck shown on the map is founded upon a single sounding of exactly 50 feet. The greatest depth, 65 feet, was observed in several spots situated towards the eastern end of the loch. The area with depths over 50 feet is estimated at 47 acres, or 35 per cent. of the entire area of the loch, while the area with depths less than 50 feet is estimated at 88 acres, or 65 per cent. of the area of the loch.

*Loch Lubnaig* (see Plate VI.).—The outflow from Lochs Doine and Voil passes by the river Balvag, 5 miles in length, into Loch Lubnaig, the surface of whose waters is, according to the Ordnance Survey maps, 405 feet above sea-level, or 9 feet lower than that of the other two lochs. A consideration of the intervening ground indicates that in post-glacial times these three lochs formed one single sheet of water.

Loch Lubnaig has a total length of nearly 4 miles, following approximately a line drawn down the centre of the loch, with a maximum width of about two-fifths of a mile. The mean breadth is nearly a quarter of a mile, or 422 yards, being 6 per cent. of the length. Its waters cover an area of about 614 acres (or nearly 1 square mile), and it drains an area  $36\frac{1}{2}$  times greater, or about 22,400 acres (nearly 35 square miles). The total number of soundings taken in Loch Lubnaig was 394, the average depth of these being  $20\frac{1}{2}$  feet, and the greatest depth observed 146 feet ( $24\frac{1}{3}$  fathoms). The bulk of water contained in the loch is estimated at 1,144,000,000 cubic feet, and the mean depth at  $42\frac{3}{4}$  feet (or 7 fathoms), being 29 per cent. of the maximum depth. The length of the loch is 145 times the maximum depth, and 493 times the mean depth.

Loch Lubnaig differs from the other lochs in the neighbourhood in that it does not constitute a single basin. The bottom is apparently very irregular; the contour lines of depth do not follow the contour of the loch, hollows and ridges alternate with each other, and in some places comparatively deep water is found close to the shore, while in other places shallow water extends a considerable distance from shore. The loch is also, comparatively speaking, very narrow and shallow considering its size, nearly two-thirds of the area being under 50 feet in depth. The loch may be conveniently divided into two halves, defined by the central constriction in the outline of the loch at the entrance of the Archchullarie burn, where the bottom shallows and separates the two principal deep depressions; the northern half trends in a north-west

and south-east direction, while the southern half trends almost directly north and south.

There are two depressions in which the depth exceeds 100 feet, with an isolated sounding of 106 feet between them. The larger depression is contained in the southern half of the loch, and is over half a mile in length, with a maximum width of about one-sixth of a mile; the greatest depth in this depression is 118 feet. The smaller but deeper depression is situated at the base of the northern half of the loch, occupying a central position, and is over a quarter of a mile in length, with a maximum width of about one-sixth of a mile. The deepest sounding in the loch (146 feet) is centrally placed in this depression,

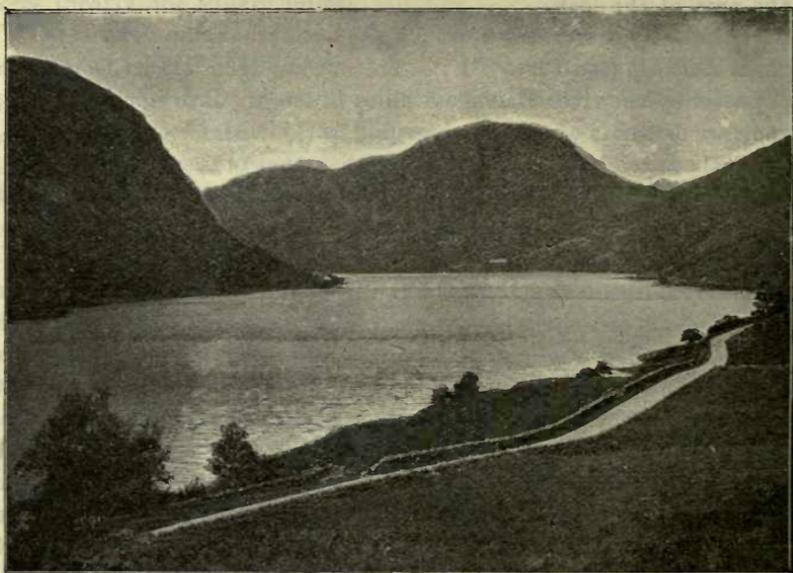


FIG. 8.—LOCH LUBNAIG, LOOKING NORTH.

(*Photograph by G. W. Wilson.*)

lying north-westward of the point where the Ardchullarie burn enters the loch. The area of over 100 feet in depth is estimated at about 55 acres, or 9 per cent. of the entire area of the loch

There are three depressions in which the depth exceeds 50 feet. The largest is contained in the southern half of the loch, and is over  $1\frac{1}{2}$  miles in length, with a maximum width of over a quarter of a mile. The second in point of size is centrally placed, and is over half a mile in length, with a maximum width of over a quarter of a mile. The third and smallest (and also the shallowest, the deepest sounding in it being 62 feet) is situated near the northern end of the loch, and is little more than a quarter of a mile in length and about one-eighth of a mile

in greatest width. At the upper end of the loch, where the river Balvag enters, there is a long spit formed of detritus brought down by the river, and this end of the loch for a distance of three-quarters of a mile is very shallow, while at the lower end the 50-foot contour is found within 200 yards of the outlet. The area between the 50-foot and 100-foot contours is estimated at about 162 acres, or 26 per cent. of the total area of the loch, while the area with depths under 50 feet is estimated at about 397 acres, or 65 per cent. of the area of the loch.

When the loch was visited on April 6, 1899, it appeared from marks on the shore that the water had lately been 4 feet 10 inches higher than at that time, and it has been known to have been 12 or 18 inches lower, so that the rise and fall is about 6 feet in all. On one occasion a disc was visible down to a depth of  $17\frac{1}{2}$  feet, and on another down to  $20\frac{1}{2}$  feet.

On the western shore, between  $1\frac{1}{4}$  and  $1\frac{1}{2}$  miles from the southern end of the loch, there is a remarkable sandy spit, which stretches out towards the centre of the loch, the origin of which appears to us somewhat puzzling (see the Geological Notes by Messrs. Peach and Horne).

*Loch Chon* (see Plate VIII.).—There are two lochs in Perthshire bearing this name, the one a little loch in the parish of Blair Atholl. The Loch Chon now under consideration lies to the south of Loch Katrine, and trends in a north-west and south-east direction. It lies at a height of 296 feet above sea-level, and the river into which it flows expands, a little distance to the south-east, into the small loch, Lochan Dubh or Loch Dhu, the surface of which is 10 feet lower. Loch Chon is over  $1\frac{3}{8}$  miles in length, and the greatest width is about one-third of a mile. The mean breadth, obtained by dividing the area of the loch by its length, is a quarter of a mile, being 15 per cent. of the length. Its waters cover an area of about 277 acres, or less than half a square mile, and it drains an area about  $14\frac{1}{2}$  times greater, or nearly 4000 acres (nearly  $6\frac{1}{4}$  square miles). The number of soundings taken in Loch Chon was 157, the greatest depth observed being 75 feet. The mass of water contained in the loch is estimated at 358,000,000 cubic feet, and the mean depth at over 29 feet, or 39 per cent. of the maximum depth. The length of the loch is 120 times the maximum depth, and 305 times the mean depth.

Loch Chon is irregular in outline, and the contour-lines are also irregular. The deepest part of the loch (*i.e.* exceeding 50 feet) forms a long, narrow depression, situated approximately in the centre of the loch, but closer to the western than to the eastern shore, about seven-twelfths of a mile in length, with a maximum width of over one-sixth of a mile. The maximum depth, 75 feet, was found comparatively very close to the western shore, being in fact only about 130 yards distant; this gives a slope of almost 1 in 5, and a similar steep slope is indicated by the near approach to the shore of the contour-lines for a considerable

distance along the western side of the loch. The slope from the eastern shore is, generally speaking, more gradual. The 25-foot depression is divided into two portions by the rising of the floor of the loch about a quarter of a mile from the southern end. The maximum depth in the smaller southern depression is 49 feet. The larger 25-foot depression, separated from the smaller one by an interval of about one-eighth of a mile, is over  $1\frac{1}{4}$  miles in length, approaching close to the north-western end of the loch, with a maximum breadth of three-eighths of a mile. This larger depression is very irregular in outline, occupying nearly the full width of the loch towards the centre, while a short distance farther south there is a narrow constriction in the vicinity of the Heron islands.



FIG. 9.—LOCH CHON.

(Photograph by G. W. Wilson.)

The area of the bottom between the shore line and the 25-foot contour is about 119 acres, or 43 per cent. of the total area of the loch; that between the 25- and 50-foot contours is about 127 acres, or 46 per cent., and that deeper than 50 feet is about 32 acres, or 11 per cent.

*Lochan Dubh* (see Plate VIII.).—This little basin is one-fifth of a mile in length, and less than one-sixth of a mile in maximum width. Its waters cover an area of about  $11\frac{1}{2}$  acres, and it drains an area eighteen times greater, or about 205 acres. The mean breadth is less than one-tenth of a mile, or 45 per cent. of the length. Twenty-five soundings were taken in Lochan Dubh, the maximum depth observed being 41 feet. The cubic mass of water is estimated at 586,000 cubic

feet, and the mean depth at nearly 21 feet, or 50 per cent. of the maximum depth. The length of the loch is 28 times the maximum depth, and 56 times the mean depth.

Lochan Dubh is very simple in construction, shoaling on all sides down to the deepest part. As in Loch Chon the slope seems to be much steeper off the western than the eastern shore, a cast of 35 feet having been taken comparatively very close to the west side. The water shallows where the loch narrows a little above the outlet, a depth of  $3\frac{1}{2}$  feet being found where the bottom is covered with reeds. The area of the bottom between the shore and the 25-foot contour line is about 7 acres, or 60 per cent. of the area of the loch, and that deeper than 25 feet is nearly 5 acres, or 40 per cent.



FIG. 10.—LOCH ARD, WITH BEN LOMOND IN THE DISTANCE.

(Photograph by J. Valentine.)

*Loch Ard* (see Plate IX.).—Loch Ard receives the outflow from Lochan Dubh and Loch Chon; it trends in an east and west direction, sending out one prolongation to the south and another to the east. Its level is 105 feet above the sea. It is over three miles in extreme length, including the eastern prolongation, but the body of what may be called the loch proper is about  $2\frac{1}{3}$  miles in length: from the head of the loch to Helen's rock. The greatest width, measured from the extremity of the southern prolongation to the northern shore of the loch, is over one mile, the mean breadth being two-fifths of a mile. Its waters cover an area of over 600 acres (nearly one square mile), and it drains an area of more than ten times greater, or about 6250 acres ( $9\frac{3}{4}$  square miles). The

number of soundings taken in Loch Ard was 308, the maximum depth being 107 feet. Thus the deepest part of Loch Ard dips two feet below sea-level. The cubic mass of water contained in the loch is estimated at 1,150,000,000 cubic feet, and the mean depth at nearly 44 feet, or 41 per cent. of the maximum depth. The length of the loch is 113 times the maximum depth, and 277 times the mean depth.

Loch Ard proper forms a comparatively simple basin, shoaling from the shores down to the deepest part. The 100-foot depression occupies a central position, and is about three-quarters of a mile in length. The 75-foot depression is over  $1\frac{1}{4}$  miles in length, while the principal 50-foot depression, over  $1\frac{1}{2}$  miles in length, is separated by a very short interval from a small detached area in the north-western part of the loch at Kinlochard, in which the depth exceeds 50 feet. The 25-foot contour-line is very irregular, and there are four isolated patches in which the depth exceeds 25 feet: the largest one in the southern prolongation at Couligartan has a maximum depth of 39 feet; a second small area occurs between the southern prolongation and the island of Eilean Gorm, in which the maximum depth is 35 feet; the other two areas are situated in the eastern prolongation of the loch, the maximum depth in the eastmost depression near the outlet of the loch being 33 feet, and in the other 39 feet. The soundings taken between Duke Murdoch's castle and Briedach show that the bottom is very irregular: the first sounding gave a depth of 17 feet, followed by 44 feet, then 38 feet, then 23 feet, then 31 feet, the bottom rising on approaching the elevation on which Briedach and a beacon are situated.

The area of the bottom between the shore and the 25-foot contour-line is about 240 acres, or 40 per cent. of the area of the loch; that between the 25- and 50-foot contours is about 154 acres, or 25 per cent.; that between the 50- and 75-foot contours is nearly 64 acres, or 11 per cent.; that between the 75- and 100-foot contour-lines is about 78 acres, or 13 per cent.; and that deeper than 100 feet is nearly 65 acres, or 11 per cent.

*Lake of Menteith* (see Plate X.).—The Lake of Menteith resembles Loch Leven somewhat in outline, and in being relatively a very shallow basin. It is also historically related with Loch Leven, since Queen Mary at one time lived within their precincts; the ruins of the Priory on Inchmahome, in which she resided before her removal to France, are of great architectural beauty and antiquarian interest. Its surface is only 55 feet above the sea. Its maximum length is over  $1\frac{1}{2}$  miles, and the maximum width over one mile, the mean width being five-eighths of a mile. Its waters cover an area of 652 acres (over one square mile), and it drains an area  $6\frac{1}{4}$  times greater, or over 4000 acres (nearly  $6\frac{1}{2}$  square miles). The number of soundings taken in the Lake of Menteith was 375, the maximum depth being 77 feet. A small portion of the bottom

thus falls below sea-level, as indicated on Plate X. The cubic mass of water contained in the loch is estimated at 562,000,000 cubic feet, and the mean depth at  $19\frac{3}{4}$  feet, or 26 per cent. of the maximum depth. The length of the loch is 110 times the maximum depth, and 427 times the mean depth.

The bottom of the Lake of Menteith is apparently very irregular. The 10-foot line follows approximately the outline of the loch, except that it is considerably removed from the south and south-east shores, where the land is bordered by reeds; it also surrounds the islands of Inchmahome, on which the Priory is situated, and Inch Talla, on which the castle is situated, Dog Isle, and a submerged crannog covered by

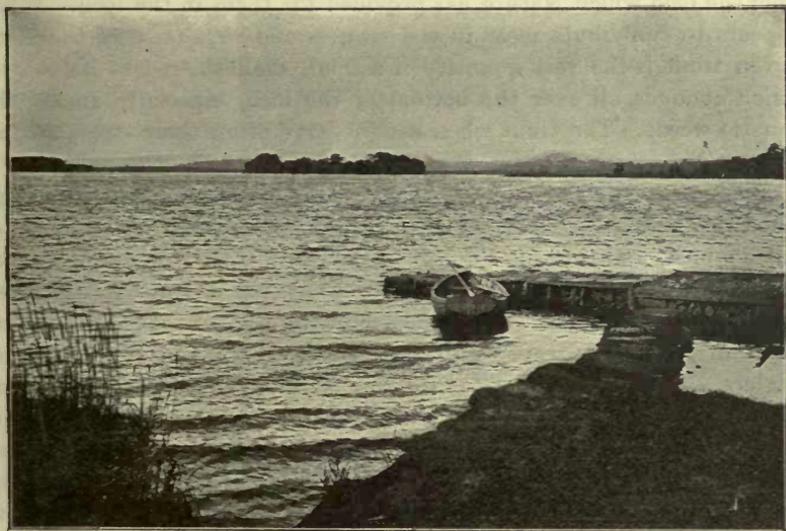


FIG. 11.—LAKE OF MENTEITH.

(*Photograph by G. W. Wilson.*)

four feet of water in the north-eastern angle of the loch at Port of Menteith. The area of the bottom covered by more than 25 feet of water is cut up into three portions. The eastmost of these 25-foot depressions has a maximum depth of 48 feet; the central 25-foot depression is almost triangular in outline, with a maximum depth of 49 feet. The westmost 25-foot depression is the largest and the deepest: it is almost divided into two halves by a narrow constriction between Inch Talla and Stable Point, the deepest water observed in the southern half being 49 feet, while the northern half contains the deepest water found in the loch. Here the bottom falls below the depth of 50 feet over an area of nearly 32 acres, the 50-foot depression being about a third of a mile in length and over a sixth of a mile in maximum width. It encloses a small patch

in which depths of 75, 76, and 77 feet were observed—the maximum depth of the lake—situated comparatively close to the northern shore at Coilledon.

The area of the bottom between the shore and the 10-foot line is about 223 acres, or 34 per cent. of the whole area of the loch; that between the 10- and 25-foot contours is about 255 acres, or 39 per cent.; that between the 25- and 50-foot contours is about 142 acres, or 22 per cent.; and that over 50 feet nearly 32 acres, or 5 per cent.

*Loch Leven* (see Plate XI.).—Loch Leven has long been famous for its trout. In the old *Statistical Account of Scotland*\* we read:—"The high flavour and bright red colour of the trout seem evidently to arise from the food which Nature has provided for them in the loch. What appears to contribute most to the redness and rich taste of the Loch Leven trout is the vast quantity of a small shellfish, red in its colour, which abounds all over the bottom of the loch, especially among the aquatic weeds. The trout when caught have often their stomachs full of them."

About the year 1770 the trout brought about a halfpenny each, large and small, and perch a halfpenny per dozen. Some years later the price was doubled, and towards the end of the century the trout were sold at 4d. per lb., pike 2d. per lb., and perch 2d. per dozen. In 1845 two boats and four boatmen were employed during part of the fishing season, while in 1891 there were twenty-two boats on the loch for the use of anglers. Extensive operations for the draining of the loch were completed about the year 1845 at a cost of £40,000, by which the loch was lowered  $4\frac{1}{2}$  feet, and the area reduced by about 1400 acres; some people maintain that the quality of the trout has been injuriously affected by the draining. Prior to 1856 rod fishing was disappointing, but about that time, from some cause that does not appear to have been satisfactorily explained, the fish rose more freely to the bait, angling became more encouraging, and Loch Leven became a resort for anglers from all parts of the country. Some years ago the fishing was taken over by the Loch Leven Angling Association, Limited, who pay a rental of £1000 per annum. The statistics regarding the trout caught by rod in the loch, and their weight, show great fluctuations from season to season. In 1872 over 17,000 were taken, the average weight being nearly 1 lb.; in 1873 the take fell to 13,400, in 1874 to 6400, in 1875 to 5000, and in 1876 even less. In 1877 the take rose again to 6000, in 1878 to 13,000, and in 1879 to 21,000, but the average weight seems to have been less. The best year recorded during the last quarter of a century was in 1888, when 23,516 trout were taken weighing 21,074 lbs. In 1893, 1898, 1899, and 1900 the takes again exceeded 20,000, but the weight never

\* Vol. vii. pp. 166, 168, 1793.

equalled the 21,000 lbs. of 1888, the nearest approach being in 1893, when 23,100 trout, weighing 19,500 lbs., were caught. Last year (1900) the trout taken by the rod numbered 23,811, weighing 15,584 lbs., an average of 0·654 lb.

Perch are also abundant, and pike are not uncommon. Formerly charr were frequently taken, but they appear to have become scarce in recent years. The American weed (*Elodea canadensis*) appears to have become firmly established in certain parts of the loch, and is causing a great deal of trouble, all the means hitherto tried for the purpose of destroying it being only of temporary benefit.

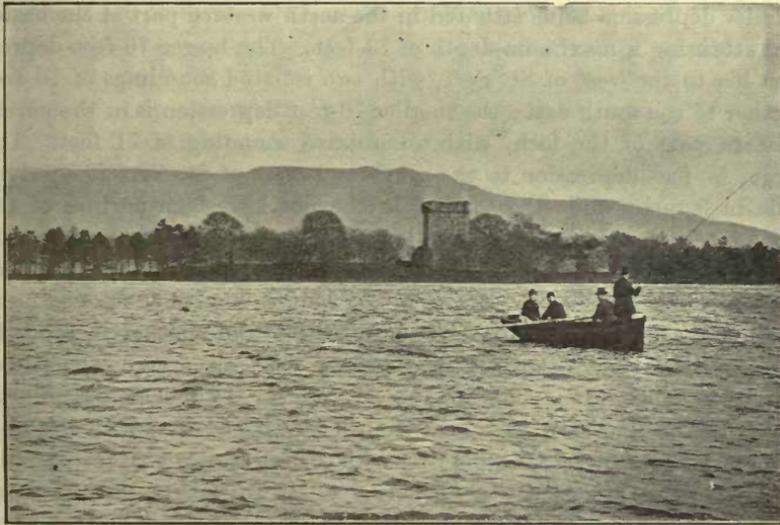


FIG. 12.—LOCH LEVEN AND CASTLE.

(Photograph by J. Valentine.)

On St. Serf's island (which is about 80 acres in extent) are the remains of a Priory dedicated to St. Serf, said to have been founded by a Pictish king, and given to the Culdees. The castle (on Castle island, which has an area of about 5 acres) is said to have been founded by Congal, son of Dongart, king of the Picts. It is famous in history as the prison in which the unfortunate Queen Mary was incarcerated for eleven months, and from which she effected her romantic escape.

Considering the area covered by the waters of Loch Leven, it is an extremely shallow loch. When measured by the Ordnance Survey officers in August, 1893, its surface was found to be 349·6 feet above the level of the sea. In form it is somewhat pear-shaped, the greatest length being  $3\frac{2}{3}$  miles from south-east to north-west, and the greatest width is about  $2\frac{2}{3}$  miles. The mean width is nearly  $1\frac{1}{2}$  miles, being 40 per cent. of the length. Its waters cover an area of nearly 3400 acres

( $5\frac{1}{2}$  square miles), and it drains an area nearly ten times greater, or about 32,500 acres (nearly 51 square miles). The number of soundings taken in Loch Leven was 538, the maximum depth being 83 feet. The bulk of water contained in the loch is estimated at 2,195,000,000 cubic feet, and the mean depth at less than 15 feet, being 18 per cent. of the maximum depth. The length of the loch is 232 times the maximum depth, and 1296 times the mean depth.

An examination of the map shows how uneven the bottom of Loch Leven is. The deepest part of the loch is cut up into two portions, the larger depression lying to the west and south of St. Serf's island, with a maximum depth of 83 feet—the greatest depth observed in the loch—the smaller depression being situated in the north-western part of the basin, and attaining a maximum depth of 79 feet. The larger 70-foot depression lies to the west of St. Serf, with two isolated soundings of 70 feet farther to the south-east; the smaller 70-foot depression is in the north-western part of the loch, with an isolated sounding of 71 feet. The larger 50-foot depression to the south and west of St. Serf is nearly a mile in length, while the smaller in the north-western portion of the basin is a little over half a mile in length. The larger 20-foot depression is very irregular in outline, extending from near the outlet of the loch at the river Leven along the southern and western shores of St. Serf, and sending a wide branch in a westerly direction and another in a north-westerly direction towards Castle island, with an extreme length of about two miles. It is separated by an interval of about half a mile (in which the bottom rises in a pear-shaped elevation—a sunken island—covered by 5 to 9 feet of water) from the north-western 20-foot depression, which is apparently extremely regular in outline, being about two-thirds of a mile in length, and over one-third of a mile in maximum width. The 10-foot line follows approximately the contour of the loch, except off the eastern shore to the north of St. Serf, where the 10-foot line runs on an average nearly three-quarters of a mile distant from the shore. The 10-foot line also surrounds Reed Bower, Castle island, and Scart island, and in addition to the elevation in the central part of the loch already mentioned, there is another small elevation covered by depths of 3 to 7 feet near the southern shore off Waterbutts plantation.

The area of the bottom between the shore and the 10-foot contour-line is about 1430 acres, or 42 per cent. of the whole area of the loch; that between the 10- and 20-foot contours is nearly 1450 acres, or 43 per cent.; that between 20 and 50 feet is about 375 acres, or 11 per cent.; that between 50 and 70 feet is nearly 110 acres, or 3 per cent.; and that over 70 feet is about 25 acres, or 1 per cent. It will thus be seen that no less than 85 per cent. of the bottom is covered by less than 20 feet of water, and the mean depth as already mentioned is less than 15 feet.

The details regarding the physical features of the different lochs are collected together in the following table for convenience of reference:—

Loch.	Elevation of surface above the sea.		Number of soundings.	Length, Miles.	Breadth, miles.		Mean breadth per cent. of length.	Depth, Feet.			Ratio of depth to length.		Volume, million cubic feet.	Area of loch.		Drainage area.	
	Feet.	Sea.			Max.	Mean.		Mean per cent. of max.	Max.	Mean.	Max.	Mean.		Square Miles.	Total in square miles.	Ratio to area of loch.	
Katrine	364	...	775	8.00	1.00	0.60	7.5	495	199.189	40.4	85	211	27,274	4.78	37.42	7.83	
Arklet	455	...	135	1.00	0.50	0.33	33.3	67	24.190	36.1	79	218	222	0.33	5.33	16.15	
Achray	276	...	171	1.25	0.33	0.26	20.8	97	36.009	37.1	68	183	321	0.32	44.48	1.39	
Vennachar	270	...	423	4.00	0.75	0.40	10.0	111	42.410	38.2	190	498	1,903	1.61	75.33	46.79	
Drunkie	416	...	155	1.00	0.25	0.21	21.0	97	36.050	37.1	54	147	217	0.22	2.20	10.00	
Voil	414	...	279	3.50	0.33	0.24	6.9	98	40.936	41.8	189	451	1,000	0.88	38.47	35.29	
Doine	414	...	90	1.00	0.25	0.21	21.0	65	33.130	51.0	81	160	196	0.21			
Lubnaig	405	...	394	4.00	0.40	0.24	6.0	146	42.773	29.3	145	493	1,144	0.96	73.44	76.50	
Chon	296	...	157	1.7	0.3	0.25	14.7	75	29.382	39.2	120	305	358	0.43	6.21	14.44	
Lochan Dubh	286	...	25	0.2	0.12	0.09	45.0	41	20.700	50.5	28	56	0.6	0.02	6.53	326.30	
Ard	105	...	308	2.3	1.1	0.41	17.8	107	43.863	41.0	113	277	1,150	0.94	15.97	16.99	
Lake of Menteith.	55	...	375	1.6	1.0	0.64	40.0	77	19.770	25.7	110	427	562	1.02	6.35	6.23	
Leven	350	...	538	3.65	2.6	1.45	39.7	83	14.869	17.9	232	1296	2,195	5.30	50.92	9.61	
			3825										36,542.6	17.02	227.66*	13.37	

\* The drainage area of Loch Vennachar includes those of Lochs Katrine, Achray, and Drunkie; the drainage area of Loch Lubnaig includes those of Lochs Doine and Voil; and the drainage area of Loch Ard includes those of Lochs Chon and Dubh.

From the table on previous page it will be seen that in the thirteen lochs over 3800 soundings were taken, and that the aggregate area of water-surface is about 17 square miles, so that the average number of soundings per square mile is 225. The aggregate volume of water contained in the lochs is estimated at 36,543 millions of cubic feet. The area drained by these lochs is about 228 square miles, or about 13 times the area of the lochs.

*Deposits.*—As a general rule, the materials forming the deposits in these fresh-water lochs become finer grained the further from the shore and the deeper the water. Off the mouths of rivers and burns there is frequently a considerable accumulation of gravel and fine sand, extending for some distance into the lake and occasionally reaching rather deep water. Large stones, gravel, and sand are usually found all round the shores within the limits of wave-action. The height and length of the waves, and the depth to which wave-action extends, depend on the size and depth of the loch.

The central parts of the lochs are occupied by a fine impalpable mud, which is found in its most characteristic form in the greater depths far from shore; it is usually of a light or dark brown colour, and sometimes there are indications of different-coloured layers. The usual mineral species are quartz, felspars, black and white mica, amphibole, pyroxene, magnetite, garnets, &c. Chemical analysis showed that these fine muds contained no appreciable calcareous matter, but traces of sulphuretted hydrogen were always present. The loss on ignition after drying at 90° C., due to organic matter and combined water, varied from 13 to 26 per cent. Diatoms were observed in nearly all the samples, and vegetable fibre was usually present in greater or less abundance.

The samples from the deepest part of Loch Katrine were brownish, fine-grained homogeneous muds, with glittering mica-flakes, consisting principally (50 to 70 per cent.) of angular mineral particles exceeding 0.05 mm. in diameter, the mean diameter being about 0.15 mm., with clayey and vegetable matter, and many minute mineral particles less than 0.05 mm. in diameter. A few diatoms were observed, and one sample, after drying at 90° C., gave 19.91 per cent. loss on ignition.

The mud from the deepest part of Loch Achray was of a grey-brown colour, containing much vegetable and clayey matter, the mineral particles exceeding 0.05 mm. in diameter making up probably 30 or 40 per cent. of the whole deposit. Some fine diatoms were observed, and the loss on ignition, after drying at 90° C., amounted to 12.84 per cent.

The mud from a depth of 102 feet in Loch Vennachar was yellowish-brown in colour, containing about 20 per cent. of mineral particles with a mean diameter of 0.1 mm., but principally made up of amorphous clayey matter with vegetable matter, and many minute mineral particles less than 0.05 mm. in diameter. There were a few

diatoms; the loss on ignition, after drying at 90° C., amounted to 14 per cent.

The mud from the deeper part of Loch Drunkie was of a dirty brown colour, containing 10 to 20 per cent. of mineral particles with a mean diameter of 0·1 mm., but consisting principally of amorphous clayey matter, with many small mineral particles, and vegetable matter. A few diatoms were observed. The loss on ignition, after drying at 90° C., amounted to 26·38 per cent.

The deposit from the deeper parts of Loch Arklet was similar to that from Loch Drunkie, with even a larger quantity of vegetable matter.

The mud from the deeper parts of Lochs Doine and Voil was of a brown colour, with 30 to 40 per cent. of mineral particles, and clayey and vegetable matter, and a few diatoms. A sample from a depth of 80 feet in Loch Voil, after drying at 90° C., gave 22·74 per cent. loss on ignition.

The material from a depth of 136 feet in Loch Lubnaig was a brown impalpable mud, with 30 to 40 per cent. of mineral particles, much clayey and vegetable matter, and a few diatoms. The loss on ignition, after drying at 90° C., amounted in one sample to 16·29 per cent., and in another sample to 15·76 per cent.

Three brown muds were examined from Loch Chon, from depths of 10 feet, 14 feet, and 37 feet. The colour was lighter, and the mineral particles were more abundant and larger, in the shallower water. In the deposit from 10 feet the mineral particles made up probably 35 to 40 per cent., and included a few rock fragments which sometimes attained a diameter of 10 mm., the mean diameter of the mineral particles exceeding 0·05 mm. in diameter being about 0·3 mm., while in the deposit from 37 feet the percentage falls to about 10, with a mean diameter of 0·1 mm. Inversely, clayey matter and vegetable matter were more abundant in the deeper water, mixed with minute mineral particles, impregnated with ferric oxide, and containing diatoms, Sponge spicules, arenaceous Foraminifera, and Entomostracous skeletal fragments.

A sample from the deepest part of Loch Ard was a dark-grey mud, consisting principally of vegetable and clayey matter, the mineral particles not exceeding 10 per cent., with a mean diameter of about 0·1 mm. The organic remains observed were the same as in Loch Chon.

A fine-grained dark-brown mud from a depth of 60 feet in Loch Leven contained probably not more than 5 per cent. of mineral particles exceeding 0·05 mm. in diameter, the bulk of the deposit consisting of clayey and vegetable matter, containing many beautiful diatoms, with Sponge spicules and Entomostracan remains.

*Temperature Observations.*—During the various visits to the different lochs, many observations were made on the temperature of the water,



both on the surface and at intervals below the surface, down to the bottom. All the serial temperatures taken in Lochs Katrine, Arklet, Achray, Drunkie, Vennachar, Doine, Voil, and Lubnaig have been collected together in the table,\* and, in order to make the record more complete, the temperatures taken by Jardine in 1812 and 1814 in Loch Katrine are given in the first two columns.

*Loch Katrine.*—The surface temperatures taken in Loch Katrine during the seven days from June 5 to 11, 1897, are extremely interesting, as illustrating the effect of the wind. The range of temperature during this time was  $12\frac{1}{2}^{\circ}$ , from  $45^{\circ}\cdot3$  to  $57^{\circ}\cdot8$ , the highest reading being observed at Trossachs pier on the evening of June 5, and the lowest at the same place on the evening of June 9. This was evidently the result of a strong east wind, which commenced to blow on the 6th, and continued from the same direction till the 9th, blowing the warm surface water before it from the east towards the west end of the loch, while colder water from below was drawn up to the surface at the east end of the loch to take its place. The gradual cooling of the water at the east end of the loch is well shown by the temperatures taken at Trossachs pier from day to day: thus at 6.30 p.m. on June 5 the temperature was  $57^{\circ}\cdot8$ ; at 11.30 a.m. on the 6th it was  $56^{\circ}\cdot2$ ; and at 4 p.m.  $55^{\circ}\cdot3$ ; at 7 a.m. on the 7th it was  $49^{\circ}\cdot2$ ; at 10.30 a.m. on the 8th it was  $46^{\circ}\cdot3$ ; and at 7.15 p.m. on the 9th it was  $45^{\circ}\cdot3$ . By 9.30 a.m. on the 11th it had again risen to  $50^{\circ}\cdot1$ . The effect of the wind was also shown by a series of surface temperatures taken from the steamer on its way from Stronachlachar pier to the Trossachs pier on the evening of June 9: thus at Stronachlachar the temperature was  $52^{\circ}\cdot6$ ; near the waterworks,  $52^{\circ}\cdot0$ ; near Letter,  $49^{\circ}\cdot6$ ; near Brenachoil,  $48^{\circ}\cdot8$  and  $48^{\circ}\cdot0$ ; near Ellen's isle,  $47^{\circ}\cdot4$  and  $47^{\circ}\cdot0$ ; and finally at Trossachs pier,  $45^{\circ}\cdot3$ . It will thus be seen that it is very unsafe to rely on a single observation at one spot as giving a sure indication of the temperature of the surface waters of a loch as a whole at any given season. A year later (from June 4 to 9, 1898) the temperature of the surface waters of Loch Katrine was not observed to fall below  $50^{\circ}$ . On November 26, 1897, the surface temperature varied only from  $46^{\circ}\cdot8$  to  $47^{\circ}\cdot4$ , and on April 13 and 15, 1899, from  $41^{\circ}\cdot2$  to  $42^{\circ}\cdot7$ .

The serial temperatures in Loch Katrine are shown graphically in the accompanying curves (Fig. 13), which exhibit the march of temperature in the waters of the loch throughout the year. The curve for April shows that the water from top to bottom has a temperature ranging between  $41^{\circ}$  and  $42^{\circ}$  Fahr. In the two curves for June the heating effect of the sun on the surface layers is indicated, but in depths beyond

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\* Temperature observations in the surface waters of some of the lochs under consideration have been taken by Mr. Thomas Scott, and the results published in the *Annual Reports of the Fishery Board for Scotland*.

20 fathoms the temperature has not been appreciably affected. In June, 1898, the whole body of water in the loch was apparently slightly warmer than in the previous June. The November curve shows a great accumulation of summer heat in the layers down to depths of 30 and 35 fathoms. By this time cooling has set in, and progresses slowly until the spring, when the whole of the layers assume the nearly uniform temperature indicated by the April curve. The temperature of the bottom of the loch in depths of 400 feet may vary one or two degrees from year to year, this variation being due to the strength of the winds and general character of the climate in different years.\* The highest

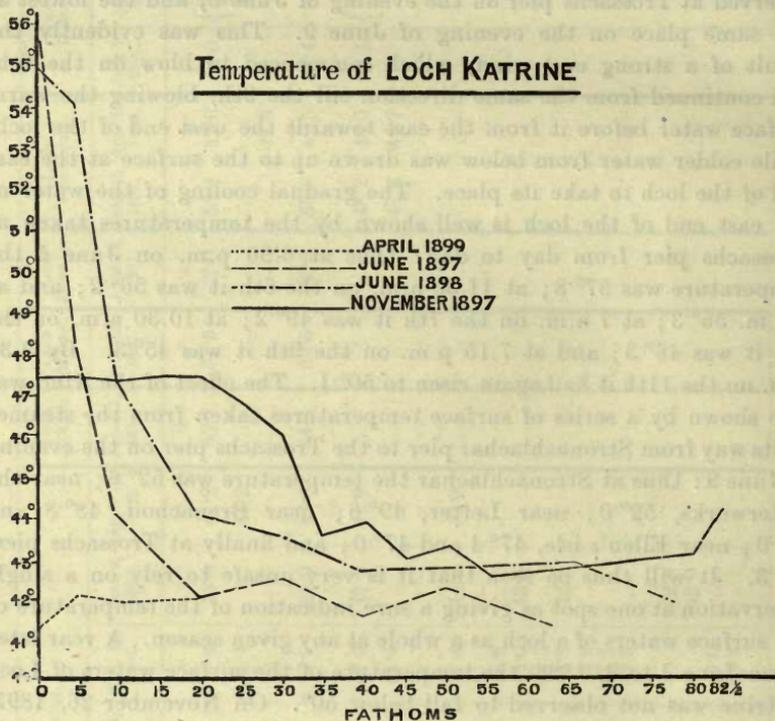


FIG. 13.—CURVES OF TEMPERATURE IN LOCH KATRINE.

temperature recorded in Loch Katrine is  $58^{\circ}4$ , so that the range in the central parts of the loch throughout the whole year is probably about  $18^{\circ}$  Fahr.

\* See Murray, "Some Observations on the Temperature of the Water of the Scottish Fresh-water Lochs" (*Scottish Geographical Magazine*, vol. xiii. p. 1, 1897). At noon on March 10, 1900, in calm and frosty weather, the temperature of the surface water of Loch Katrine, over the deepest part of the loch, was  $40^{\circ}3$ , at 10 feet  $40^{\circ}2$ ; at all other depths down to 492 feet the temperature-readings were  $40^{\circ}0$  and  $40^{\circ}1$ . On the same date the readings in shallow water were  $39^{\circ}4$ .

*Loch Arklet.*—Temperature observations taken in the centre of Loch Arklet on June 11, 1897, gave a temperature at the surface of  $55^{\circ}4$ , and at 5 fathoms  $54^{\circ}4$ ; on April 13, 1899, the surface temperature was  $42^{\circ}7$ . Temperatures as high as  $61^{\circ}$  have been recorded in this loch, so that the annual range probably exceeds  $29^{\circ}$ .

*Loch Achray.*—Observations taken in June and November, 1897, and April, 1899, showed that the temperature of the surface waters varied from  $41^{\circ}$  in April to  $59^{\circ}5$  in June, the temperature in November being  $46^{\circ}$ . An intermediate observation at 5 fathoms in the centre on June 12, 1897, gave  $53^{\circ}5$ . The highest reading recorded at the surface of this loch is  $64^{\circ}1$ , so that the annual range probably exceeds  $32^{\circ}$ .

*Loch Drunkie.*—Observations taken on June 12, 1897, showed that the surface waters had a temperature of  $57^{\circ}$ , and an intermediate observation at 5 fathoms gave  $52^{\circ}6$ . On April 14, 1899, the surface temperature was  $42^{\circ}4$ .

*Loch Vennachar.*—The temperature observations taken in June, July, and November, 1897, and April, 1899, showed that the temperature of the surface water varied from  $41^{\circ}$  in April to  $56^{\circ}5$  in June, the temperature in November being  $46^{\circ}$  to  $47^{\circ}$ , while the water of Blairgarry stream had a temperature of  $42^{\circ}2$ . Serial observations in the centre of the loch on June 10, 1897, showed a gradual fall in the temperature from  $55^{\circ}8$  at the surface to  $47^{\circ}2$  at 15 fathoms; while on April 11, 1899, the temperature was practically uniform from surface to bottom at  $42^{\circ}5$  to  $42^{\circ}7$ .

*Loch Doine.*—Observations taken on July 7, 1897, and April 10, 1899, showed that the temperature varied from  $42^{\circ}$  in April to  $54^{\circ}$  in July. Serial observations in the centre of the loch in July gave a temperature at the surface of  $54^{\circ}$ , falling to  $52^{\circ}1$  at 10 fathoms, while in April the temperature was found to be nearly uniform from surface to bottom, ranging from  $41^{\circ}8$  to  $42^{\circ}6$ .

*Loch Voil.*—Observations taken in July, 1897, and April, 1899, showed that the temperature of the surface water varied from  $41^{\circ}2$  in April to  $56^{\circ}5$  in July. Serial observations taken on July 7, 1897, showed that in the centre of the loch the temperature at the surface was  $55^{\circ}0$ , at 5 fathoms  $54^{\circ}0$ , and at 16 fathoms  $54^{\circ}5$ , while further down the loch the temperature appeared to be rather higher, viz.,  $56^{\circ}0$  at the surface, and  $55^{\circ}3$  at 3 fathoms and 8 fathoms. Serials taken on April 10, 1899, showed that the whole body of water was practically uniform in temperature at about  $42^{\circ}$ .

For the sake of comparison, a few surface temperatures were taken at the head of Loch Earn on July 6, 1897, the temperature of the loch varying from  $48^{\circ}8$  to  $49^{\circ}2$ , while that of the streams flowing into the loch was  $52^{\circ}2$ . On the following day (July 7, 1897) the surface of Loch Voil near the shore had a temperature of  $56^{\circ}4$ , and a little distance

from the shore  $54^{\circ}6$ , while the water of the burn flowing into the loch had a temperature of  $53^{\circ}6$ , and higher up the stream  $53^{\circ}1$ . It thus appears that the waters of Loch Voil were warmer than those of Loch Earn, and in the case of Loch Voil the stream feeding the loch had a lower temperature than the loch itself, while in the case of Loch Earn the streams were warmer than the waters of the loch.

*Loch Lubnaig*.—Observations were taken in Loch Lubnaig only on April 6 and 8, 1899, and showed that at that time the temperature of the water was nearly uniform from surface to bottom, the range being only from  $41^{\circ}8$  to  $42^{\circ}7$ .

From the point of view of temperature, the Scottish fresh-water lochs may be divided into those which freeze during hard winters, and those which never freeze. Those which freeze over in winter are shallow lochs, and when frozen the water-temperature beneath the ice is at the maximum density point of fresh water ( $39^{\circ}1$ ) or lower. In spring the temperature of these shallow lochs rises much more quickly through the heat of the sun, and the whole mass of water attains a higher temperature than in the case of the deeper lochs; they also lose their heat much more quickly in the autumn than the deep lochs, and consequently have a much wider range of annual temperature. In the deep lochs—those with 400 or more feet of depth—the temperature of the water never rises so high in summer, nor sinks so low in winter, as in the shallow lochs, and the range is much less. The temperature of the bottom water in some cases does not change more than  $1^{\circ}$  Fahr. from year to year, and in the deepest lochs it appears to be practically constant at all times and seasons;  $40^{\circ}$  is the lowest temperature that has been recorded at the bottom in any of these deep Scottish lochs, so that the maximum density point is never reached. In summer, autumn, and even early winter, it is possible, by observing the temperature of the surface and sub-surface waters, to form a fairly accurate idea of the depth of a loch, the temperature being higher the shallower the loch. The waters from a deep loch—like Loch Katrine—are much the best for the water-supply to a city, for in summer the temperature is relatively low and in winter it is relatively high.

The serial temperature observations taken in Lochs Chon, Ard, Menteith, and Leven are given in the following table, but many temperature observations were taken at the surface, which are not, of course, included in the table:—

Depth in Feet.	Loch. Chon.	Lochan Dubh.	Loch Ard.		Lake of Menteith.	Loch Leven.		
	May 15, 1900.	May 15, 1900.	Aug. 6, 1899.	May 16, 1900.	May 14, 1900.	June 11, 1900.	June 22, 1900.	Sept. 1, 1900.
0	51·8	54·7	63·0	51·7	51·3	58·7	62·3	58·0
5	...	...	...	...	...	58·4	62·2	...
6	50·7	51·1	61·3	51·4	51·1	...	...	...
10	...	...	...	...	...	58·0	62·1	...
12	...	...	61·3	50·5	...	...	...	...
18	...	...	61·3	48·5	...	...	...	...
20	49·5	...	...	...	50·7	57·5	...	...
24	...	...	61·2	48·3	...	...	...	...
30	...	...	60·5	47·7	...	57·4	61·5	...
35	...	47·6	...	...	...	...	...	...
40	48·6	...	...	...	50·5	56·6	..	...
48	...	...	50·1	47·1	...	...	...	...
50	...	...	...	...	...	56·5	59·3	57·3
60	48·5	...	48·2	46·9	50·2	56·3	56·8	56·6
70	...	...	...	...	...	...	56·2	56·6
76	...	...	...	...	...	...	...	...
90	...	...	47·5	46·5	...	...	...	...
96	...	...	47·5	46·5	...	...	...	...
100	...	...	...	46·4	...	...	...	...

*Loch Chon and Lochan Dubh.*—These lochs were sounded on the 15th May, 1900, when the surface temperature in Loch Chon varied between 51°·8 and 54°·5; below the surface the temperature decreased gradually down to 48°·5 at 60 feet, so that the range observed throughout the whole body of water was only about 6°. In Lochan Dubh the surface temperature was slightly higher than in Loch Chon (54°·7), while the temperature of the deeper water was observed to be about 1° lower (47°·6), so that in the small body of water contained in Lochan Dubh the range was greater than in the larger Loch Chon, viz., 7°.

*Loch Ard.*—Loch Ard was visited on the 5th and 6th August, 1899, and again on the 16th May, 1900. The highest surface temperature (64°·6) was observed in the southern prolongation of the loch in August, the maximum temperature observed at the same time in the body of the loch proper being 63°. It will be seen that the whole body of water was warmer in August, and that a drop of 10° was recorded between the depths of 30 and 50 feet, the extreme range of temperature from surface to bottom being 17°. No steep gradient was observed in May, the temperature decreasing gradually from top to bottom, the extreme range observed in May being 8°·7.

*Lake of Menteith.*—The Lake of Menteith was visited on the 7th August, 1899, and the 14th May, 1900. No serials were taken in August, when the surface temperature varied only from 62°·2 to 63°·2. In May the surface temperature varied from 51°·1 to 52°·2, and the temperature decreased gradually from surface to bottom, the range observed in May throughout the whole body of water being only 2°—

from  $50^{\circ}2$  to  $52^{\circ}2$ ; the extreme range shown by all the observations amounts to  $13^{\circ}$ .

*Loch Leven.*—Loch Leven\* was sounded on the 11th, 12th, and 22nd June, 1900, and again on the 1st September and the 23rd October. A reading at the surface on the 11th June at 5 p.m. gave  $58^{\circ}7$ , and on the 12th June at 4.50 p.m. a temperature of  $67^{\circ}5$  was observed—a range of nearly  $9^{\circ}$  in one day. This reading of  $67^{\circ}5$  may be specially referred to as being, so far as we are aware, the highest temperature hitherto recorded in the waters of Scottish lochs, the next highest reading being one of  $65^{\circ}$  observed by Mr. Scott at the surface of Loch Oich in August, 1897. In September the surface temperature ranged only from  $57^{\circ}$  to  $58^{\circ}5$ . We are doubtful as to the working of the thermometer made use of in the October visit, and the readings have therefore not been included in the table.

The serials taken in June indicate the rapidity with which the waters of a shallow lake like Loch Leven become heated up in summer. During the eleven days between June 11th and 22nd the whole body of water had acquired a higher temperature, amounting to about  $4^{\circ}$  in the upper layers down to 30 feet, to nearly  $3^{\circ}$  at 50 feet, and to half a degree at 60 feet. But, while the body of water in a shallow lake absorbs heat more rapidly than that in a deep lake, it also loses heat more rapidly, and therefore the quantity of heat stored up in the waters of a deep lake may not be less than that stored up in the waters of a shallow lake, as Delebecquet† seems to think. From a preliminary study of our temperature observations in the Scottish lochs we believe the reverse to be the case. For instance, Loch Katrine and Loch Leven are comparable as regards superficial area, but Loch Katrine is six times as deep as Loch Leven, and contains twelve times as much water; if the temperature of the water in the two lochs were taken simultaneously before and after a definite interval in summer, it seems probable that, while the temperature in Loch Leven might have been raised much higher than in Loch Katrine, the amount of heat stored up, as represented by the number of cubic feet raised  $1^{\circ}$ , would be found to be greater in Loch Katrine than in Loch Leven, and that the difference would bear some relation to the ratio between the bulk of water and the area of surface exposed to the rays of the sun. We shall endeavour to work this matter out in greater detail as our temperature observations accumulate, and we may return to the subject in a later paper.

*Biology.*—Tow-net and other observations show that the nature and

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\* We understand that the temperature of the water of Loch Leven has been taken at the pier once a day (at 12 noon) during the five months of the fishing season for the past twenty-five years, but we have had no opportunity of examining the observations.

† "La quantité totale de chaleur emmagasinée dans un lac variera d'autant moins que ce volume sera plus grand par rapport à cette surface" (*Les Lacs français*, p. 150).

amount of the organic life in the fresh-water lochs are subject to great variation in the different lochs when compared with each other, and in the same loch at different seasons of the year. Large numbers of observations are being collected, and we may look for interesting results when these are in a state for discussion. Generally speaking, the pelagic fauna and flora are much more abundant in the warm summer months than at other times of the year, and are also more abundant in the shallow lochs than in the deep ones. In the spring months there is a great development of diatoms and other Phytoplankton, which render the water less transparent than at other times of the year.

Mr. Thomas Scott has lately been comparing the fauna in several of the Scottish lochs at different seasons of the year; some of his results for the lochs now under consideration may be noted.

In Loch Katrine the Entomostraca and other invertebrates were scarcer than in the other lochs examined. Fourteen species are recorded, *Bosmina longispina* being the only species present in all the gatherings; *Leptodora* was entirely absent from the gatherings collected during the colder months. *Cyclops strenuus* and *Polyphemus* appeared to be more frequent in the upper part of the loch, and *Bosmina* and *Leptodora* in the lower part. The sides of Loch Katrine do not generally present conditions very favourable to shore-dwellers, and an examination of the shore about Stronachlachar yielded scarcely anything that differed from the tow-net captures, while at the lower end the shore between the Trossachs pier and Ellen's isle yielded much better results. Here forty species of Crustacea were obtained, as well as one or two species of Mollusca, but they were all individually scarce. The Cladocera were more numerous in species in the warmer than in the colder months, while with the Copepoda the reverse was observed, though the difference was not so great.\*

In Loch Arklet, *Holopedium gibberum*, one of the most remarkable species of the Cladocera in Britain, was moderately common in the tow-net gatherings collected in September and November, 1897, and in June, 1898, it was abundant all through the water, but when the loch was visited in March, 1898, not a trace of *Holopedium* could be seen. In June, when *Holopedium* was so abundant, other species previously observed were either very scarce or absent, as if they had been more or less crowded out by this particular cladoceran. Eleven crustacean species are recorded, *Daphnia* being the only form obtained in all the gatherings; *Bythotrephes* was observed in September and June, but not in November and March, and *Leptodora* occurred only in September. Infusoria (*Ceratium*, &c.) and micro-algæ were much less frequent in June than in the other gatherings. Forty-two species of Entomostraca were obtained by hand-net round the shores of Loch Arklet, including

\* Scott, *Seventeenth Annual Report of the Fishery Board for Scotland*, pt. iii. pp. 148-151, 1899.

a few comparatively rare forms; very few molluscs were observed in any of the gatherings.\*

Twelve species of Entomostraca were captured by the tow-nets in Loch Achray, *Diaptomus*, *Daphnia*, and *Bosmina* being taken in all the gatherings. *Holopedium*, though common in September and June, was not observed in November and March; *Bythotrephes* also appears to be subject to somewhat similar seasonal variation. Fifty species of Entomostraca and four species of Mollusca were obtained by the hand-net, and by dragging the tow-net for a short distance over the bottom of Loch Achray. Three rare species: *Diaptomus wierzejskii*, *Lathonura rectirostris*, and *Monospilus dispar* were obtained, and in June a green fresh-water sponge (*Spongilla fluviatilis*) appeared to be moderately common in some shallow parts of the loch.†

Loch Vennachar contains a rich crustacean fauna, as well as other invertebrates, most of which are suitable for fish food. Of forty-five species of Crustacea recorded from Lochs Katrine, Achray, and Vennachar, thirty-five species were observed in Loch Vennachar; thirteen of the species from Loch Vennachar were not observed in either Lochs Katrine or Achray; fifteen of the species were common to the three lochs.‡

Twenty-five species of Crustacea and four species of Mollusca are recorded from Loch Lubnaig, including a new cladoceran (*Alona neglecta*), and one or two species new to Britain.§

The following results were obtained by Mr. Scott in Loch Leven in 1890, 1897, and 1898.||

In June, 1890, Mr. Scott found the fauna to be abundant and varied—Mollusca, Arthropoda, Annelida, and Protozoa being more or less common all over the loch. Mollusca were common and generally distributed, except at that part of the loch called the "Shallows," the bottom of which consists of little else than fine sand, and is therefore not so suitable as a habitat for these organisms as where the bottom consists of mud or vegetable debris. Fourteen species of Mollusca were obtained, comprising five Lamellibranchs and nine Gasteropods. The more common forms were *Sphærium corneum*, *Pisidium fontinale*, *Valvata piscinalis*, and *Planorbis contortus*. The swan-mussel (*Anodonta cygnæa*) appeared also to be frequent.

The Crustacea were by far the most numerous and varied of the invertebrate fauna of the loch. Cladocera and Copepoda occurred in great profusion all over and through the water. *Daphniæ* were

\* Scott, *Seventeenth Report of the Fishery Board for Scotland*, pt. iii. pp. 143-146.

† *Ibid.*, pp. 153-156.

‡ Scott, *Fourteenth Report of the Fishery Board for Scotland*, pt. iii. p. 167, 1895.

§ Scott, *Thirteenth Report of the Fishery Board for Scotland*, pt. iii. p. 247, 1894.

|| See *Ninth and Seventeenth Annual Reports of the Fishery Board for Scotland*, part iii., 1890 and 1899.

most abundant. *Cyclops*, especially *C. strenuus*, was also plentiful. Ostracoda were not so common in the loch itself as they were around its margin, particularly those parts that were more or less overgrown with vegetation, as round the north-east shore. Seventeen species of Ostracoda were obtained along this part of the shore; twelve species were obtained from the south shore, and only eight from the loch itself. Among the Cladocera the rare and interesting *Leptodora hyalina* occurred in considerable numbers; *Monospilus tenuirostris* was also frequent in the material collected at one or two places. The following were the common species:—*Gammarus pulex*, *Diaptomus gracilis*, *Cypria serena*, *C. ophthalmica*, *Limnocythere sancti-patrici*, *Daphnia lacustris*, *Pleuroxus trigonellus*, *Chydorus sphericus*.

The larvæ of insects were abundant in the loch, especially the larvæ of the Iphemeridæ. The Libellulidæ and Phryganidæ were also represented in the larval stage more or less frequently. Some idea may be formed of the myriads of these organisms present in the loch when it is stated that a conspicuous ridge composed of cast-off skins of insect larvæ, which had been washed ashore during the preceding stormy weather, extended along the margin of the loch for a considerable distance. The curious so-called "water-bears" (Tardigrada), now included in the class Arachnida, were common among the decaying vegetable matter at the bottom. Species of Notonectidæ or "water-bugs," and of aquatic Coleoptera were also more or less common, though their distribution seemed to be more localised.

The worms were represented by several species—parasitic and non-parasitic. Among the former were *Schistocephalus solidus*, obtained from the body-cavity of a Stickleback (*Gasterosteus aculeatus*), and a species of tape-worm (*Bothriocephalus latus?*), several of which were found in the alimentary canal of the trout, six specimens being taken from one fish. The heads of the parasites were fixed at the extreme end of the *cæca* or blind tubes of the stomach, and their bodies were so elongated as to extend well down into the intestine. Usually one parasite occupied a *cæcum*. *Tubifex rivulorum* was very common in the loch.

Rhizopoda were common all over the loch. Several forms were obtained in the dredged and hand-netted material; the more typical varieties observed were:—*Diffugia pyriformis*, *D. globularis* (much less frequent than the first named), *D. corona* (appeared scarce), *D. marsupiformis* (of frequent occurrence). Diatomacea were abundant, especially in the deeper parts of the loch, and included a considerable number of species.

Mr. Scott visited Loch Leven again in September and December, 1897, and in March and June, 1898, when he found that the free-swimming Entomostraca, though very abundant, consisted mainly of the one species, *Daphnia lacustris*. *Leptodora hyalina* was moderately

common in the September gathering, but was not observed in any of the other three. *Diaptomus gracilis* was frequent in the gathering collected in December, but was scarce in the others. *Bythotrephes longimanus*, though present in both the September and June gatherings, was not observed in those collected in December and March. *Cyclops strenuus*, though present in all the gatherings, was scarce.

A few male *Daphnia* were observed in the December gathering, but in none of the others; females with *pseudova* were frequent in all the gatherings. When the loch was examined in June, 1890, both *Daphnella brachyura* and *Polyphemus pediculus* were observed in the tow-net gatherings, but neither of these species was obtained in any of the gatherings recently collected. Infusoria and micro-algæ, which were moderately frequent on the first three occasions when the loch was examined, were quite abundant in the loch in June, but these minute forms did not appear to be generally diffused, apparently occurring in shoals, and being particularly plentiful to the south of Reed Bower.

The examination of the shore yielded a much greater number of species than were captured by the tow-nets, but individuals were not nearly so numerous. Fifty-five species of Crustacea were obtained in the shore gatherings collected during the recent experiments. The records of species obtained when the loch was examined in 1890 include a few that were not observed in the recent gatherings (viz., *Cypria exsculpta*, *Candona lactea*, *Ilyocypris biplicata*, *Bosmina longirostris*, *B. longispina*), and if these and the species captured with the tow-nets be added, they increase the number of crustacean species to sixty-five; it is quite probable that even this number will yet be added to when the loch comes to be more thoroughly examined. Only five species were observed in all the gatherings in 1890, 1897, and 1898, viz., *Canthocamptus staphylinus*, *C. minutus*, *Cypria ophthalmica*, *Candona candida*, *Chydorus sphaericus*. The species recently captured include one Amphipod (*Gammarus pulex*), and eighteen each of Copepoda, Ostracoda, and Cladocera. The largest number of species of Crustacea, obtained in any of the recent shore gatherings from Loch Leven was in that collected on 13th June. This gathering yielded thirty-nine species, or only four less than the total number observed in the tow-net and hand-net gatherings collected in June, 1890.

The Cladocera, as a whole, were scarcer in those gatherings collected in the colder months than in the others. It may also be stated that in March the level of the water was much higher than during any of the other visits, and this no doubt accounted, partly at least, for the great scarcity of Cladocera in the gathering collected at that time; the reduced temperature incidental to the season may also have had some influence in bringing about this result.

*Rainfall and Outflow.*—An attempt has been made to arrive at an

approximation to the total amount of rain falling annually on the drainage areas of the lochs draining into the river Teith, although the available records are far from sufficient for the purpose. Dr. Alexander Buchan, F.R.S., has kindly supplied us with information regarding the readings of the rain-gauges at observing stations within, and in the vicinity of, the catchment-basins of these lochs. The positions of these rainfall stations, and the mean annual rainfall, are shown on one of the accompanying maps (see Plate III.), and further particulars will be found in the following table:—

Station.	Height of rain-gauge above sea-level.	Years observed.	Mean annual rainfall in inches.
	Feet.		
Ardlui ... ..	50	1865-70	115·10
Firkin ... ..	100	1866-79	98·38
Arrochar ... ..	15	1864-98	81·31
Head of Duchray ... ..	1800	1854-98	84·27
Glengyle ... ..	380	1854-98	92·25
Top of hill, Loch Katrine tunnel	830	1861-98	77·95
Brig o' Turk ... ..	270	1854-98	64·47
Loch Drunkie ... ..	420	1861-98	63·62
Loch Vennachar ... ..	275	1861-98	57·31
Between Ben Ledi and Glen Finlas	1800	1854-98	53·68
The Gart ... ..	230	1872-98	54·47
Leny ... ..	345	1861-98	54·23
Blaircreach ... ..	460	1893-98	82·63
Stronvar ... ..	422	1860-98	75·49
Lochearnhead ... ..	320	1866-84	65·50
Tyndrum ... ..	792	1858-61, 72-3, 76-7	99·10

Grouping these stations and their mean annual rainfall into those likely to represent the rainfall on the catchment-basin flowing out of Loch Vennachar, and those representing the rainfall on the catchment-basin flowing out of Loch Lubnaig, we arrive at an average rainfall of 76·25 inches for the Loch Lubnaig catchment, the mean height of the rain-gauges being 538 feet above the level of the sea, and an average rainfall of 75·37 inches for the Loch Vennachar catchment, the mean height of the gauges being 528 feet.

The entire catchment-basin flowing out of Loch Vennachar (*i.e.* the combined drainage-areas of Lochs Katrine, Achray, Drunkie, and Vennachar) is about 75·29 square miles, and the mean height calculated from the bulk of land above the level of the lochs is about 704·185 feet; the mean height of the surfaces of these four lochs above sea-level is 331½ feet, so that the mean height above the sea of the entire catchment is about 1035·685 feet. The entire catchment-basin flowing out of Loch Lubnaig (*i.e.* the combined drainage-areas of Lochs Voil, Doine, and Lubnaig) is about 73·39 square miles, and the mean height above the level of the lochs is about 935·129 feet; the mean height of the surfaces

of these lochs above sea-level is 412 feet, so that the mean height above the sea of the entire catchment is about 1347·129 feet.

The usual practice among engineers is to add  $2\frac{1}{2}$  per cent. of rainfall for each 100 feet of height above rain-gauges. Applying this rule to the Loch Vennachar catchment-basin, where we have an observed rainfall of 75·37 inches at an average height of 528 feet, we must add 12·7 per cent. for the additional 508 feet of mean height, making an average annual rainfall over the entire catchment of 84·94 inches. This would give an annual fall of rain on the entire catchment equal to 14,857,214,000 cubic feet. Applying this rule, in like manner, to the Loch Lubnaig catchment-basin, where we have an observed rainfall of 76·25 inches at an average height of 538 feet, we must add 20 per cent. for the additional 809 feet of mean height, making an average annual rainfall over the entire catchment of 91·5 inches. This would give an annual fall of rain on the entire catchment equal to 15,600,760,000 cubic feet.

There is another method of estimating the rainfall, without taking the mean height of the drainage-area into consideration. Supposing the usually accepted increase of  $2\frac{1}{2}$  per cent. per 100 feet of height, and also the mean annual rainfall at the average height of the rain-gauges, to be approximately correct, it is possible to calculate the rainfall at any given height. For the Loch Vennachar catchment the probable rainfall at the same heights and intervals as the contour-lines on the Ordnance Survey maps has been calculated from the starting-point of the mean of the observing stations 75·37 inches at 528 feet. Thus at the surface of Loch Vennachar the rainfall would be about 70·5 inches; at 500 feet above the sea, 75·2; at 750 feet, 79·9; at 1000 feet, 84·6 inches; and so on, adding  $6\frac{1}{4}$  per cent. for each succeeding interval of 250 feet. Multiplying the area between any two consecutive contour-lines by the mean of the two figures calculated for the same two lines should give an approximation to the amount of rain falling on that area. The result as obtained by this method for the entire catchment-basin flowing out of Loch Vennachar is given in the following table:—

				Cubic feet.	
Level of lochs to	500 feet,	16·53 square miles	×	72·8 inches	= 2,795,710,000
500 „	750 „	10·67 „	×	77·5 „	= 1,921,117,000
750 „	1000 „	10·35 „	×	82·2 „	= 1,976,514,000
1000 „	1250 „	9·46 „	×	86·9 „	= 1,909,847,000
1250 „	1500 „	10·22 „	×	91·6 „	= 2,174,874,000
1500 „	1750 „	7·86 „	×	96·3 „	= 1,758,476,000
1750 „	2000 „	5·94 „	×	101·0 „	= 1,393,784,000
2000 „	2250 „	3·06 „	×	105·7 „	= 751,422,000
2250 „	2500 „	0·99 „	×	110·4 „	= 253,917,000
Over 2500 „		0·21 „	×	115·1 „	= 56,154,000
Total ... ..					14,991,815,000

This result comes very near to that obtained from the calculation

based upon the mean height, which gave a total annual rainfall of 14,857,124,000 cubic feet.

Applying the same method to the entire catchment-basin flowing out of Loch Lubnaig, we arrive at the following result:—

				Cubic feet.	
Levels of lochs to	500 feet,	6.82 square miles	×	74.6 inches	= 1,181,982,000
500 „	750 „	7.15 „	×	77.9 „	= 1,293,991,000
750 „	1000 „	9.05 „	×	82.7 „	= 1,738,769,000
1000 „	1250 „	9.70 „	×	87.4 „	= 1,969,568,000
1250 „	1500 „	9.89 „	×	92.2 „	= 2,118,434,000
1500 „	1750 „	9.43 „	×	97.0 „	= 2,125,060,000
1750 „	2000 „	8.06 „	×	101.7 „	= 1,904,337,000
2000 „	2250 „	6.64 „	×	106.5 „	= 1,642,879,000
2250 „	2500 „	3.30 „	×	111.3 „	= 879,148,000
2500 „	2750 „	1.88 „	×	116.1 „	= 507,081,000
2750 „	3000 „	1.02 „	×	120.8 „	= 286,256,000
Over 3000 „		0.35 „	×	126.6 „	= 102,941,000
Total ... ..					15,750,446,000

Here, again, there is a close agreement between the result obtained by this method and that calculated from the mean height, which gave a total annual rainfall of 15,600,760,000 cubic feet.

A third method of estimating the amount of rain falling on any particular region is afforded by drawing lines of equal rainfall, measuring the areas between the lines, and multiplying by the mean annual rainfall. Where the lines are based upon sufficiently numerous records of rainfall at various heights, this method should give excellent results; but in the cases under discussion the number of observing stations is small, and the majority of the rain-gauges are situated on the low-lying grounds, only two being placed at heights exceeding 1000 feet, both at 1800 feet: therefore the figures obtained in these cases are most probably below the truth. Nevertheless, we have attempted to lay down the lines of equal rainfall from the available records, as shown on the accompanying rainfall map (see Plate III.). The areas enclosed by the lines of rainfall have been measured with the planimeter, and the rainfall calculated for the Loch Vennachar catchment-basin, with the following results:—

				Cubic feet.	
50 to 60 inches,	12.35 square miles	×	55 inches	= 1,578,040 000	
60 „ 70 „	28.97 „	×	65 „	= 4,374,714,000	
70 „ 80 „	18.93 „	×	75 „	= 3,298 372,000	
80 „ 90 „	8.55 „	×	85 „	= 1,688,400,000	
90 „ 100 „	4.21 „	×	95 „	= 929,166,000	
100 „ 110 „	2.28 „	×	105 „	= 556,175,000	
Total ... ..					12,424,867 000

In like manner, the rainfall has been calculated for the Loch Lubnaig catchment-basin, with the following results:—

				Cubic feet.
50 to 60 inches,	3.79	square miles	× 55 inches	= 484,272,000
60 „ 70 „	23.89	„	× 65 „	= 3,607,591,000
70 „ 80 „	21.79	„	× 75 „	= 3,796,700,000
80 „ 90 „	19.02	„	× 85 „	= 3,755,928,000
90 „ 100 „	4.41	„	× 95 „	= 973,307,000
100 „ 110 „	0.49	„	× 105 „	= 119,530,000
Total ... ..				12,737,328,000

The results obtained by these three methods may be summarized thus:—

	Vennachar catchment.	Lubnaig catchment.
First method ...	14,857,214,000	15,600,760,000
Second „ ...	14,991,815,000	15,750,446,000
Third „ ...	12,424,867,000	12,737,328,000
Mean ...	14,091,299,000 c. ft.	14,696,178,000 c. ft.

Since Loch Katrine has been made use of by the Glasgow Corporation as the source of the water-supply to that city, a record has been kept of the amount of water flowing out of Loch Vennachar—or rather, a record has been taken twice a day of the depth of water flowing over a weir at Coilantogle, from which the quantity of water discharged may be calculated. When the height of the water on the weir exceeded 5 inches, the weir became a drowned weir, so that it was difficult to estimate the outflow, as there was a considerable velocity of approach, especially during floods.

Mr. Gale has kindly supplied us with the readings, taken twice a day during the year 1869, of the depth of the outflowing water at Coilantogle, and from these figures the outflow has been estimated for that year at 9,572,000,000 cubic feet. The year 1869 was the driest year during a period of twenty-four years, and we are not satisfied that this computation can be accepted as a very correct estimate of the outflow from this catchment-basin even for that year. It would have been interesting to have calculated the outflow for twenty-five years in the same way as we have done for the year 1869, and to have taken the mean. However, accepting the above estimate for the year 1869, and adding to it the quantity of water supplied to Glasgow for that year, which, from Mr. Gale's table showing the average amount of water supplied per day during the first six months of the years 1866 and 1871, may be taken at about 1,659,300,000 cubic feet, we find that the mean rainfall exceeds the outflow in this year by

According to the first method ... ..	3,625,914,000 cubic feet.
„ „ second „ ... ..	3,760,515,000 „
„ „ third „ ... ..	1,193,567,000 „
Or a mean of ... ..	2,859,999,000 „

Leslie\* made experiments for twenty consecutive years on the

\* See *Jour. Scot. Met. Soc.*, vol. v. p. 108, 1878.

allowance to be made for absorption by vegetation and for loss by evaporation, and he calculated that the average annual amount of water absorbed and evaporated is equal to about 13 inches of rainfall. On this basis, and assuming for the present that the evaporation from the surface of the water is equal to absorption and evaporation from the land, the total amount of water lost through absorption and evaporation over the entire catchment-basin of Loch Vennachar would be about 2,273,885,000 cubic feet per annum.\* Comparing this figure with the figures given above showing the excess of rainfall over outflow, we observe that, according to the mean of the three methods, the difference between the rainfall and outflow is greater than would be accounted for by absorption and evaporation as estimated by Leslie, there being an excess according to the first two methods, and a deficiency according to the third method.

The foregoing figures, calculated for the year 1869, show that the rainfall unaccounted for by outflow at Coilantogle, and supply of water to Glasgow, is according to the first method 26 per cent., according to the second method 27 per cent., and according to the third method 8 per cent.: this percentage must be referred to loss by absorption, evaporation, and the loss of water through underground channels.

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#### NOTES ON THE GEOLOGY OF THE LOCH KATRINE DISTRICT.

By MESSRS. BEN. N. PEACH, F.R.S., and JOHN HORNE, F.G.S., from unpublished observations made during the course of the Geological Survey of Scotland. With Geological Map (Plate II.). Published by permission of Sir Archibald Geikie, D.C.L., F.R.S., Director-General of the Geological Survey of the United Kingdom.

The lochs in this district to be first treated of, with the exception of Loch Arklet, lie within the catchment-basin of the river Teith above Callander. Though situated about a mile to the west of Loch Katrine, the small lake, Loch Arklet, drains into Loch Lomond.

##### 1. *Geological Structure of the area embracing these Lochs.*

All the lochs, save the lower part of Loch Vennachar, lie within the territory of the crystalline schists of the Highlands, which are bounded along the Highland border by a powerful fault stretching from Stonehaven to the Firth of Clyde. As shown on the geological sketch-map, this dislocation extends from Aberfoil north-east by Leny to Luirgeann on the Kelty water. On the south-east side of this fault the strata

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\* The evaporation from the surface of the lakes will, of course, exceed Leslie's figures for loss through absorption and evaporation.

belong to the lower Old Red Sandstone formation, comprising, next the fault, andesitic lavas and agglomerates well seen in the Kelty water. Further to the south-east there is a broad belt of conglomerate arranged in beds, which are inverted or vertical near the fault, and as the observer approaches the plain they dip towards the south-east and pass underneath the overlying red sandstones.

On the north-west side of this great boundary fault of the Highlands there is a narrow strip of sedimentary rocks about half a mile in breadth, referred provisionally to the Arenig division of the Silurian system, and consisting of red and black shales, radiolarian cherts, limestones, and grits.

To the north of this belt of doubtful strata, the whole of the area included in the geological map accompanying this paper is occupied by rocks grouped under the general term of the crystalline schists of the Highlands. The latter are arranged in a definite order, but as yet it is uncertain whether it indicates the original sequence of deposition. The groups are here given in apparent descending order—

7. Garnetiferous mica-schists.
6. Loch Tay limestone with sills of epidiorite.
5. Mica-schists with sills of epidiorite.
4. Schistose epidotic grits ("Green Beds").
3. Ben Ledi grits, massive and sometimes schistose.
2. Aberfoil slates with subordinate bands of grit.
1. Leny and Aberfoil grit.

For a distance of about 5 miles northwards from the great boundary fault, the members of groups 1 to 4 are arranged in more or less parallel belts or strips running south-west and north-east, the strata dipping at high angles to the north-west. The groups appear in consecutive order, the Leny and Aberfoil grit being exposed immediately to the north of the doubtful Arenig rocks, while the Aberfoil slates and Ben Ledi grits appear successively to the north. The schistose epidotic grits (group 4), which lie apparently at the top of the Ben Ledi grits, are developed still further to the north, being traceable from a point not far to the south of Ben Lomond, north-east by Loch Chon and the lower part of Loch Katrine, thence across the hills to Strathyre and Loch Voil. From the Braes of Balquhidder they can be followed northwards to Glen Dochart, and they reappear in Glen Falloch in the extreme north-west part of the map. At the head of Loch Lubnaig and in the Braes of Balquhidder sills or intrusive sheets of epidiorite occur at no great distance from the "Green Beds."

In the belt between Loch Chon and Loch Lubnaig the "Green Beds," together with the Ben Ledi grits, form a series of compound synclinal folds, the strata being inclined at high angles. To the north and west of the "Green Beds" the representatives of the Ben Ledi

grits reappear and cover a wide area, extending from Ben Lomond north-east by Loch Katrine and the heights surrounding the head of Loch Voil, northwards by Ben More and westwards to Glen Falloch. Throughout this extensive area the strata are inclined at gentle angles: in marked contrast with the structure along the Highland border already indicated. There is here a change, over part of the area at least, in the lithological characters of the Ben Ledi grit group. The strata become more schistose and micaceous, merging in places into mica-schists. The accompanying geological map shows generally where these grits still retain their massive character and where they merge into mica-schists.

The outcrop of the Loch Tay limestone is indicated on the geological map, from which it will be seen that this limestone, together with the sills of epidiorite, is traceable from the upper part of Strathyre, by the Kirkton Glen, to Luib, in Glen Dochart.

In addition to the great boundary fault already referred to, separating the lower Old Red Sandstone from the crystalline schists, various faults trending N.N.E. and S.S.W. traverse the south-east part of the area under consideration. These are, in the main, branches of the great dislocation which has been traced across the Highlands for a distance of 60 miles, from Loch Vennachar by Loch Lubnaig and Loch Tay to Glen Tilt. In common with the dislocation referred to, the branch faults have a down-throw to the west or north-west, and they shift for some distance the outcrops of the strata which they traverse. They are truncated by the great boundary fault of the Highlands, and may be of pre-Old-Red-Sandstone age.

The existing valley-system of the basin of the Teith has been carved out of a table-land of crystalline schists of varying hardness. Though there is conclusive evidence of great erosion during the successive glaciations of the region, yet it is clear that the present valley-system must have been developed in pre-glacial time. There is one point connected with the geological structure of this region which has had an important bearing on the evolution of the valley-system. Along the Highland border, as already indicated, there is a great development of conglomerates, coarse pebbly grits, and greywackes, belonging partly to the crystalline schists and partly to the Old Red Sandstone. These strata, being vertical or nearly so, would be much less easily eroded than the gently inclined schistose rocks lying to the north-west. Such an arrangement would naturally lead to the formation of narrow and comparatively flat-bottomed valleys behind rocky gorges, the latter being cut through the vertical beds of hard grit and conglomerate along the Highland border. That this remarkable structure must have likewise contributed to the erosion of rock-basins during the glacial period will become apparent on a closer examination of the geological structure of the area traversed by the larger lakes.

In the case of Loch Katrine, which is the largest and deepest of the lochs under consideration, there is a great rocky barrier at its outlet due to the Ben Ledi grits. Here they form a belt over a mile in breadth, and give rise to the rugged scenery so characteristic of that region. They appear on the crags of the Trossachs at the mouth of the loch, on the crest and slopes of Ben Venue (2393 feet), on Ben Bhreac (2295 feet), and on the heights round Ben An (1326 feet). The strike of these hard and durable strata is E.N.E. and W.S.W.—that is, at right angles to the outlet of the loch, and the beds are vertical or highly inclined.

The potency of the Ben Ledi grits as a rocky barrier must have been considerably increased by the development of epidotic grits or "Green Beds" lying immediately to the north. The latter, though not so massive as the Ben Ledi grits, are hard and durable; they are repeated by a series of compound folds for nearly a mile across the strike, their northern limit being near Brenachoil Lodge. Their trend is likewise north-east and south-west, and the beds are vertical or highly inclined.

On both sides of Loch Katrine above Brenachoil Lodge the geological structure is widely different, for in this area the Ben Ledi grits, greywackes, and slates reappear in a highly schistose form, the strata dipping generally at low angles to the south-east. Over much of this region, as already indicated, the altered sediments merge into mica-schists owing to the development of mica. It is obvious that these materials would yield more readily to the agents of denudation than the massive pebbly grits of Ben Venue and the Trossachs.

Loch Achray, which lies about a mile to the east of the outlet of Loch Katrine, is only about 88 feet below the level of the latter loch. A powerful fault or dislocation, trending north-east and south-west, crosses the head of the loch near the Trossachs Hotel, which brings the massive Ben Ledi grits to the west in contact with slates to the east. It is a true rock basin which has been excavated mainly in the group of less durable slates.

Loch Vennachar is crossed by the great boundary fault, already referred to, along the Highland border, the floor of the eastern portion being composed of Old Red Sandstone conglomerate, while that of the western part is formed of grits and slates belonging to the crystalline schists. Though there is a covering of drift on both sides of the lower part of the loch, still this sheet of water forms a true rock basin, for the Old Red conglomerate is exposed in the river about 1200 yards below the outlet.

Loch Drunkie presents several interesting geological features. On referring to the map it will be seen that an arm of this loch runs nearly east and west for upwards of half a mile; the northern margin is composed of massive grits, while the southern margin and probably the floor of this branch of the loch is formed of less durable slates. Another arm of this lake runs N.N.E., in the direction of Loch Vennachar, the

eastern margin of which nearly coincides with the course of a fault that crosses Loch Vennachar to the east of Lanrick.

The three lakes, Loch Doine, Loch Voil, and Loch Lubnaig, must have formed one continuous sheet of water in post-glacial time. Loch Doine is now separated from Loch Voil by two cones of alluvium, to be referred to presently. Loch Voil is separated from Loch Lubnaig by a narrow plain of alluvium 5 miles in length, the surface of Loch Lubnaig being 9 feet lower than that of Loch Voil. These lochs form isolated parts of a true rock basin. Below the outlet of Loch Lubnaig there is a prominent rocky barrier composed of the massive grit of Leny and Aberfoil, from half to three-quarters of a mile in breadth. The strike of this pebbly grit is north-east and south-west, and the beds are inclined to the north-west at high angles.

Loch Lubnaig is traversed by several faults, to which special reference will be made in the sequel. The lower part of the loch coincides with the trend of two faults, which, in all likelihood, determined for some distance the course of the river in remote geological time.

## 2. *Glaciation.*

The glacial phenomena in the lake district of the basin of the Teith prove beyond doubt that, during the climax of the ice-age, the ice-sheet lay to the north of the area now under consideration; that the ice-movement was more or less independent of the existing valley-system; and that even the highest mountains were over-ridden by the ice. This great development was followed by a period of local glaciation, when the glaciers were confined mainly to the existing valleys, and when the boulder-clay or ground-moraine of the earlier period was largely removed. The upper limit of the valley glaciation is frequently defined by prominent lines of moraines strewn with boulders, which rise to a considerable height on the mountain-slopes. The evidence pointing to these conclusions may now be briefly summarized.

On the watershed to the north of Lochs Doine and Voil, the trend of the ice-movement during the great glaciation, as proved by the striæ, was S.S.E. Again, on the lofty watershed east of Loch Lubnaig and south of Loch Earn, between Ben Each (2660 feet) and Ben Vorlich (3224 feet), there is conclusive evidence that the highest mountains in that part of the lake district were overridden by the ice. There the mountains are composed of grits, and the striæ are well preserved. On Ben Each the striæ point S.E.; on the col between that hill and Stuc a Chroin, S. 40° E.; on the latter mountain about S.E., and on the slopes of Ben Vorlich, at a height of 2500 feet, the trend of the ice-markings is E. 40° S. In the tract between Loch Lubnaig and Loch Katrine similar evidence is obtained of a south-easterly movement at great elevations. For example, on Ben Vane (2685 feet), at a height of 2642 feet, the

striæ point S.  $15^{\circ}$  to  $20^{\circ}$  E.; on the north and west slopes of Ben Ledi, S.  $35^{\circ}$  E., and on the crest of that mountain, at a height of 2875 feet, the direction is S.E. In like manner the mountains guarding the outlet of Loch Katrine are glaciated to the summit. Striæ occur on the top of Ben Venue at a height of 2386 feet, pointing S.  $40^{\circ}$  E.; on Ben An, at an elevation of 1750 feet, E.  $30^{\circ}$  S.; and on Ben Bhreac, to the west of Ben Venue, the direction of the ice-markings is S.  $30^{\circ}$  to  $40^{\circ}$  E. Again, on the watershed between Loch Voil and Loch Katrine, the evidence indicates a south-easterly movement during the great extension of the ice. For instance, at various points on Taobh na Coille, at elevations between 2000 and 2250 feet, the striæ point S.  $30^{\circ}$  E., and on Meall Gaothach, S.  $30^{\circ}$  E. In the tract immediately to the south-west of Loch Katrine the trend of the ice-markings varies from S.S.E. to E.S.E. For example, on Maol Mor (2249 feet) about the 2000-foot contour-line, to the north of Loch Arklet, the direction is about S.  $15^{\circ}$  E.; and on the crest of Ben Uaimhe, to the south of that loch, S.  $10^{\circ}$  to  $15^{\circ}$  E. Eastwards, throughout the tract between Loch Chon and the Trossachs, the trend is E.S.E. To the south of the lofty heights stretching from Ben Venue towards Ben Ledi, the direction of the striæ is more easterly, thus showing that the ice, after crossing the high ground, was deflected more towards the east (see glacial striæ on Plate II.).

The general south-easterly movement of the ice during the great glaciation, throughout the lake district of the basin of the Teith, is confirmed by the dispersal of stones in the boulder-clay, and by the transport of erratics. Many of the boulders have been carried far from their source, and are now found on the tops of the highest mountains of the district, some even at greater elevations than the parent rock.

To the east of Loch Lubnaig, on Ben Vorlich, at a height of 3000 feet boulders of garnetiferous mica-schist are found resting on glaciated surfaces of pebbly grit. Again, on the same mountain, at a similar elevation, there are erratics of epidiorite and hornblende schist—rocks which are associated with the Loch Tay limestone, and which must have been transported from lower ground to the north. Similar boulders are met with on Stuc a Chroin and on Ben Each. Again, in the boulder-clay on the slopes of Ben Ledi, blocks of hornblende schist occur, which must have been transported for some distance. On the south side of Loch Katrine, between Stronachlachar and the aqueduct of the Glasgow waterworks, boulders of quartzite and garnetiferous mica-schist, which are foreign to the basin of Loch Katrine, are found in the boulder-clay. Eastwards near Brenachoil Lodge, on the north side of Loch Katrine, there are blocks of black schist, like that which accompanies the quartzite of central Perthshire, and which has not been detected within the catchment-basin of Loch Katrine. These examples are sufficient to prove that, during the climax of the glacial period,

the ice-movement was independent of the existing valley-system. Indeed, from the evidence furnished by the striæ and the transport of boulders, it may be inferred that the minimum thickness of the ice-sheet during this period must have been not less than 3000 feet in the lake district of Perthshire.

The boulder-clay or ground-moraine, which was laid down during the great glaciation, must have been extensive, for it is found at great elevations, and it sometimes attains a great thickness. For instance, in the lee of the ridge of Ben Vane, to the west of Loch Lubnaig, it reaches a height of 2290 feet, and in places it is over 100 feet thick. But a large part of this deposit was removed during the later glaciation by the valley glaciers, for the relics occur above the limits of the valley-moraines, the latter resting frequently on the solid rock.

Only a brief allusion is necessary to show the development of the later glaciers. The striæ produced by this later movement coincide generally with the trend of the existing valleys. But though this is true, there is evidence to prove that even the larger valley-glaciers were thick enough to overflow minor watersheds. For instance, the glacier which descended the basin of Loch Katrine was thick enough to override the low col between that loch and Loch Chon, while another branch passed westwards by Loch Arklet towards Loch Lomond. Another example of the same phenomenon might be quoted. The glacier which descended the basin of Loch Voil towards Loch Lubnaig was thick enough to overflow the col between Strathyre and Loch Earn, while another branch ascended Glen Buckie and joined the Loch Lubnaig glacier at Laggan.

Moraines are well developed in most of the valleys, and are frequently arranged in concentric lines, as in Glen Finglas, north of Brig o' Turk. On the south side of Loch Katrine, between the jetty and Glasahoile, the moraines are distributed in parallel lines along the shore of the lake. As already indicated, the upper margins of the valley-glaciers are defined by the moraines.

### 3. *The Soundings viewed in Relation to the Geological History of the Area, and with reference to the Origin of the Lakes.*

*Loch Doine, Loch Voil, and Loch Lubnaig.*—Reference has already been made to the fact that, in post-glacial time, Loch Doine, Loch Voil, and Loch Lubnaig must have formed one continuous sheet of water, and that their subsequent isolation has been due to the deposition of sediment.

Loch Doine has been separated from Loch Voil by alluvial cones laid down by two streams, one from the north at Monachylemore, and another from the south at Monachyle Tuarach. The 50-foot subaqueous line has been traced round the Loch Doine basin, and the deepest sound-

ing is 65 feet. At the head of this loch there is an alluvial flat that stretches westwards for  $1\frac{1}{2}$  miles, formed by the Lochlarig river and its tributaries. The gradual silting up, which is in constant progress at the head of Loch Doine at the mouths of the Lochlarig river and Allt Carnaig, is well shown by the resultant curve in the 50-foot contour-line.

That Loch Voil is merely a continuation of the Loch Doine basin is further proved by the soundings, for immediately to the east of the cones just referred to, the 50-foot contour-line is met with, and has been traced round both sides of the loch eastwards to about Ledereich—a distance of about 2 miles. From this point eastwards the lake gradually shallows towards the alluvial flat at Balquhidder, where moraines occur within 400 yards of Kirkton and Stronvar Bridge. The deepest part of the lake is enclosed by the 90-foot contour-line at the head of the loch near Monachylebeg, and the deepest sounding within this line is 98 feet.

The trend of Lochs Doine and Voil roughly coincides with the strike of the crystalline schists in that district. It is oblique—indeed, nearly at right angles—to the movement of the great ice-sheet during the climax of glacial conditions, and it harmonizes with the course of the later valley-glacier. Several small faults occur on the Braes of Balquhidder, north of Loch Voil, and on the hill-slope south of Loch Doine, but these are of little structural importance.

The long stretch of alluvium that separates Loch Voil from Loch Lubnaig has been laid down by the Calair burn in Glen Buckie, by the Kirkton burn at Balquhidder, and by various streams on both sides of Strathyre. The silting up now in progress at the head of Loch Lubnaig is well shown by the tongues of alluvium, on both sides of the Balvag river, that project for some distance into the loch and isolate small basins of fresh water. About half a mile north of Loch Lubnaig a moraine rises out of the alluvium, probably a fragment of the adjacent moraine on both sides of the valley. As the top of this moraine probably rose above the level of the ancient united lake, the depth of the latter near this locality could not have been very great.

A glance at the chart of Loch Lubnaig will show that its floor is much more irregular than that of Loch Voil. This may be accounted for partly by the presence of alluvial cones formed by various streams, and by features connected with the geological structure of the basin.

The deepest parts of this lake form two basins enclosed by the 100-foot contour-line, one to the north and the other to the south of Ardchullarie More. The upper one, about 500 yards long, is 146 feet deep, and the lower one, about 900 yards long, is 108 feet in depth. Though now separated by alluvial detritus brought down by the Ardchullarie burn from the north-east, and by the Dubh Shruith burn from the south-west, these basins were probably originally continuous. The powerful Loch Tay fault with a N.N.E. and S.S.W. course, and with a downthrow to the west, crosses Loch Lubnaig immediately to the south

of Ardochullarie More, and strikes the west margin of the lake near the spit of sand to be referred to presently (see Plate II.). The steep gradient on the west side of the lake to the north and south of this spit of sand coincides with the course of the Loch Tay fault. About a quarter of a mile to the west of the Loch Tay fault a minor dislocation, with a similar trend and downthrow, crosses the lake and follows the channel of the Dubh Shruith burn. Now the lower deep basin lies to the east or upthrow side of the Loch Tay fault, and the upper deep basin is on the west or downthrow side of the Dubh Shruith fault. These dislocations doubtless produced brecciation of the strata along the lines of movement, which led to more rapid disintegration of the materials.

Close to the north-west limit of the upper basin enclosed by the 100-foot contour-line the loch shallows to 20 feet, and from thence north-westwards to a point opposite Bienacreag the depth increases to 62 feet. Here there is a small basin enclosed by the 50-foot contour-line.

At the lower end of the loch, on the east side, there is a steep gradient which coincides with a line of fault, having a downthrow to the west (see Plate II.). As already indicated, this dislocation together with the Loch Tay fault may have determined in part the course of the river in remote geological time. But an impartial consideration of the evidence furnished by the soundings shows that the faults cannot account for the erosion of the lake basin. The striking fact that the lower deep basin of Loch Lubnaig coincides with the upthrow side of the Loch Tay fault—the most powerful dislocation traversing the crystalline schists of this area—shows that this rock-basin must be ascribed to an erosive agent acting independently of the lines of fault. It has further been shown that Lochs Voil and Doine must have been originally continuous with Loch Lubnaig. The deepest sounding in Loch Voil is 98 feet, and in Loch Lubnaig 146 feet, and it is obvious that their erosion must be ascribed to a common cause. The upper part of Loch Lubnaig coincides roughly with the trend of the ice-sheet during the great glaciation, which, from the evidence adduced in the foregoing pages, must have attained a minimum thickness of 3000 feet. But the basin must have undergone further erosion by the large valley-glacier.

About half a mile to the south of Ardochullarie More, on the west margin of Loch Lubnaig, there is a prominent spit of sand extending into the lake for about 100 yards. It occurs not far to the south of the bend in the lake, at the meeting-point of the waves produced by the prevalent westerly winds. By the action of the waves the sand is steadily borne outwards on both sides of the spit, and from the soundings it is clear that this feature projects far into the lake. Further, it must have been in process of formation when the loch stood at a higher level, for a section appears in the adjacent railway cutting, which shows the sloping layers of sand coinciding with the form of the spit.

Loch Lubnaig originally extended to a point below Coireachrombie, about three-quarters of a mile below its present outlet. This point has been silted up by the detritus laid down by the Stank and Anie burns. The original southern termination of the lake touched the rocky barrier formed by the Leny grit. It is worthy of note also, that the level of Loch Lubnaig has been lowered about 20 feet by the denuding action of the river Leny.

*Loch Katrine.*—For a distance of 4 miles, west from Brenachoil Lodge to Stronachlachar—about the half of the total length of the loch—this lake has a comparatively flat bottom, enclosed by the 400-foot contour-line. The deepest sounding in Loch Katrine, 495 feet, is at the eastern limit of this basin, nearly due south of Brenachoil. The chart shows that the soundings throughout this basin gradually increase in depth eastwards to Brenachoil Lodge. The position of the deepest sounding is of interest, seeing that the strata which form the floor of the lake at this point consist of schistose micaceous grits, to the north-west of the epidotic grits (“Green Beds”) and the Ben Ledi grits, the two latter groups having formed the great rocky barrier at and above the outlet of the lake.

Near the upper end of the loch a rocky barrier crosses the lake from Portnellan by the Black island to Rudha Maoil Mhir an-t Salainn. The deepest sounding along this barrier is 90 feet, and the shallowest is 48 feet. On its lower side the 100-foot contour-line well-nigh crosses the lake. Above it there is another basin over half a mile in length, the greatest depth of which is 128 feet, immediately in front of the rocky ridge just referred to. Westwards the lake shallows, and at its head it has been silted up for a distance of half a mile by the alluvium laid down by the Gyle river.

Below Brenachoil Lodge the soundings show an uneven floor, due probably to ridges of rock rather than to morainic deposits, if we may judge from the geological features on both sides of the lake. Ellen’s isle is composed of epidotic grits (“Green Beds”), and the promontories of Am Priosan partly of “Green Beds” and partly of Ben Ledi grits. The promontory between the pier and the sluice is formed of Ben Ledi grits.

During the geological survey of that region several small faults were found to cross Loch Katrine, but these are of minor importance, and have produced locally a slight brecciation of the strata. It is a typical example of a rock basin. The deepest sounding occurs in the front of the great rocky barrier in the lower part of the lake, in accordance with what we might naturally expect on the theory of glacial erosion. Though the soundings prove the deepest part of the lake to be 131 feet below sea-level, yet this depth is in proportion to the vast thickness of the ice during the successive glaciations of the basin.

*Loch Achray.*—This lake forms one basin, the deepest part being

enclosed by the 90-foot contour-line, and the deepest sounding being 97 feet. A fault, with a downthrow to the west, crosses the head of the loch at the Trossachs Hotel, which has produced considerable brecciation of the strata, a feature probably continued along the floor of the loch between the hotel and Achray. The greater part of this lake is on the upthrow side of the fault just referred to, and the basin, as already indicated, has been excavated mainly in slates.

*Loch Vennachar.*—Between Loch Achray and Loch Vennachar there is a strip of alluvium, the difference in level between the two lakes being 6 feet. The successive terraces show that these two lakes originally formed one sheet of water, which stood at a somewhat higher level. Loch Vennachar contains one prominent basin, about 2 miles in length, enclosed by the 50-foot contour-line. Within this limit there are two smaller basins, which fall below the level of the 100-foot contour-line (see Plate V.). The deepest sounding is 111 feet, which occurs to the north-east of Invertrossachs, on the line of the great boundary fault along the Highland border, which has a downthrow to the south-east. West of this dislocation the floor of the lake rises sharply to a level of 20-feet below the surface. Westwards, however, near Lanrick, the depth increases to 50 feet, a feature which coincides with the course of two faults crossing the loch—branches of the Loch Tay fault, and each having a similar downthrow to the west. Doubtless where the deep soundings coincide with lines of fault, the strata have been much shattered and crushed, which has led to the more rapid disintegration of the materials. But though these faults may have led to local modifications of the floor of the lake, they obviously do not account for the excavation of the basin. The long, narrow hollow, crossing obliquely these lines of dislocation, points to glacial erosion.

*Loch Drunkie.*—Reference has already been made to the geological features of this basin (see p. 42). In the western portion of the west branch, where the hollow has been scooped out of slates, a small part of the floor is enclosed within the 50-foot contour-line. The deepest sounding, 97 feet, occurs in the north branch of the lake in front of a ridge to the east, which rises to a height of about 150 feet above the loch. The direction of the striæ at Loch Drunkie is E. 20° S., and the deepest sounding is found where the erosion must have been greatest.

*Loch Arklet.*—This lake lies across the path of the great ice-sheet, and coincides with the trend of the later movement (see pp. 44 and 45). Both the north and south shores of this loch are surrounded by moraines, but though such is the case the stream flows over solid rock, where it leaves the alluvial flat  $1\frac{1}{2}$  miles west of the outlet, and continues to flow for half a mile over solid rock. Originally the lake must have extended westwards to this barrier, for the intervening strip of alluvium has been laid down by the burns joining the Arklet water not

far from the outlet. On this flat there are moraines rising up in the midst of the alluvium. The greatest depth of the loch is 67 feet. At the upper or east end, where the loch is shallow, two islets appear, one formed of solid rock and the other of moraine matter.

The soundings of the various lakes in the basin of the Teith above Callander, when viewed in connection with the geological structure and glacial phenomena of that area, furnish strong evidence in support of the theory of their excavation by ice-action. It is probable that, though the lakes lie, as a rule, across the path of the great *mer de glace*, they may have been partially eroded by that ice-sheet; at the same time there can be little doubt that their final modification must have been produced by the large valley-glaciers.

The other lochs surveyed may be briefly characterised as follows:—

*Loch Chon.*—Loch Chon is a striking example of a rock basin. The upper portion of the lake is floored by mica-schists, and the lower portion by the Ben Ledi grits and schistose epidotic grits ("Green Beds"), the members of the two latter groups being repeated by sharp folds. The trend of the loch—N.N.W. and S.S.E.—is oblique to the strike of the strata. At the head of the lake there is a broad alluvial flat, where it has been silted up for a distance of one-third of a mile by the detritus laid down by the adjacent streams. In the northern part of the basin the deepest soundings vary from 33 to 37 feet; but at a point about half a mile below the present head of the lake the depth increases from 40 to upwards of 60 feet. This feature coincides with a line of fault that crosses the loch in a north-east and south-west direction, its downthrow being to the south-east. From this point southwards for half a mile there is a narrow basin enclosed within the 50-foot contour-line, and within this basin there is a narrow trough, about 100 yards long and upwards of 75 feet deep, near the west margin of the lake. There is ground for the belief that nearly the whole of the basin bounded by the 50-foot contour-line is floored by mica-schist.

About a mile below the head of the lake the soundings prove a remarkable decrease in the depth, the 25-foot contour-line near the Heron islands being deflected towards the centre of the loch. The shallowing of the basin here takes place along the outcrop of very massive epidotic grits ("Green Beds"), several glaciated rocky islands appearing along this line. Southwards to the mouth of the lake there are alternations of Ben Ledi grits and schistose epidotic grits, the narrowest parts of the lake coinciding with the exposures of the latter group.

About 100 yards below the outlet of the lake a prominent band of schistose epidotic grits occurs, which evidently formed a rocky barrier during the glaciation of that region. Beyond this outcrop there is a

small shallow basin, about 41 feet deep (Lochan Dubh), floored by schistose grits, which is traversed by a fault trending north-east and south-west, with a downthrow to the east. Across the mouth of this basin a band of massive, pebbly grits of the Ben Ledi type has been traced.

A reference to the geological map will show that the direction of the ice-flow during the great glaciation coincides generally with the trend of the loch, striæ being found on the rocky islands as well as round the margin of the lake. The evidence supplied by the soundings tends to support the theory that the basin-shaped hollow has been eroded by ice-action. The dislocations referred to above have doubtless produced local modifications of the floor of Loch Chon and of that of the small basin (Lochan Dubh), but they do not account for the excavation of the basin.

*Loch Ard.*—Loch Ard is also a true rock basin, which lies along the outcrop of a belt of slates between two bands of grit, the deepest part of the loch, as proved by the soundings, coinciding with the outcrop of the slates.

From the Mill of Chon downwards to the head of the lake there is a small alluvial flat pointing to the former extension of the loch in that direction. At the upper end the soundings show that the average depth is 25 feet, with the exception of one small depression opposite Ledard burn, reaching 57 feet in depth. Eastwards, where the loch becomes narrower, the depth increases. The basin enclosed by the 50-foot contour-line is  $1\frac{1}{2}$  miles long, while that surrounded by the 100-foot contour-line is three-quarters of a mile in length, the deepest sounding being 107 feet.

The dislocation, with a downthrow to the east, that crosses the loch in line with Allt-na-Sgéith in a north-east and south-west direction has not produced any local modification of the floor of the lake, if we may judge by the soundings. The 100-foot basin crosses this fault without any apparent increase in depth on the side of the downthrow, which is probably due to the fact that the dislocation brings slates into contact with slates. The band of massive grit which forms for a long distance the southern margin of the loch evidently acted as a barrier during the period of glacial erosion. Crossing the lake at Briedach, this band of grit forms the promontory south-east of Glashart.

On referring to the geological map, it will be seen that the band of grit just described is followed southwards by slates, the outcrop of which coincides with an expansion of the loch at its outlet, the deepest sounding being 52 feet. About 600 yards to the east of the outlet the trend of the latter belt of slates is E.N.E., and here occurs another small basin upwards of 30 feet in depth.

No ice-markings have been found round the margin of the loch or near it; but about half a mile to the south of the upper end of the lake

the direction of the striæ is E. 20° S., which coincides generally with the long axis of the loch. Reference has already been made to the more easterly movement of the ice as it left the mountainous region and approached the low-lying districts; the course of Loch Ard coincides with this easterly trend of the ice.

From the evidence adduced it is obvious that the geological structure of the basin of Loch Ard has had an important influence in the development of its present features, the latter being adequately explained by the theory of glacial erosion.

The Lake of Menteith lies in various superficial deposits, composed partly of boulder-clay and stratified beds of the 100-feet beach. It is within the area occupied by the Old Red Sandstone, and the solid rock is visible only at one locality, at Coiledon. Loch Leven likewise lies in superficial deposits.

## LOCHS OF THE TAY BASIN.

*Extent of the Tay Basin.*—The whole area of the drainage basin of the Tay, including the estuary as far as a line joining Tents Muir Point with Monifieth, as measured with the planimeter on the 1-inch Ordnance Survey maps, is 2509.73 square miles.\* Considerably more than one-fourth of this area drains directly into fresh-water lochs, of which there

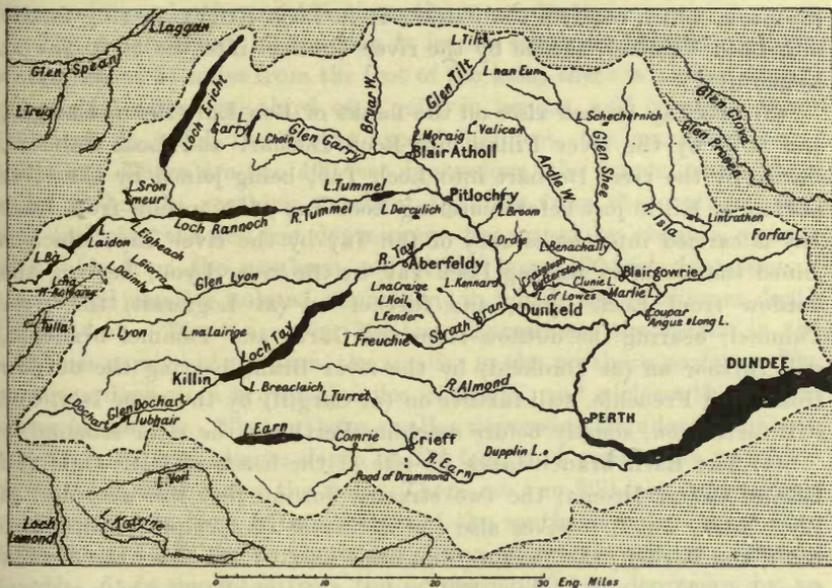


FIG. 14.—INDEX MAP OF THE TAY BASIN.

are seventy, including some of the largest in Scotland—Lochs Tay and Erich, for instance, being over 14 miles in length, while eight of them exceed 2 miles in length.

\* Geikie (*An Elementary Geography of the British Islands*, London, 1888, p. 86) gives the drainage basin of the Tay as 2250 square miles and Lawson (*The Geography of River Systems*, London, N.D., p. 6) as 2400 [square] miles. According to Geikie, the Tay pours a larger volume of water into the sea than any other British river, and its drainage area is the largest in Scotland, and seventh in point of size in the British Islands, being exceeded by that of the Shannon in Ireland, the Thames, Severn, Ouse, Trent, and Great Ouse in England.

The river-systems, which arise in the most mountainous and magnificent regions of Scotland, may be divided into four principal branches, viz., the Garry branch (the most northerly), the Tummel branch, the Tay branch, and the Earn branch (the most southerly).

(1) The Garry branch rises on the flanks of Beinn Mholach, Beinn Bhoideach, and Carn Beag an Laoigh, flowing by various streams into Loch Garry, thence by the river Garry into the river Tummel at Faskally, to the north-west of Pitlochry, receiving the waters of the Erochy at Struan, and those of the Tilt at Blair Atholl.

(2) The Tummel branch rises in the Black Mount, the westernmost of the sources of the Tay river-systems, flowing by the river Bà into Loch Buidhe, Lochan na Stainge, and Loch Bà, which receives the outflow from Lochan na h-Achlaise, thence flowing into Loch Laidon, thence into Loch Eigheach—an expansion of the river Gaur—receiving the waters from Lochan Sròn Smeur, and then flowing into Loch Rannoch, which receives the outflow from Loch Ericht, flowing finally into Loch Tummel, thence by the river Tummel into the river Tay at Logierait.

(3) The Tay branch rises on the flanks of Ben Lui (Beinn Laoigh), and flows by the river Fillan into Loch Dochart and Loch Iubhair, thence by the river Dochart into Loch Tay, being joined by the river Lochay at Killin just before entering Loch Tay; the outflow from Loch Tay is carried into the estuary of the Tay by the river Tay, which is joined shortly after leaving Loch Tay by the river Lyon, bearing the outflow from Loch Lyon, and further on (at Logierait) the river Tummel, bearing the outflow from the Garry and Tummel branches, still further on (at Dunkeld) by the river Bran, bearing the outflow from Loch Freuchie, still further on (at Cargill) by the river Isla, and still further on, shortly before reaching Perth, by the river Almond.

(4) The Earn branch takes its rise at the heads of Glen Ogle and Gleann Ceann Droma, the two streams flowing into the west end of Loch Earn, which receives also the waters of the Ample burn, Beich burn, the Vorlich, the Tarken, and other smaller streams; the outflow from Loch Earn passes at St. Fillans into the river Earn, which receives the waters of the Ruchill and Lednock near Comrie, those of the Turret bearing the outflow from Loch Turret, near Crieff, and other smaller streams as it flows eastward to join the Tay at the head of the estuary.

*Loch Ericht* (see Plates XII. and XIII.).—Loch Ericht is a large Highland loch situated partly in Perthshire and partly in Invernessshire, at a high elevation among the Grampians. It is one of the wildest and most magnificent lochs of Scotland, presenting all along its shores scenes of lonely grandeur and sublimity, the mountains rising from the water's edge to great altitudes, their sides scarred by mountain torrents. The surface, when measured by the Ordnance Survey officers in 1872,

was found to be 1153·4 feet above the level of the sea; it is thus one of the most elevated of the larger Scottish lochs. It is known to anglers as the home of large *Salmo ferox*, as well as of trout said to be equal in quality to those of Loch Leven. It trends in a north-east and south-west direction, and is broadest near the southern end, narrowing gradually towards the northern end. It is over  $14\frac{1}{2}$  miles in length, and over one mile in maximum breadth; the mean breadth is about half a mile, being  $3\frac{1}{2}$  per cent. of the length. Its waters cover an area of over 4600 acres (or nearly  $7\frac{1}{4}$  square miles), and it drains an area seven times greater, or over 32,000 acres (nearly  $50\frac{1}{2}$  square miles). The total number of soundings taken in Loch Ericht was 488, which show that it is a comparatively deep loch, the greatest depth observed being 512 feet. The mass of water contained in the loch is estimated at 38,027,000,000 cubic feet, and the mean depth at 189 feet, being 37 per cent. of the maximum depth. The length of the loch is 150 times the maximum depth, and 405 times the mean depth.

The deepest part of the loch is in the southern broader portion, where, about  $3\frac{1}{2}$  miles from the foot of the loch, there is a small central depression, about one-third of a mile in length, and covering about 58 acres, in which the depths exceed 500 feet, the maximum being 512 feet. There are two 400-foot depressions, the larger, about three miles in length, reaching to about  $1\frac{1}{2}$  miles from the southern end, and enclosing the 500-foot depression. Separated by about a quarter of a mile from the northern end of the large 400-foot depression is the second smaller isolated depression, in which the maximum depth is 410 feet. There are two 300-foot depressions, the larger in the southern portion of the loch, the smaller in the northern portion. The southern depression is over  $4\frac{1}{2}$  miles in length, and encloses the deepest water in the loch. The northern smaller depression is under one mile in length, with a maximum depth of 314 feet, and approaches to within  $2\frac{1}{2}$  miles of the head of the loch. There are two 200-foot depressions; the larger runs from within a mile of the southern end to more than half-way towards the northern end, being over seven miles in extreme length. It is separated from the northern 200-foot depression by an interval of  $2\frac{3}{4}$  miles, in which the depth varies from 127 to 194 feet. The northern 200-foot depression is nearly  $2\frac{3}{4}$  miles in length, approaching to within about  $1\frac{1}{4}$  miles from the northern end, and enclosing the small northern 300-foot depression already mentioned. The 100-foot depression is a continuous area extending from within less than half a mile of the southern end to within less than a mile of the northern end, and is about  $13\frac{1}{4}$  miles in total length. The 50-foot depression follows approximately the contour of the loch. Opposite Loch Ericht Lodge an isolated sounding of 44 feet was observed between the 50- and 100-foot lines, and about  $1\frac{1}{2}$  miles farther down, opposite the entrance of the Allt Càmus nan Cnàmh, another isolated sounding of 20 feet was taken, surrounded by deeper water.

The area of the bottom of the loch between the shore and the 50-foot line is estimated at about 880 acres (or 19 per cent. of the total area of the loch), that between the 50-foot and 100-foot contours is estimated at 695 acres (or 15 per cent.); that between the 100- and 200-foot contours is estimated at about 1160 acres (or 25 per cent.); that between the 200- and 300-foot contours at about 875 acres (or 19 per cent.); that between 300 and 400 feet at 476 acres (or over 10 per cent.); that between 400 and 500 feet at about 474 acres (or over 10 per cent.); and that over 500 feet at 58 acres (or  $1\frac{1}{4}$  per cent.).

It will thus be seen that Loch Ericht is of very simple conformation. The deeper parts are divided into two basins, by the constriction in the outline of the loch in the vicinity of Loch Ericht Lodge, where, in one place, it is less than a quarter of a mile in width, but even here the depth in the centre exceeds 100 feet.

*Deposits.*—The deposits from Loch Ericht are interesting because of the evidence of layers of different colours. At a depth of 50 feet a red sandy mud was obtained; at 112 feet the mud was white beneath and brown on top; at 124 feet it was all brown; at 153 feet all brown; at 182 feet sandy and white; at 184 feet white and brown; at 245 feet the deposit was a light-coloured mud, with a thin brown layer one inch in thickness on the top; at 270 feet it was white below, black-brown above; at 366 feet the mud was all dark brown; at 385 feet there was a white clay or mud with a dark layer on the top; at 456 feet the mud was all black; at 497 feet a section of black mud 5 inches in thickness was obtained; and at 510 feet the same black mud was found, without any trace of the lighter-coloured mud.

The sand from 50 feet consisted largely of mineral particles (probably 70 per cent. of the whole deposit) with a mean diameter of about 0.6 mm., one or two rock fragments attaining a diameter of 7 mm. The remainder of the deposit consisted of clayey and vegetable matter, with minute mineral particles less than 0.05 mm. in diameter, Diatoms, Sponge spicules, and Entomostracous skeletal remains. The light-brown mud from 150 feet contained about 30 per cent. of mineral particles, with a mean diameter of 0.5 mm., the largest being 5 mm. in diameter, with clayey and vegetable matter, and organic remains as previously mentioned. The dark-brown mud from 366 feet contained only about 10 per cent. of mineral particles (quartz, black and white mica, &c.) exceeding 0.05 mm. in diameter, the mean diameter being about 0.2 mm. Samples of the two different-coloured layers of mud from a depth of 385 feet were submitted to analysis, with the following results:—

		Bottom layer.	Top layer.
Organic matter	... ..	10.00 per cent.	26.8 per cent.
Insoluble residue	.. ..	73.70 ,,	57.6 ,,
Iron oxide	... ..	13.64 ,,	17.2 ,,
		<hr/>	
		97.34	101.6

These analyses seem to show that the upper layer contained more organic matter (presumably vegetable matter) and a little more iron than the lower layer. Microscopic analysis of the two layers indicates that the mineral particles were rather more numerous and larger in the top layer, while the clayey matter seemed to be more abundant in the lower layer.

*Loch Garry* (see Plate XV.).—Loch Garry\* lies to the east of Loch Ericht, at a still higher elevation, and the scenery round about is very wild; the height of the surface of the loch above sea-level is not given on the Ordnance Survey map, but a height of 1326 feet is shown near the outlet, so that the level of the loch is probably about 1320 feet above the sea. In trend and in outline it somewhat resembles Loch Ericht, narrowing towards the northern end. It is over  $2\frac{1}{2}$  miles in length, the maximum width being over a quarter of a mile; the mean breadth is slightly under a quarter of a mile (being 9 per cent. of the length). Its waters cover an area of about 390 acres (three-fifths of a square mile), and it drains an area thirty-seven times greater (or about  $22\frac{1}{2}$  square miles). The total number of soundings taken in Loch Garry was 141, the maximum depth observed being 113 feet. The mass of water contained in the loch is estimated at about 846,000,000 cubic feet, and the mean depth at nearly 50 feet (being 44 per cent. of the maximum depth). The length of the loch is 119 times the maximum depth, and 260 times the mean depth.

Loch Garry forms a simple basin, except that the bottom sinks into two depressions exceeding 100 feet in depth, separated by depths of 82 to 93 feet. The larger but shallower depression is situated in the southern half of the loch, and is over a quarter of a mile in length, the maximum depth therein observed being 105 feet. The smaller but deeper depression is situated in the northern half of the loch, being only about one-sixth of a mile in length, and containing the maximum depth of the loch—113 feet. The 75-foot, 50-foot, and 25-foot depressions form continuous areas, following approximately the outline of the loch. The 75-foot depression is nearly  $1\frac{3}{4}$  miles in length, the 50-foot depression nearly 2 miles in length, and the 25-foot depression  $2\frac{1}{8}$  miles in length.

The area of the bottom between the shore and the 25-foot contour-line is about 117 acres (or 30 per cent. of the total area of the loch); that between the 25- and 50-foot contour-lines is about 83 acres (or 21 per cent.); that between 50 and 75 feet is almost the same; that between 75 and 100 feet is about 87 acres (or 22 per cent.); and that over 100 feet is about 19 acres (or 5 per cent.).

*Temperature Observations.*—The serial temperatures taken while sounding out Lochs Ericht and Garry in June, 1900, are given in the

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\* This loch must not be confounded with the larger Loch Garry in Inverness-shire.

following table, and those taken in Loch Ericht are shown graphically in the temperature section (Plate XIV.), since they are extremely interesting as illustrating the effect of the wind upon the distribution of temperature:—

Depth in feet.	Loch Garry.	Loch Ericht.					
	June 21, 1900.	June 19, 1900, $\frac{1}{2}$ mile from S. end.	June 20, 1900, $1\frac{1}{2}$ miles from S. end.	June 20, 1900, $3\frac{1}{2}$ miles from S. end.	June 16, 1900, $9\frac{1}{2}$ miles from N. end.	June 15, 1900, $5\frac{1}{2}$ miles from N. end.	June 20, 1900, 1 mile from N. end.
0	57·0	47·3	49·0	50·0	50·0	53·2	55·1
5	...	47·0	48·7	49·7	...	...	...
6	...	...	...	...	50·0	...	...
10	56·9	47·2	47·8	49·5	...	...	...
25	...	...	...	...	49·9	...	...
30	49·5	46·1	47·5	48·6	...	...	54·2
40	...	...	...	45·8	...	...	...
50	...	44·6	44·7	44·7	44·8	...	52·3
60	46·3	43·4	...	...	...	...	...
75	...	42·6	43·2	...	...	...	44·0
98	...	...	...	...	...	41·5	...
100	...	42·2	...	42·9	42·6	...	...
105	46·0	...	...	...	...	...	...
120	...	...	...	...	...	...	42·7
150	...	41·3	...	...	...	...	...
200	...	...	...	41·0	41·1	...	...
300	...	...	...	40·7	40·5	...	...
400	...	...	...	40·5	40·5	...	...
500	...	...	...	40·5	...	...	...

*Loch Ericht.*—Like Loch Katrine, Loch Ericht is said never to freeze over, and the surface temperature remains comparatively low throughout the summer. The surface temperatures taken in Loch Ericht during the visit from 15th to 20th June show a range of  $10^{\circ}\cdot4$ , viz., from  $46^{\circ}\cdot6$  to  $57^{\circ}$ ; the higher temperatures were obtained towards the northern end of the loch, and the lower temperatures towards the southern end of the loch. A glance at the temperature section (Plate XIV.), based upon the observations given in the table, shows that the warmer water was all collected towards the upper end of the loch, as the result of a south-easterly wind which blew at times during the six days that were devoted to the survey of the loch, colder water having been drawn up at the opposite end of the loch to supply the place of the warmer surface water driven before the wind.

*Loch Garry.*—Loch Garry was visited on the 21st June, 1900, when the surface temperature was found to vary from  $57^{\circ}$  at the south-west end to  $59^{\circ}\cdot4$  at the north-east end, and this would seem to indicate a distribution of temperature similar to that observed in Loch Ericht, but since only one temperature series was taken, it is impossible to form an idea of the distribution of temperature throughout the whole body of water.

*Rannoch Moor Lochs.*—No coach road in Britain probably passes through more magnificent scenery than that between the Bridge of Orchy and Ballachulish. About half-way between Inveroran Hotel and King's House Hotel the river Bà crosses the road, and to the west lies Corrie Bà, the sanctuary of the Black Mount forest, where no shot is ever fired, and consequently this splendid corrie is the home of the deer, the golden eagle, the fox, and other wild animals. Here also is the most westerly source of the rivers of the Tay basin. In rainy weather a large amount of water passes down the river Bà and other streams into the moor of Rannoch, and about a mile or two to the eastward of the road a large extent of the moor is flooded, and presents the



FIG. 15.—MOOR OF RANNOCH, SHOWING LOCH BUIDHE AND LOCHAN NA STAINGE.

(*Photograph by Sir John Murray.*)

appearance of a vast lake. In drier weather there are distinct basins, which have received the names of Loch Buidhe, Lochan na Stainge, Lochan na h-Achlaise, and Loch Bà (or A-baw), all of them situated in drift and encumbered with rocks and small islands; they are all shallow. These lochs all contain trout, and have boats on them; they belong to the Marquis of Breadalbane, and are strictly preserved. On Eilean Molach in Loch Bà the heron still breeds in large numbers, and formerly the osprey used to breed in the same place. In making the survey of these lochs, the staff were much obliged to Mr. M'Intyre, the head stalker to the Marquis of Breadalbane.

*Loch Buidhe* (see Plate XVI.).—Loch Buidhe (or Buie) is very shallow, and in places covered with weeds, though its surface is practically free from islands. It is somewhat quadrangular, though irregular, in outline, the maximum diameter (or length) from east to west being about one-third of a mile, and the maximum breadth from north to south about a quarter of a mile, the mean breadth being about one-sixth of a mile. Its waters cover an area of about 35 acres, or one-nineteenth of a square mile, and it drains an area 222 times greater, or over 11 square miles. It is deepest towards the eastern shore, where the maximum depth (3 feet) was observed in several places, shoaling towards the western shore, off which the weeds are most abundant; the volume of water contained in it is estimated at 2,265,000 cubic feet. It was surveyed on April 15, 1902, about 40 soundings being recorded. The surface of the water was determined by the Ordnance Survey officers in 1897 as being 981 feet above sea-level. The temperature of the surface water at 7 p.m. on April 15, 1902, was 48° Fahr.

*Lochan na Stainge* (see Plate XVI.).—Lochan na Stainge (or na-Sting) is extremely irregular in outline, and includes three comparatively large islands, as well as a number of small ones. Its length from north to south is over half a mile, the maximum breadth being two-fifths of a mile, and the mean breadth about one-seventh of a mile. Its waters cover an area of over 51 acres, or rather more than one-twelfth of a square mile, and it drains directly about two-thirds of a square mile, but, since it receives the outflow from Loch Buidhe, its total drainage area is nearly 12 square miles, or 147 times the area of the loch. The loch is divided into two portions by a barrier at the central constriction, on which there is only 1 foot of water, the maximum depth observed in the northern portion (between the large island and the northern shore) being 8 feet, while the maximum depth of the loch (14 feet) was found in the southern portion immediately to the south of the barrier referred to. The volume of water contained in the loch is estimated at 11,407,000 cubic feet, and the mean depth at 5 feet. The loch is on the whole shallow, nearly 99 per cent. of its floor being covered by less than 10 feet of water. It was surveyed on April 19, 1902, 55 soundings being recorded. The level of the loch was not determined by levelling, but on the new edition of the Ordnance Survey map (1897) there is a spot-level of 972 feet on the southern shore near the inflow, and another of 968 feet on the northern shore at the outflow, so that the surface of the water is probably about 970 feet above the sea. The drift-marks around the loch showed that it sometimes rises 5 feet higher than on the date surveyed, and during floods the whole valley looks like one loch, with knolls projecting above the water. The temperature of the surface water at 10.30 a.m. on April

19, 1902, near the boathouse was  $43^{\circ}$ , and on returning to the same place at 12.30 (noon) it had risen to  $46^{\circ}4$ ; in the main basin, near the centre, the surface temperature was  $42^{\circ}6$ .

*Lochan na h-Achlaise* (see Plate XVI.).—Lochan na h-Achlaise (or na-Hachlich) is irregular in form, the outline being somewhat triangular or heart-shaped, with the apex pointing south. It includes many larger and smaller islands, and the bottom in the shallower places is covered by stones and boulders. The length from north to south is over four-fifths of a mile, while the maximum breadth from east to west is about three-quarters of a mile, the mean breadth being over one-third of a



FIG. 16.—LOCHAN NA H-ACHLAISE.

(Photograph by R. M. Clark, B.Sc.)

mile. Its waters cover an area of about 183 acres, or nearly three-tenths of a square mile, and it drains an area of over one square mile, or nearly four times the area of the loch. The north-western portion of the loch is shallow, the deeper water being found in the southern and eastern portions. The 10-foot basin is a continuous area, extending from near the southern shore in a northerly and then north-easterly direction to near the north-eastern shore, excluding the islands lying off the eastern shore, and is nearly three-quarters of a mile in length. The 10-foot basin includes two 20-foot basins, the more southerly being the larger and deeper, the maximum depth of the loch (28 feet) having

been found towards the north-eastern end of this basin, and comparatively close to the eastern shore. The volume of water contained in the loch is estimated at 76,236,000 cubic feet, and the mean depth at  $9\frac{1}{2}$  feet. The loch is on the whole comparatively shallow, about 63 per cent. of the bottom being covered by less than 10 feet of water, while only 9 per cent. of the bottom is covered by over 20 feet of water. The loch was surveyed on April 16, 1902, over 100 soundings being recorded. The surface of the water was found to be 962 feet above sea-level by the officers of the Ordnance Survey in 1897. The temperature of the surface water at 6 p.m. on April 16, 1902, was  $45^{\circ}2$ .

*Loch Bà* (see Plate XVI).—Loch Bà (or A-baw) is extremely irregular in outline, studded with large and small islands, and with many rocks and boulders. Its length from south-west to north-east in a straight line is over 2 miles, and following the axis of deep water about  $2\frac{1}{2}$  miles. Its maximum breadth in the southern portion from east to west is over a mile, and the mean breadth is nearly half a mile. Its waters cover an area of about 585 acres, or nine-tenths of a square mile, and it drains directly an area of  $4\frac{1}{2}$  square miles, but, since it receives the outflow from Loch Buidhe, Lochan na Stainge, and Lochan na h-Achlaise, its total drainage area is nearly  $17\frac{1}{2}$  square miles, or nineteen times the area of the loch.

The bottom of Loch Bà is very irregular. The deepest water occurs in the northern portion between the islands of Eilean Molach and Eilean na h-Iolaire, where there is a small basin less than a quarter of a mile in length, and over 20 feet in depth, the maximum depth of 30 feet having been observed about one-sixth of a mile to the north of the northern point of Eilean Molach. An isolated sounding of 20 feet was taken close to the western shore of the southern portion of Eilean Molach. There are three irregular basins with depths exceeding 10 feet: the central one, enclosing the 20-foot basin, and extending on both sides of Eilean Molach and to the west and north of Eilean na h-Iolaire, is nearly three-quarters of a mile in length and over a quarter of a mile in breadth; the southern one, occupying the wide south-eastern portion of the loch, is nearly half a mile in maximum diameter; and the third, situated in the north-eastern extension of the loch, is nearly half a mile in length and nearly a quarter of a mile in breadth. The volume of water contained in the loch is estimated at 206,497,000 cubic feet, and the mean depth at 8 feet, being 27 per cent. of the maximum depth. The length of the loch is 378 times the maximum depth and 1402 times the mean depth. Over 70 per cent. of the floor of the loch is covered by less than 10 feet of water, and only  $1\frac{1}{2}$  per cent. by more than 20 feet of water. The loch was surveyed on April 17 and 18, 1902, over 300 soundings having been taken. The level of the loch was determined by the Ordnance Survey officers in 1897 as being 957 feet above sea-level.

The temperature of the surface water near the boathouse, when commencing the survey at 2.45 p.m. on April 17, was 50°·8 Fahr., but later on, out in the open water, the surface temperature was 44°·2 Fahr.; on the 18th at noon the surface temperature near the shore was 50°·0 Fahr., while in the bay to the north of the boathouse the temperature was 46°·0 Fahr.

Lochan Beinn Caorach and some other small basins of water in

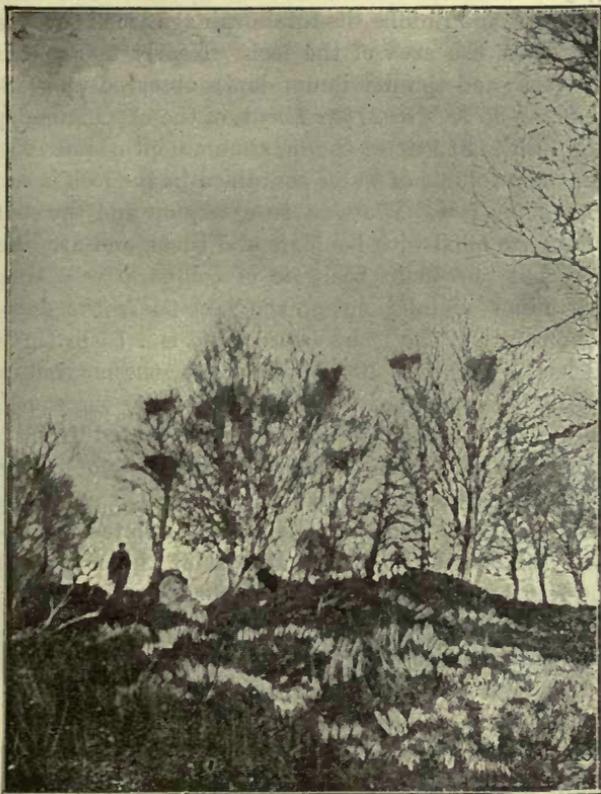


FIG. 17.—HERONS' NESTS ON EILEAN MOLACH IN LOCH BÀ.

(Photograph by T. N. Johnston, M.B., C.M., F.R.S.E.)

this region were without boats and could not be sounded; they were evidently all quite shallow and of the same character as Loch Buidhe.

*Loch Laidon* (see Plate XVII.).—Loch Laidon (or Lydoch, or Luydan) lies partly in Perthshire and partly in Argyllshire, the boundary running along the centre of the western arm and for a certain distance up the main loch. It is one of the best trouting lochs

in the district, or perhaps in Scotland. It is about  $5\frac{1}{3}$  miles in length from north-east to south-west, but it sends out an arm towards the west, which is over  $1\frac{1}{2}$  miles in length, and a line following the axis of the loch from the north-east end to the extremity of the western arm would be over 6 miles in length. Its maximum breadth is nearly three-quarters of a mile, and the mean breadth about one-third of a mile, or 6.4 per cent. of the length. Its waters cover an area of about 1149 acres, or over  $1\frac{3}{4}$  square miles, and it drains directly an area of  $30\frac{1}{4}$  square miles; but, since it receives the outflow from Lochs Bà, Achlaise, Stainge, and Buidhe, its total drainage area is over  $47\frac{1}{2}$  square miles or  $26\frac{1}{2}$  times the area of the loch. Nearly 500 soundings were taken in the loch, and the maximum depth observed was 128 feet, the mean depth being 35 feet, or  $27\frac{1}{2}$  per cent. of the maximum depth. The length of the loch is 219 times the maximum depth, and 795 times the mean depth. The volume of water contained in the loch is estimated at 1,761,733,000 cubic feet. The western extension and the southern end of Loch Laidon are filled with boulders and islets, and are like Loch Bà in character, but the main basin is of comparatively simple form, though with minor undulations of the lake-floor, the deepest water occupying the centre of the loch, where there is a basin three-quarters of a mile in length and over 100 feet in depth, the maximum depth of 128 feet having been observed about  $2\frac{3}{4}$  miles from the south-west end and  $2\frac{1}{2}$  miles from the north-east end. Separated from this main 100-foot basin by shallower water, there is a sounding of 104 feet a short distance to the south-west, and half a mile further south there is an isolated sounding of 100 feet; there is also an isolated sounding of 100 feet a quarter of a mile to the north-east of the main basin. The principal 50-foot basin extends from less than a mile from the south-west end to less than  $1\frac{1}{2}$  miles from the north-east end, and is nearly 3 miles in length. Separated from this larger basin by an interval of a quarter of a mile is a smaller one, about one-third of a mile in length, situated in the north-eastern part of the loch, and nearly midway between them is an isolated sounding of 50 feet. The western arm of Loch Laidon is shallow and filled with rocks and boulders, the greatest depth observed being 17 feet in three different places. Of the entire lake floor, 53 per cent. is covered by less than 25 feet of water, 21 per cent. is covered by water between 25 and 50 feet in depth, 22 per cent. by water between 50 and 100 feet in depth, and 4 per cent. by water exceeding 100 feet in depth. Loch Laidon was surveyed on April 9 to 25, 1902, and the surface of the loch was found by levelling to be 923.9 feet above sea-level. When surveyed by the Ordnance Survey officers on July 28, 1860, the level of the loch was 924.6 feet above the sea. At the north-eastern end of Loch Laidon is a small basin called Dubh Lochan, which was found by levelling on April 14, 1902, to be 2 feet higher than Loch Laidon, and should therefore, strictly speaking, be

looked upon as a distinct lake, but in the foregoing description the two lakes have been regarded as one. Many temperature observations were taken in Loch Laidon on April 9, 10, 14, 15, and 25, the surface readings varying from  $38^{\circ}\cdot 8$  at 5 p.m. on the 9th to  $48^{\circ}\cdot 2$  at the head of the loch at 1 p.m. on the 10th—a range of  $9^{\circ}\cdot 4$  in the temperature of the water, while the range in the air-temperature during the same period was only  $5^{\circ}$  (from  $45^{\circ}\cdot 2$  to  $50^{\circ}\cdot 2$ ). Two serial temperature observations were taken in the centre of the loch, the first at 5 p.m. on April 9, when the readings were identical ( $39^{\circ}\cdot 8$ ) at the surface and at depths of 5 and 25 feet, the second at 5.20 p.m. on the 10th, when the

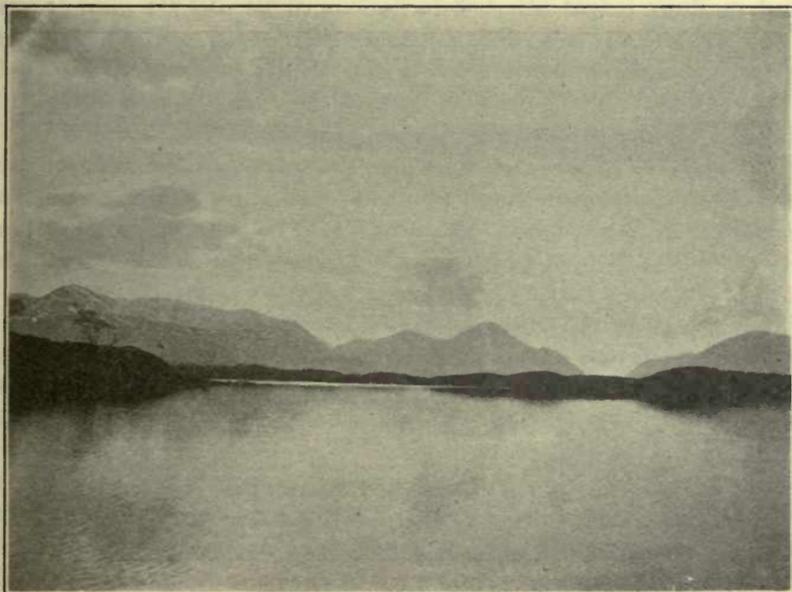


FIG. 18.—LOCH LAIDON.  
(*Photograph by Miss Margaret Murray.*)

surface readings were  $39^{\circ}\cdot 8$  and  $41^{\circ}$ , that at 5 feet  $39^{\circ}\cdot 7$ , and that at 20 feet  $39^{\circ}\cdot 4$ . The surface temperature in Dubh Lochan on April 14 was  $43^{\circ}\cdot 9$ .

The western arm of Loch Laidon receives the waters from a small loch (Lochan Gaineamhach) lying about 2 miles to the west. This loch, and the neighbouring one to the north, were visited on May 20, 1903, but, as there were no boats on them, they were not sounded. They were found to be of the same general character as the other lochs of Rannoch Moor—shallow, with stony shores, containing boulders and islets, some of the latter with small trees on them. In Lochan Gaineamhach, weeds were seen only in some very small bays, but in

the other lochan weeds were seen in several places, with a little open water in the eastern half.

To the north of the north-eastern end of Loch Laidon lies the little Lochan a' Chlaidheimh, where three counties (Perthshire, Argyllshire, and Inverness-shire) meet. This lochan was visited on May 14, 1902, but was not sounded, as there was no boat on it. It is evidently very shallow in all parts, full of rocks and boulders, a rock showing above water even in the very centre, and all along the shores rocks are numerous, extending in lines out from the shore. A couple of miles to the east of Lochan a' Chlaidheimh lies Lochan Sròn Smeur, next to be dealt with, on which there was a boat.



FIG. 19.—LOCHAN SRÒN SMEUR.

(Photograph by H. C. Lamb.)

*Lochan Sròn Smeur* (see Plate XVIII.).—Lochan Sròn Smeur (or Sròn Smeur) is situated a little to the east of the road running from Rannoch to Loch Ossian, and is said to contain small black trout, but is strictly preserved. It is over half a mile in length, less than a quarter of a mile in maximum breadth, the mean breadth being one-seventh of a mile, or 25 per cent. of the length. Its waters cover an area of over 50 acres (or about one-twelfth of a square mile), and it drains an area of nearly two square miles, nearly twenty-four times the area of the loch. It was surveyed on May 12, 1902, the maximum depth observed being 33 feet. The volume of water contained in the lake is estimated at 22,592,000 cubic feet, and the mean depth at 10·3 feet, or 31 per cent. of the maximum depth. The loch is of simple conformation, the western

half being comparatively shallow, while the deeper water occurs in the eastern half, the maximum depth having been found about one-eighth of a mile from the eastern end. The 10-foot basin approaches quite close to the eastern shore, and is about one-third of a mile in length, enclosing the 20-foot basin, which is about one-fifth of a mile in length. About 61 per cent. of the lake-floor is covered by less than 10 feet of water, while about 12 per cent. is covered by over 20 feet of water. No bench-marks were found near the loch, but a little distance up the river which feeds it there is a spot-level of 1134 feet. There was little evidence of much rise and fall in the level of the water, the range possibly not exceeding 2 feet. The temperature of the surface water varied from 47°·4 to 50°·5, a range of 3°·1, the higher readings being taken in shallow water near shore. Readings at 10 feet and at 20 feet near the centre of the loch gave 48° in each case, the surface temperature at the same time being 47°·6.

Less than a mile to the east of Lochan Sròn Smeur is Lochan Lòin nan Donnlaich (or Lochan Lòin nan Dubhach, or Loch-an-Londonich), said to contain large trout. When visited, many rocks and boulders were observed showing above the water, and grass filled the bay at the outlet.

*Loch Eigheach* (see Plate XVIII.).—Loch Eigheach (or Eaigh), about 3 miles from where the river Gaur passes its waters into Loch Rannoch, is an expansion, or rather three expansions, of the river Gaur, the two western expansions lying on a higher level than the eastern one, and hence strong currents run in an easterly direction. In high floods the whole area is practically submerged. A large part of the loch is covered by reeds, and the bottom is very weedy. The entire loch is nearly nine-tenths of a mile in length, with a maximum breadth of less than a quarter of a mile, the mean breadth being one-tenth of a mile. Its waters cover an area of about 59½ acres, or less than one-tenth of a square mile, and it drains directly an area of nearly 14 square miles, but since it receives the outflow from Lochan Sròn Smeur and from Lochs Laidon and Bà, &c., its total drainage area is nearly 63½ square miles, or 705 times the area of the loch. The loch was surveyed on April 21, 1902, about 80 soundings being recorded, the maximum depth observed being 28 feet. The surface of the eastern expansion was found by levelling to be 818·2 feet above sea-level, and the water apparently rises about 3½ feet above its level on the date surveyed. The volume of water contained in the loch is estimated at 15,794,000 cubic feet, and the mean depth at 6 feet, or 22 per cent. of the maximum depth. The eastern expansion is the deepest, the maximum depth of 28 feet having been found to the west of the island near the east end of this expansion; the north-western expansion has a maximum depth of 7 feet observed not far from the outlet, but the majority of the

soundings run from 2 to 5 feet; the south-western expansion is the shallowest, with a maximum depth of 3 feet to the west of the central large island (Eilean na Coille), the bottom to the east and south of that island being covered by only 1 foot of water. Over 90 per cent. of the entire lake-floor is covered by less than 10 feet of water, and less than 2 per cent. by over 20 feet of water. The surface temperature in the eastern expansion at 11 a.m. on April 21, 1902, was  $44^{\circ}2$ .

*Loch Rannoch* (see Plate XIX.).—Loch Rannoch, one of the larger and more important of the lochs in the Tay basin, was the headquarters of the Lake Survey for nearly four months, from March 20 to July 10, 1902, and during that period a great many soundings, as well as observations on the temperature of the water, on the biology, and on the rise and fall of the surface of the loch, were taken, all the members of the staff taking part in the work. The lake trends in an east-and-west direction, and is a lovely sheet of water, the hills on both sides, and the woods clothing its shores in many places, adding beauty to the scene. The famous Black Wood of Rannoch on the south side is of great antiquity. The loch contains many small trout, and is famed for large *Salmo ferox*. It is nearly  $9\frac{3}{4}$  miles in length, considerably over a mile in maximum breadth, the mean breadth being about three-quarters of a mile, or about 8 per cent. of the length. Its waters cover an area of over 4700 acres, or nearly  $7\frac{1}{2}$  square miles, and it drains directly an area of about 130 square miles, but, since it receives the outflow from Loch Ericht, Loch Eigheach, Loch Laidon, Loch Bà, &c., its total drainage area is about  $243\frac{1}{2}$  square miles, or 33 times the area of the loch.

Over eight hundred soundings were taken in Loch Rannoch, the maximum depth observed being 440 feet, or 20 feet deeper than the maximum depth recorded by Mr. Grant-Wilson during his survey in the year 1888, when he took about 320 soundings. The volume of water contained in the loch is estimated at about 34,387,131,000 cubic feet, or less than a quarter of a cubic mile, and the mean depth at  $167\frac{1}{2}$  feet, or 38 per cent. of the maximum depth. The length of the loch is 116 times the maximum depth, and 306 times the mean depth. The loch is widest and deepest in the eastern half, narrowing and shallowing towards the west on approaching the island Eilean nam Faioileag, then deepening again to the west of that island. It consists of one large main basin, with two subsidiary small basins over 50 feet in depth towards the west end, separated from the main basin by the shallow water in the neighbourhood of Eilean nam Faioileag. The larger of the two subsidiary basins is about three-quarters of a mile in length, stretching from south of the island An t-Eilean Fearna, at the entrance of the river Ericht, towards the west end of the loch, and the maximum depth recorded in it was 84 feet; the smaller basin lies between the two islands mentioned and towards the northern shore,

soundings of 52 and 54 feet having been obtained therein. The main 50-foot basin is about  $7\frac{3}{4}$  miles in length, occupying the great body of the loch east of Eilean nam Faoileag, and covering an area exceeding 5 square miles. The 100-foot basin is nearly 7 miles in length, extending from between the mouths of the Killichonan burn and the Allt Camghouran towards the east end of the loch. The 200-foot basin is 6 miles in length, stretching from within a quarter of a mile from the

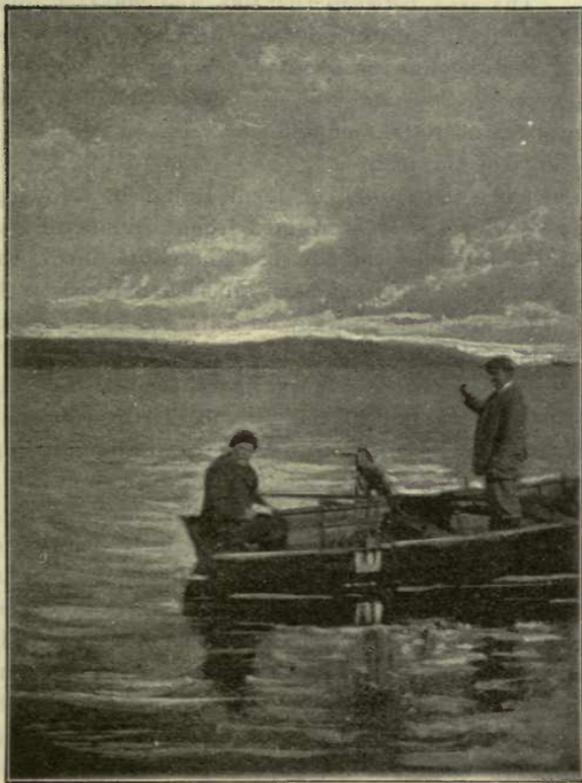


FIG. 20.—LOCH RANNOCH.  
(*Photograph by Miss M'Pherson.*)

east end to opposite the house Talla Bheith on the northern shore. The main 300-foot basin is nearly 4 miles in length, stretching from less than half a mile from the east end to opposite Dall on the southern shore, and separated from it by an interval of a quarter of a mile is an isolated sounding of 304 feet. Within the 300-foot basin the bottom sinks in three places along the central axis of the loch below the 400-foot line. The easternmost of these three 400-foot basins is the largest and deepest, situated about  $1\frac{1}{2}$  miles from the east end, about two-thirds

of a mile in length, and enclosing the maximum depth of the loch (440 feet); a short distance to the west (opposite Craiganour) is a second small basin based upon a sounding of 404 feet; and three-quarters of a mile farther west is the third basin, with a maximum depth of 421 feet. The area of the lake-floor covered by less than 50 feet of water is about 1200 acres (nearly 2 square miles), or 25 per cent. of the total area, while the area between the 50-foot and 100-foot lines is about 750 acres, or 16 per cent., showing a relatively rapid descent beyond the 50-foot line. The area between the 100- and 200-foot lines is about 877 acres, or nearly 19 per cent. of the entire area. The area between the 200- and 300-foot lines is about 950 acres, or over 20 per cent., the area between the 300- and 400-foot lines is about 875 acres, or 18½ per cent., and that over 400 feet about 65 acres, or nearly 1½ per cent., of the total area of the loch.

On commencing the survey of Loch Rannoch, the height of the surface above sea-level was determined from Ordnance Survey benchmarks as 668 feet; the level of the loch fluctuated during the progress of the survey, but the soundings have all been reduced to this datum. The officers of the Ordnance Survey on July 19, 1860, found the level of the loch to be 667·5 feet above the sea.

*Temperature Observations.*—Very many temperature observations were taken between March 20 and July 10, 1902. The surface temperatures need not be discussed in detail; the lowest reading recorded was 37°·9 on March 28, and the highest 59°·8 on June 23, showing a range of 22° in the temperature of the surface water during the period of three months. An interesting series of hourly observations on the temperature of the air and of the surface water at the pier at Rannoch Lodge was taken on June 9. One thermometer was immersed in 3 feet of water outside the pier, and another in 1 foot of water inside the pier, and they were read simultaneously with an air-thermometer at intervals of one hour from 9 a.m. to 10 p.m. The temperature of the air rose gradually, though irregularly, from 48° at 11 a.m. to a maximum of 53° at 4 p.m., falling gradually again to 44°·5 at 9 p.m., and 45° at 10 p.m. The thermometer in 3 feet of water showed a gradual rise in the temperature from 51°·9 at 9 a.m. to 53° at 11 a.m., then a slight fall at noon (52°·7) and at 1 p.m. (52°·5), the maximum (53°·6) being recorded at 2 p.m., falling to 52°·9 at 4 p.m., rising to 53°·3 at 5 p.m., falling gradually to 52°·1 at 8 p.m., then rising to 52°·8 at 9 p.m., and 53° at 10 p.m. The thermometer in 1 foot of water showed a gradual rise in the temperature from 51°·4 at 9 a.m. to the maximum of 53°·6 at 2 p.m., whence it fell gradually to 51°·5 at 9 p.m., the reading at 10 p.m. being 52°. The maximum temperature of the water was recorded in each case at 2 p.m., while the maximum temperature of the air was recorded at 4 p.m., and the temperature of the air was always lower than that of the water, except when the air was at its maximum



(53° at 4 p.m.), the thermometer in 3 feet of water then reading 52°·9, while that in 1 foot of water read 53°·3. The temperature recorded in 1 foot of water was lower than that recorded in 3 feet of water in the forenoon and late evening, but at noon and 1 p.m. it was higher, at 2 p.m. and 3 p.m. it was identical, and from 4 p.m. till 8 p.m. it was higher, the greatest difference recorded being 1°·3 at 9 p.m. (52°·8 at 3 feet, and 51°·5 at 1 foot).

The temperatures taken beneath the surface have been collected together and arranged chronologically in the foregoing table, which may be useful for future reference and comparison. The great majority of them were taken in the small 80-foot basin towards the west end of the loch, while one series was taken near the east end on April 3, and three series were taken towards the middle of the loch, opposite Craiganour, on May 1, 2, and 23. The table shows well the heating up of the water with the advance of summer. The readings taken near the west end in March are all below 39° Fahr.—that is, below the maximum density point, though surface temperatures exceeding 39°, and in one or two cases exceeding 40°, were recorded near the shore during the last days of March. On April 2 and subsequently, the temperature was above that of maximum density (39°·1), but the observations taken near the east end on April 3 showed that the temperature of the water from surface to bottom was just below maximum density point. The water in the small western basin had a temperature under 40° up to April 10, and was practically uniform from top to bottom, but on April 21 and subsequently the temperature rose, and there was a considerable range between the temperature of the upper and lower layers. The water in the main basin had a temperature of 40° at 200 and 300 feet on May 1; on May 2 the temperature was 40°·2 at 200 feet; and on May 23 it was 41°·9 at 100 feet. By the beginning of June the water near the surface had attained a temperature of 50°, and by June 21 that temperature extended down to 50 feet, the upper 10 feet having on that date a temperature of 52°.

*Loch Lyon* (see Plate XXI.).—Loch Lyon lies at a high elevation at the head of Glen Lyon, amid grand and mountainous scenery, its waters being carried by the river Lyon into the river Tay a short distance above the mouth of Loch Tay; it contains both salmon and trout. It trends in a north-east and south-west direction, and is extremely simple both in outline and in the conformation of the bottom. It is of nearly uniform width, except for a cone of alluvium, brought down by the river, on the south-eastern shore. It is about  $1\frac{3}{4}$  miles in length, with a maximum breadth of over a quarter of a mile, the mean breadth being over one-fifth of a mile, or 12 per cent. of the length. Its waters cover an area of about 236 acres, or over one-third of a square mile, and it drains an area of over  $10\frac{1}{2}$  square miles, an area nearly

twenty-nine times greater than that of the loch. Over 100 soundings were taken in Loch Lyon, the maximum depth observed being 100 feet. The volume of water contained in the loch is estimated at about 460,750,000 cubic feet, and the mean depth at 45 feet, or 45 per cent. of the maximum depth. The length of the loch is 92 times the maximum depth, and 205 times the mean depth. As stated, the loch forms a simple basin, the bottom sinking gradually on all sides towards the deepest part, which is approximately centrally placed. The deep water,

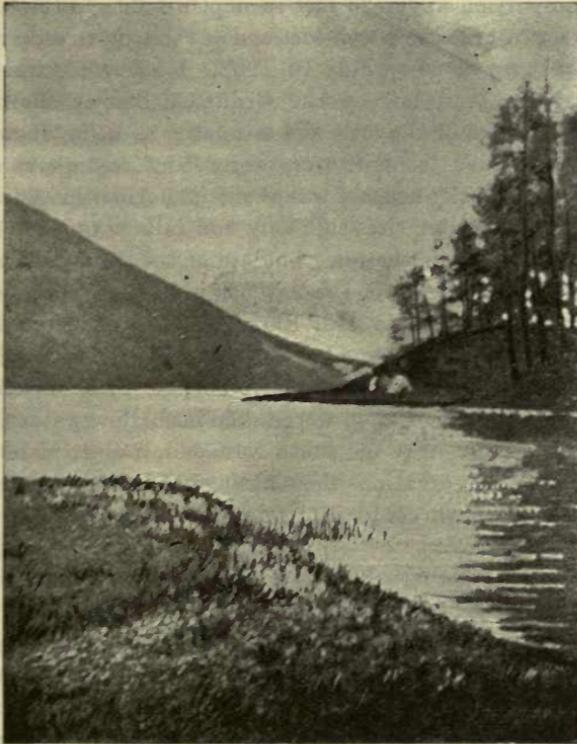


FIG. 21.—LOCH LYON.

(*Photograph by Sir John Murray.*)

however, approaches much closer to the south-west end than to the north-east end, where the 25-foot line is distant about a quarter of a mile from the shore, probably through silting up of the lake-floor at that end. The 25-foot basin is nearly  $1\frac{1}{2}$  miles in length, the 50-foot basin is about  $1\frac{1}{3}$  miles in length, and the 75-foot basin is about  $1\frac{1}{8}$  miles in length. The area of the lake-floor covered by less than 25 feet of water is about 92 acres, or 39 per cent. of the total area of the loch; the area between the 25- and 50-foot contour-lines is about 36 acres, or over 15 per cent.; the area between the 50- and 75-foot contours is about

55 acres, or over 23 per cent. ; and the area over 75 feet in depth is about 53 acres, or less than 23 per cent. of the entire area of the loch. The comparatively flat-bottomed character of the deep basin is indicated by the larger proportion of the bottom covered by water between 50 and 75 feet in depth, as compared with the proportion covered by water between 25 and 50 feet, the average slope being thus considerably steeper in depths of 25 to 50 feet than in depths of 50 to 75 feet ; and this latter gentler slope is continued into the deeper water over 75 feet in depth, as shown by the nearly equal areas on both sides of the 75-foot line. The large proportion under 25 feet in depth is due to the considerable silted-up area towards the north-east end of the loch already referred to. Loch Lyon was surveyed on May 10, 1902. No bench-marks were to be seen along the shores, nor on the Ordnance Survey charts, but the height of the surface of the loch was estimated as being about 1050 feet above the sea. Lines of drift were observed 4 feet above the water, which, according to the keeper, was about its normal height at the time of the survey ; the water rises suddenly and falls as quickly, and might fall perhaps a foot lower than on the date of the survey. Thus a range of about 5 feet in the level of the water is indicated. The temperature of the surface water on May 10, 1902, when commencing the survey, about noon, was  $48^{\circ}7$  at the edge of the bank at the north-east end, and readings taken along the shore gave  $50^{\circ}$ ,  $51^{\circ}8$ ,  $52^{\circ}5$ , and  $58^{\circ}$ . In the afternoon, readings of  $47^{\circ}9$  were taken in shallow water towards the northern shore,  $48^{\circ}9$  near the south-west end, and  $46^{\circ}4$  in the centre of the loch. These observations show a range of  $11^{\circ}6$  in the temperature of the surface water throughout the day, viz. from  $46^{\circ}4$  to  $58^{\circ}$ .

*Loch Dochart* (see Plate XX.).—Loch Dochart, situated at the foot Ben More amid beautiful scenery, is the westernmost of the lochs belonging to the Tay branch of the Tay river-system, being evidently an expansion of the river Fillan, which forms the headwaters of this branch. It receives the drainage from a considerable tract of country, is very shallow, the bottom is very weedy, and there are many reeds, especially at the west end. Loch Dochart is nearly two-thirds of a mile in length, with a maximum breadth of nearly one-sixth of a mile, the mean breadth being over one-tenth of a mile, or 18 per cent. of the length. Its waters cover an area of about 46 acres, or nearly one-fourteenth of a square mile, and it drains an area of nearly 39 square miles, or 555 times the area of the loch. Nearly 70 soundings were taken in Loch Dochart, the maximum depth observed being 11 feet ; but this depth is of very limited extent, only two isolated soundings being recorded near the west end of the loch, while by far the greater portion of the bottom is covered by less than 5 feet of water. The volume of water contained in the loch is estimated at 10,032,000 cubic feet, and the mean depth at 5 feet, or 46 per cent. of the maximum

depth. The length of the loch is 298 times the maximum depth, and 652 times the mean depth. Loch Dochart was surveyed on April 28, 1902, and the level of the surface of the water was determined from Ordnance Survey bench-mark as being 513 feet above sea-level. The temperature of the surface water at 11.30 a.m. on that date was  $50^{\circ}.1$ .

*Loch Iubhair* (see Plate XX.).—Loch Iubhair (or Nubhair) receives the outflow from Loch Dochart by a river considerably less than half a mile in length, so that they may almost be regarded as forming one lake. It affords fair trout-fishing, and the scenery round about is very beautiful. Loch Iubhair is about  $1\frac{1}{2}$  miles in length, with a maximum breadth of about one-third of a mile, the mean breadth being nearly one-sixth of a mile, or 12 per cent. of the length. Its waters cover an area of about  $135\frac{1}{2}$  acres, or over one-fifth of a square mile, and it drains directly an area of about  $5\frac{3}{4}$  square miles; but, since it receives the outflow from Loch Dochart, its total drainage area is over  $44\frac{1}{2}$  square miles, or 212 times the area of the loch. Over 100 soundings were taken in Loch Iubhair, and the maximum depth observed was 65 feet. The volume of water contained in the loch is estimated at 147,284,000 cubic feet, and the mean depth at 25 feet, or 38 per cent. of the maximum depth. The length of the loch is 110 times the maximum depth, and 286 times the mean depth. Loch Iubhair trends in a north-east and south-west direction, and is rather peculiar in outline, resembling somewhat the italic letter *f*, constricted in the central portion, where a ridge crosses the loch with a maximum depth of 36 feet on it. The loch widens and deepens on each side of this constriction, the maximum depth of the loch having been found in the north-eastern part, where the loch is widest, the greatest depth observed in the south-western part being 49 feet. The 25-foot basin is a continuous area over a mile in length, approaching close to the northern shore, but distant about a quarter of a mile from the south-west end. The area of the lake-floor covered by less than 25 feet of water is about 72 acres, or 53 per cent. of the total area of the loch; the area between the 25- and 50-foot contours is about 59 acres, or 44 per cent., while the area covered by over 50 feet of water is about 5 acres, or 3 per cent. of the entire area of the loch. Loch Iubhair was surveyed at the same time as Loch Dochart, on April 28, 1902, the level of its surface being a foot lower than that of Loch Dochart, viz. 512 feet above the level of the sea.

*Loch Earn* (see Plate XXII.).—Loch Earn is situated amid lovely surroundings, the hills on both sides being clothed with rich woods, and splendid mountain scenery bounds the horizon towards the west, while on the south Ben Vorlich towers to a height of 3200 feet. It contains trout and salmon, and also *Salmo ferox*. It has been said that the loch is 100 fathoms (= 600 feet) deep in some places, but this is disproved by

the soundings taken by different surveyors. Mr. Grant-Wilson took over 180 soundings in 1888, Sir John Murray and the late Mr. F. P. Pullar took about 150 soundings in 1900, and the Lake Survey took 500 soundings in 1902, but in no case was the depth found to exceed 288 feet. On the accompanying map only the Lake Survey soundings are laid down, and the contour-lines drawn in from them.

Loch Earn is  $6\frac{1}{2}$  miles in length, and four-fifths of a mile in maximum breadth, the mean breadth being three-fifths of a mile, or  $9\frac{1}{2}$  per cent. of the length. The waters of the loch cover an area of over 2400 acres, or nearly 4 square miles, and it drains an area of over  $54\frac{1}{2}$

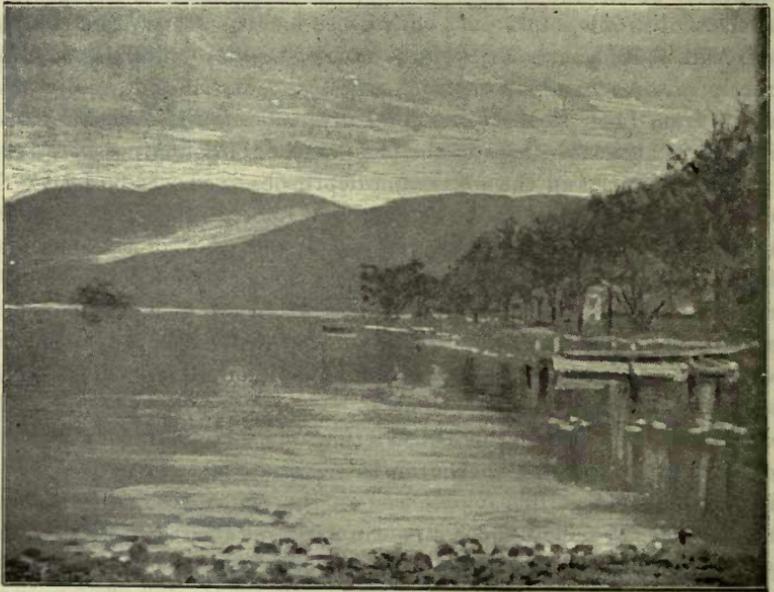


FIG. 22.— LOCH EARN.

(*Photograph by J. Parsons, B.Sc.*)

square miles—an area fourteen times greater than the area of the loch. Five hundred soundings were taken in Loch Earn, the maximum depth observed being 287 feet, which agrees very well with the maximum recorded by Mr. Grant-Wilson in 1888, viz. 48 fathoms, or 288 feet. The volume of water contained in the loch is estimated at 14,420,638,000 cubic feet, and the mean depth at 138 feet, or 48 per cent. of the maximum depth. The length of the loch is 118 times the maximum depth, and 245 times the mean depth.

Loch Earn forms a simple basin, the lake-floor sinking gradually on all sides down to the greatest depth, as is well shown by the longitudinal and three cross-sections on the map. The 50-foot contour-line follows

approximately the outline of the loch, approaching very close to the west end, where between the mouths of the Ogle and Kendrum burns a sounding of 57 feet was taken about 300 feet from the shore, giving a slope of 1 in 5.3. At the opposite end of the loch the 50-foot contour is met with about one-third of a mile from the bridge across the river at St. Fillans. The 100-foot basin approaches to within less than a quarter of a mile from the west end, and less than half a mile from the east end, and is over  $5\frac{3}{4}$  miles in length; it covers an area of nearly  $2\frac{1}{3}$  square miles. The 200-foot basin is  $4\frac{1}{2}$  miles in length, stretching from three-quarters of a mile from the west end to  $1\frac{1}{4}$  miles from the east end, and covers an area of  $1\frac{1}{8}$  square miles. The 250-foot basin is nearly 2 miles in length, and a quarter of a mile in maximum width, extending from  $1\frac{1}{2}$  miles from the west end to 3 miles from the east end. The maximum depth of 287 feet was observed near the centre of the loch, between the mouths of the Allt Bhacaidh on the north and the Allt Dhùnain on the south, about  $2\frac{3}{4}$  miles from the west end, and  $3\frac{3}{4}$  miles from the east end. The area of the lake-floor covered by less than 100 feet of water is about 926 acres, or  $38\frac{1}{2}$  per cent. of the total area of the loch; the area between the 100- and 200-foot contour-lines is about 755 acres, or  $31\frac{1}{2}$  per cent.; and the area covered by more than 200 feet of water is about 700 acres, or 30 per cent. The flat-bottomed character of the loch is indicated by the last-mentioned percentage, which is nearly equal to the preceding one, though the interval of depth is only 87 feet as compared with the previous interval of 100 feet. The comparatively uniform average slope from the shore down to a depth of 100 feet is shown by the fact that the areas on each side of the 50-foot line are nearly equal, viz. 477 acres (or nearly 20 per cent. of the entire area of the loch) between the shore and the 50-foot contour, and 449 acres (or nearly 19 per cent.) between the 50- and 100-foot contours.

Loch Earn was surveyed on May 14 to 19, 1902, and the level of the surface of the water was determined by levelling from Ordnance Survey bench-mark as 317.2 feet above sea-level. This is identical with the level determined by the surveyors of the Ordnance Survey on August 25, 1899.

*Temperature Observations.*—On May 14, at 3.45 p.m., the temperature of the surface water near Lochearnhead was  $46^{\circ}1$ ; at 6 p.m. the surface temperature was  $44^{\circ}$ , and at 7 p.m. near the shore  $47^{\circ}2$ . On May 15, at 11.30 a.m., the surface temperature near shore about a mile east of Lochearnhead was  $44^{\circ}$ . On May 16, at 10.30 a.m., the surface temperature at the St. Fillans end of the loch was  $44^{\circ}1$ , and at 1.30 p.m. it was  $44^{\circ}$ . On May 17, at 5 p.m., the surface temperature off Dalkenneth over the deepest part of the loch was  $43^{\circ}8$ . The range observed in the temperature of the surface water during those four days was thus  $3^{\circ}4$ , from  $43^{\circ}8$  to  $47^{\circ}2$ , the range in the air temperature during the same period being  $7^{\circ}5$ , from  $40^{\circ}5$  to  $48^{\circ}$ .

A series of temperatures beneath the surface was taken in the deepest part of the loch on May 17, at 5 p.m., with the following results:—

Surface ... ..	43°·8 Fahr.
5 feet ... ..	43°·5 „
10 „ ... ..	43°·4 „
20 „ ... ..	43°·3 „
30 „ ... ..	43°·2 „
50 „ ... ..	43°·2 „
100 „ ... ..	43°·1 „
125 „ ... ..	42°·3 „
150 „ ... ..	42°·1 „
200 „ ... ..	42°·0 „
250 „ ... ..	41°·5 „

This series shows a range of 2°·3 between the temperature at the surface and that at 250 feet, the greatest fall being one of 0°·8 between 100 and 125 feet.

*Loch Tummel* (see Plate XXIII).—Loch Tummel is situated amid beautiful scenery, rock, wood, and water being combined in such a way as to present pictures of rare loveliness, the crests of Farragon, Meall Tarruinn Chon, and Schiehallion rising to great heights to the south and south-west. It contains large trout and a great many pike. Loch Tummel is two and three-quarter miles in length, with a maximum breadth of half a mile, the mean breadth being a little over one-third of a mile, or 13 per cent. of the length. Its waters cover an area of 630 acres, or rather less than one square mile. It drains directly an area of  $62\frac{1}{2}$  square miles, but since it receives the outflow from Lochs Rannoch, Laidon, Bà, &c., its total drainage-area is about 306 square miles, or 312 times the area of the loch. Nearly 300 soundings were taken in Loch Tummel, the maximum depth observed being 128 feet, or 4 feet more than the maximum depth recorded by Mr. Grant-Wilson, who took 123 soundings in 1888. The volume of water contained in the loch is estimated at 1,316,635,000 cubic feet, and the mean depth at 48 feet, or  $37\frac{1}{2}$  per cent. of the maximum depth. The length of the loch is 113 times the maximum depth, and 302 times the mean depth. The floor of Loch Tummel is irregular, falling into three deep basins separated by two ridges, the maximum depth on the westerly ridge being 52 feet, and the maximum depth on the easterly ridge being 56 feet. The deepest of the three basins is situated near the west end of the loch, the maximum depth of 128 feet occupying a central position in this basin, but a short distance to the south a sounding of 74 feet is recorded in close proximity to a sounding of 127 feet. The 100-foot contour-line in this western basin is almost circular and nearly one-third of a mile in diameter; about one-fifth of a mile to the east is an isolated sounding of 102 feet, surrounded by shallower water. The central 100-foot basin is oblong in outline and nearly half a mile in length, the maximum

depth of 119 feet having been observed towards the eastern end of the basin. The eastern basin just falls short of attaining a depth of 100 feet, the maximum observed being 99 feet; the 75-foot contour is approximately oblong in outline and nearly one-third of a mile in length. The 50-foot basin is a continuous area stretching from about a quarter of a mile from the west end to within 100 yards from the east end of the loch, and is nearly two and a half miles in length.

The area of the lake-floor covered by less than 50 feet of water is about 352 acres, or 56 per cent. of the entire area of the loch; the area covered by water between 50 and 100 feet in depth is about 217 acres,



FIG. 23.—LOCH TUMMEL.

(*Photograph by J. Parsons, B.Sc.*)

or  $34\frac{1}{2}$  per cent.; and that covered by more than 100 feet of water is about 60 acres, or  $9\frac{1}{2}$  per cent. of the total area of the loch.

Loch Tummel was surveyed on April 23 and 24, 1902, the level of the surface of the water being found, by levelling from Ordnance Survey bench-mark, to be 454.5 feet above the sea. When levelled by the surveyors of the Ordnance Survey on June 26, 1860, the surface of the water was found to be 453.3 feet above sea-level.

*Temperature Observations.*—The temperature of the surface water of Loch Tummel at 1.30 p.m. on April 23, 1902, was  $43^{\circ}2$  Fahr.; at 9.45 a.m. on the next day (April 24) the surface temperature was  $45^{\circ}0$ , and at 1 p.m. in the centre of the loch the surface temperature was

43°·5. A series of temperatures was taken below the surface at 1 p.m. on April 24, 1902, in 102 feet of water, with the following results:—

Surface ... ..	43°·5 Fahr.
5 feet ... ..	43°·5 „
10 „ ... ..	43°·4 „
20 „ „ ... ..	43°·2 „
50 „ ... ..	43°·0 „
70 „ ... ..	42°·6 „
100 „ ... ..	42°·4 „

showing a gradual decrease of temperature from surface to bottom, the range of temperature being 1°·1 in the 100 feet of water.

*Loch Tay* (see Plates XXIV. and XXV.).—Loch Tay is one of the largest of the Scottish fresh-water lochs, unsurpassed in the beauty of its surroundings, and well known to anglers on account of its salmon fishings, which are among the best in Scotland. It is also a good trout-fishing loch, having been much improved within recent years by being stocked with Loch Leven trout. The scenery around the loch is very fine—grand and wild towards the south-west end, with the mighty Ben Lawers rising from its northern shores about half-way down the loch, becoming more sylvan in character towards the north-east end, a splendid view presenting itself to the eyes of a spectator from Kenmore Bridge (see Fig. 24).

Loch Tay is the largest loch in the basin of the river Tay, though Loch Ericht is a very formidable rival for this distinction, as will be seen from the following comparison:—

	Loch Tay.	Loch Ericht.
Length ... ..	14·55 miles.	14·5 miles.
Maximum breadth ... ..	1·07 miles.	1·0 mile.
Mean breadth... ..	0·70 mile.	0·5 mile.
Superficial area ... ..	10·19 square miles.	7·21 square miles.
Maximum depth ... ..	508 feet.	512 feet.
Mean depth ... ..	199·076 feet.	189·201 feet.
Volume of water ... ..	56,550 million cub. ft.	38,027 million cub. ft.

This comparison shows that the maximum depth observed in Loch Ericht slightly exceeds that observed in Loch Tay, but in all other respects Loch Tay has the advantage, though as regards length and maximum breadth the two lochs are almost identical.

Loch Tay is over 14½ miles in length, and over one mile in maximum breadth, the mean breadth being nearly three-quarters of a mile, or nearly 5 per cent. of the length. Its waters cover an area of over 6500 acres, or over 10 square miles, and it drains directly an area of about 187½ square miles, but since it receives the outflow from Lochs Dochart and Iubhair, its total drainage-area is over 232 square miles, or nearly

23 times the area of the loch. Nearly 1000 soundings were taken in Loch Tay, and the maximum depth observed was 508 feet. The maximum depth recorded by Mr. Grant-Wilson in 1888, when he took 415 soundings in Loch Tay, was 85 fathoms, or 510 feet. The volume of water contained in the loch is estimated at 56,549,745,000 cubic feet, or over one-third of a cubic mile, and the mean depth at 199 feet, or 39 per cent. of the maximum depth. The length of the loch is 151 times the maximum depth, and 386 times the mean depth.

Loch Tay trends in a north-east and south-west direction, being slightly sinuous in outline, somewhat like the italic letter *f*, as was noted



FIG. 24.—LOCH TAY, FROM KENMORE BRIDGE.

(*Photograph by T. N. Johnston, M.B., C.M., F.R.S.E.*)

in the case of Loch Iubhair, which flows into it. It is extremely simple in conformation, the bottom sloping gradually, without any pronounced irregularities, on all sides down to the deepest part, as is well shown on the longitudinal and cross sections on the map. The 50-foot basin approaches to within less than 400 feet from the south-west end and less than 800 feet from the north-east end, and is  $14\frac{1}{2}$  miles in length. The slope of the bottom is thus steeper at the south-west end than at the north-east end. In the former position a sounding of 65 feet was taken about 750 feet from shore, giving a gradient of 1 in  $11\frac{1}{2}$ , and in the latter position a sounding of 80 feet was taken about 1075 feet from shore, giving a gradient of 1 in  $13\frac{1}{2}$ . The 100-foot basin extends from

about a quarter of a mile from the south-west end to about one-third of a mile from the north-east end, and is very nearly 14 miles in length. The 200-foot basin stretches from about  $1\frac{1}{4}$  miles from the north-east end to about  $2\frac{1}{2}$  miles from the south-west end, and is about 11 miles in length. The main 300-foot basin approaches to within less than two miles from the north-east end, and is over  $7\frac{1}{2}$  miles in length; it is separated, by a slight shoaling of the bottom over an interval of about a mile, from a small subsidiary 300-foot basin (based upon soundings of 301 and 305 feet), which is over half a mile in length. The 400-foot basin is over  $3\frac{1}{2}$  miles in length, lying in the northern half of the loch, and approaching to about  $3\frac{3}{4}$  miles from the north-east end. The deepest part of the loch lies between Skiag on the south-eastern shore and Cragganruar on the north-western shore, about  $5\frac{1}{2}$  miles from the north-east end of the loch, or about 6 miles by road from Kenmore, where there is a small basin over 500 feet in depth, two soundings of 508 feet being recorded about midway between the two shores.

The area of the lake-floor covered by less than 100 feet of water is estimated at about 1972 acres (over 3 square miles), or over 30 per cent. of the total area of the loch; the area between the 100-foot and 200-foot contour-lines is about 1532 acres (nearly  $2\frac{1}{2}$  square miles), or  $23\frac{1}{2}$  per cent.; the area between the 200-foot and 300-foot contours is about 1390 acres (over 2 square miles), or over 21 per cent.; the area between the 300-foot and 400-foot contours is about 1017 acres (over  $1\frac{1}{2}$  square miles), or  $15\frac{1}{2}$  per cent.; the area between the 400-foot and 500-foot contours is over 600 acres (rather less than one square mile), or over 9 per cent.; while the area covered by more than 500 feet of water is about 9 acres, or a small fraction of 1 per cent. of the entire area of the loch. These gradually decreasing areas between the contour-lines drawn in at intervals of 100 feet indicate that the average slope of the bottom becomes steeper and steeper on proceeding from the shore out into deep water; this is also clearly shown by a comparison of the two shallow zones on both sides of the 50-foot contour-line, the area between the shore and the 50-foot line being about 1161 acres, while the area between the 50-foot and 100-foot lines is about 811 acres, or respectively about 18 and  $12\frac{1}{2}$  per cent. of the total area of the loch. The slope of the bottom of the loch is shown on the natural scale and exaggerated five times on the longitudinal and cross sections on the map.

Loch Tay was surveyed on April 29 to May 7, 1902, and the level of the surface of the water was determined by levelling from bench-marks as being 349.1 feet above the sea. The officers of the Ordnance Survey found the level to be 347.9 feet above the sea on August 12, 1899.

*Temperature Observations.*—Many surface temperatures were taken during the progress of the survey from April 29 to May 7, 1902, the readings varying from  $41^{\circ}.8$  Fahr. to  $47^{\circ}.5$ —a range of  $5^{\circ}.7$ . The higher

readings, as a rule, were taken near shore, and the lower readings towards the centre of the loch over deep water. When visited on May 28, 1903, the surface temperature at noon, about a mile from Kenmore, was found to be  $49^{\circ}3$ .

Two serial temperatures were taken beneath the surface in May, 1902, and one series in May, 1903, as given in the following table:—

Depth (feet).	May 1, 1902. Off Ardeonaig.	May 6, 1902. Between Lawers and Fearnan, 4 p.m.	May 28, 1903. 1 mile west of Kenmore, noon.
	°F.	°F.	°F.
0	43·8	42·0	49·3
3	...	...	47·0
5	43·2	42·0	44·5
10	43·2	41·9	44·0
20	42·0	41·9	...
25	...	...	43·1
30	41·9	41·8	...
50	41·7	41·8	42·9
100	41·2	41·7	42·5
150	41·0	...	...
200	40·8	41·2	...
250	40·5	...	...
300	40·3	41·0	...
350	...	41·0	...

It will be seen that on May 1, 1902, the temperature of the water down to 30 feet was higher than on May 6, 1902, while from 50 feet downwards it was lower. The range of temperature between the surface and a depth of 300 feet on May 1 was  $3^{\circ}5$  (from  $40^{\circ}3$  to  $43^{\circ}8$ ), while on May 6 it was only  $1^{\circ}$  (from  $41^{\circ}$  to  $42^{\circ}$ ). On May 28, 1903, the temperature of the water was found to be considerably higher from the surface down to a depth of 100 feet than was observed in the previous May, the range of temperature in the upper 100 feet of water being  $6^{\circ}8$  (from  $42^{\circ}5$  to  $49^{\circ}3$ ).

*Loch Derculich* (see Plate XXVI).—Loch Derculich, situated in Strathtay amid beautiful scenery, affords good fishing, but is strictly preserved; it flows by the Derculich burn into the river Tay to the north-east of Aberfeldy. It is surrounded by low rounded hills covered with heather, and there are few conspicuous boulders, but many small ones. To the north are high, steep hills (Farragon, &c.), with grey screes. The knoll forming the point at the boathouse on the south-eastern shore is high and planted with trees. The burn flows out of the loch by an artificial dam and sluice, which was open on the date of the survey, and the water in the loch was very low, a long gravelly point (not shown on the Ordnance Survey chart) appearing, and the island to the north was nearly, while the island to the south was quite, joined to the shore. Loch Derculich (pronounced Der'clich) is over half a mile

in length from north to south, and also in maximum breadth from east to west, the mean breadth being over a quarter of a mile, or 45 per cent. of the length. Its waters cover an area of over 100 acres, or about one-sixth of a square mile, and it drains an area ten times greater—over  $1\frac{1}{2}$  square miles. About 60 soundings were taken, the maximum depth observed being 70 feet. The volume of water is estimated at 108,333,000 cubic feet, and the mean depth at nearly 25 feet, or 35 per cent. of the maximum depth. The length of the loch is 44 times the maximum depth and 126 times the mean depth. A ridge crosses the loch at the narrowest part near the middle, the greatest depth on which is 34 feet. On both sides of this ridge the water deepens, the maximum depth in the southern basin being 45 feet, while the main deep basin lies to the north of the ridge, the maximum depth of the loch (70 feet) having been found less than a quarter of a mile from the north-eastern angle of the loch, where there is a small 50-foot basin about one-tenth of a mile in length; a short distance to the north-east is an isolated sounding of 50 feet, comparatively close to the north-east shore, separated from the 50-foot basin by a sounding of 38 feet. The 25-foot basin is a continuous area half a mile in length and over a quarter of a mile in breadth. The area of the lake-floor covered by less than 25 feet of water is about  $53\frac{1}{2}$  acres; that covered by water between 25 and 50 feet in depth is about  $44\frac{1}{2}$  acres; while that covered by more than 50 feet of water is about  $2\frac{1}{2}$  acres. Loch Derculich was surveyed on May 27, 1903; the elevation above the sea could not be determined.

*Temperature Observations.*—A series of temperatures was taken in the deepest part of the loch at 8 p.m. on May 27, 1903, with the following results:—

Surface	...	...	...	...	...	...	...	55°·0	Fahr.
10 feet	...	...	...	...	...	...	...	51°·0	„
15	„	...	...	...	...	...	...	49°·0	„
25	„	...	...	...	...	...	...	47°·7	„
50	„	...	...	...	...	...	...	47°·1	„
65	„	...	...	...	...	...	...	47°·0	„
70	„	...	...	...	...	...	...	47°·0	„

The range of temperature from surface to bottom was 8°·0, there being a fall of 4°·0 between the surface and a depth of 10 feet, and a further fall of 3°·3 between 10 and 25 feet. A comparison of these temperatures with those taken in Lochs Daimh and Giorra on the previous day shows that the water in Loch Derculich was much warmer from surface to bottom than in the two lochs referred to: at the surface the temperature was about 5°, and at 10 feet 3° to 4° higher; at the bottom it was 4° higher than at the bottom of Loch Daimh, and 1° higher than at the bottom of Loch Giorra at a much less depth.

*Loch Scoly* (see Plate XXVI.).—Loch Scoly, a small hill loch in

Strathtay, lying to the north-east of Loch Kennard and west of Loch Skiach, and flowing by the Balnaguard burn into the river Tay shortly before its junction with the river Tummel, is over a quarter of a mile in length, with a maximum breadth of about one-eighth of a mile, the mean breadth being about one-sixteenth of a mile or 21 per cent. of the length. Its waters cover an area of about  $11\frac{1}{2}$  acres, and it drains an area 13 times greater, or about a quarter of a square mile. Twenty-five soundings were taken, the maximum depth observed being 12 feet. The volume of water is estimated at 2,888,000 cubic feet, and the mean depth at nearly  $5\frac{3}{4}$  feet, or 48 per cent. of the maximum depth. The length of the loch is 123 times the maximum depth, and 258 times the mean depth. The loch forms a simple basin; the deeper water is found towards the southern end, the three soundings exceeding 10 feet being centrally placed in the southern half of the loch. Only three soundings were taken under 5 feet close to the shore, so that the slope of the bottom is on the whole moderately steep. The area of the lake-floor covered by less than 10 feet of water is over 10 acres, or 88 per cent. of the total area of the loch, and only a small proportion of this area is covered by less than 5 feet of water. Loch Scoly was surveyed on May 29, 1903. The temperature of the surface water was  $63^{\circ}0$  Fahr., and a reading at 5 feet gave the same result, while a reading at 10 feet gave  $56^{\circ}0$ —a fall of  $7^{\circ}0$  in the temperature of the water at 10 feet as compared with that at 5 feet.

*Loch Ordie* (see Plate XXVI.).—Loch Ordie is a very pretty loch situated amid grouse-moors to the east of the river Tay, and surrounded by wooded hills; it is a good trouting loch, but strictly preserved. It trends in an east-and-west direction, being widest towards the west end and narrowing somewhat towards the east end. It is nearly two-thirds of a mile in length, and nearly half a mile in maximum breadth, the mean breadth being over a quarter of a mile, or 44 per cent. of the length. Its waters cover an area of about 116 acres, or nearly one-fifth of a square mile, and it drains an area nearly 24 times greater—over  $4\frac{1}{4}$  square miles. Sixty-five soundings were taken, the maximum depth observed being 69 feet. The volume of water is estimated at 133,110,000 cubic feet, and the mean depth at  $26\frac{1}{3}$  feet, or 38 per cent. of the maximum depth. The length of the loch is 49 times the maximum depth, and 128 times the mean depth. Loch Ordie is extremely simple in conformation, the bottom sinking gradually on all sides down to the greatest depth, which is approximately centrally placed, though rather nearer the west than the east end. The 25-foot basin is about two-fifths of a mile in length and over a quarter of a mile in maximum width, while the 50-foot basin is about a quarter of a mile in length and one-seventh of a mile in maximum width. The area of the lake-floor covered by less than 25 feet of water is about 66 acres, or 57 per cent.

of the total area of the loch; that covered by water between 25 and 50 feet in depth is about 34 acres, or 29 per cent.; while that covered by over 50 feet of water is about 16 acres, or 14 per cent. of the entire area of the loch. Loch Ordie was surveyed on June 3, 1903, and the level of the surface of the water was determined by levelling from bench-mark as being 946·3 feet above the sea.

*Temperature Observations.*—Serial temperatures taken in the deepest part of the loch gave the following results:—

Surface	...	...	...	...	...	...	...	57°·6	Fahr.
10 feet	...	...	...	...	...	...	...	55°·3	„
15	„	...	...	...	...	...	...	49°·5	„
25	„	„	...	...	...	...	...	47°·1	„
50	„	...	...	...	...	...	...	45°·7	„
68	„	„	...	...	...	...	...	45°·4	„

The range of temperature from surface to bottom was 12°·2, there being a fall of 5°·8 between 10 and 15 feet.

*Loch na Craige* (see Plate XXVI.).—Loch na Craige (or na-Craig), one of the best trout lochs in the district, is situated in Strathtay about 3 miles to the south-east of Aberfeldy, and flows into the river Bran by the Cochill burn, which also receives the outflow from Loch Hoil. It is surrounded by low, heather-clad hills covered with stony debris. It is nearly half a mile in length, nearly one-eighth of a mile in maximum breadth, the mean breadth being about one-twelfth of a mile, or 16 per cent. of the length. The waters of the loch cover an area of about 24 acres, and it drains an area fourteen times greater, or more than half a square mile. Nearly 30 soundings were taken, the maximum depth observed being 13 feet. The volume of water is estimated at 7,871,000 cubic feet, and the mean depth at nearly 7½ feet, or 57 per cent. of the maximum depth. The length of the loch is 195 times the maximum depth, and 342 times the mean depth. Loch na Craige is a long, narrow depression trending in a north-west and south-east direction, or nearly north and south. It forms a simple basin, the deep water running along the centre of the loch, the area covered by more than 10 feet of water being over one-third of a mile in length, but it is rather curious to note that the maximum depth of 13 feet was found at the extreme southern end of the 10-foot basin and comparatively very close to the southern shore. The slope of the bottom is thus pretty steep here, and in other places the slope is steep; for instance, two soundings of 11 feet were taken about 60 feet from shore, one off the western and one off the eastern shore, giving a slope of 1 in 5·5. About 63 per cent. of the lake-floor, or about 15¼ acres, is covered by less than 10 feet of water. Loch na Craige was surveyed on May 29, 1903; the elevation of the surface of the water was determined by levelling from bench-mark as being 1297·3 feet above the sea.

*Temperature Observations.*—Temperatures were taken in the deepest part of the loch, with the following results:—

Surface ... ..	60°·0 Fahr.
5 feet ... ..	60°·0 „
10 „ ... ..	56°·5 „

*Loch Kennard* (see Plate XXVI).—Loch Kennard, a good fishing loch abounding with small trout, is situated in Strathtay, and flows into the river Bran by the Ballinloan burn. Its shores are nearly all wooded, and where not planted with trees the low hills are covered with heather. It is peculiar in outline, somewhat resembling that of a young mushroom, the stem pointing west and the apex of the crown pointing north-east. It is over two-thirds of a mile in length, and over one-third of a mile in maximum breadth, the mean breadth being over one-sixth of a mile, or 26 per cent. of the length. Its waters cover an area of about 77 acres, or nearly one-eighth of a square mile, and it drains an area seven times greater, or nearly nine-tenths of a square mile. Nearly 50 soundings were taken, the maximum depth observed being 72 feet. The volume of water is estimated at 108,439,000 cubic feet, and the mean depth at  $32\frac{1}{4}$  feet, or 45 per cent. of the maximum depth. The length of the loch is 50 times the maximum depth and 111 times the mean depth. Loch Kennard forms a simple basin, with here and there minor undulations of the bottom. The deepest water (72 feet) is found in the centre of the widest part of the loch, to the east of the constriction in its outline; in the middle of this constriction a depth of 70 feet was found, but immediately to the west the bottom rises to 50 feet beneath the surface, and falls again further west to a depth of 63 feet. The 25-foot basin is half a mile in length and over a quarter of a mile in maximum width, while the 50-foot basin is over one-third of a mile in length. The area of the lake-floor covered by less than 25 feet of water is nearly 30 acres, or 38 per cent. of the entire area of the loch; that covered by water between 25 and 50 feet in depth is about 33 acres, or 43 per cent.; while that covered by more than 50 feet of water is over 14 acres, or 19 per cent. of the total area of the loch. These figures show that the average slope is steeper between the shore and the 25-foot contour-line than between the 25-foot and 50-foot contours. Loch Kennard was surveyed on May 29, 1903; the elevation of the surface of the water above the sea was not determined.

*Temperature Observations.*—Temperatures were taken in the deepest part of the loch, with the following results:—

Surface ... ..	56°·7 Fahr.
5 feet ... ..	51°·0 „
10 „ ... ..	48°·3 „
25 „ ... ..	46°·0 „
50 „ ... ..	45°·5 „
72 „ ... ..	45°·3 „

The range in the temperature of the water from surface to bottom was thus  $11^{\circ}4$ , the fall of temperature between the surface and a depth of 5 feet amounting to  $5^{\circ}7$ , that between 5 and 10 feet amounting to  $2^{\circ}7$ , and that between 10 and 25 feet to  $2^{\circ}3$ . A comparison of these temperatures with those taken in Loch Derculich two days previously shows that the temperature of the whole body of water in Loch Kennard was lower than that in Loch Derculich (except at the surface—which may be due to the fact that the observations in Loch Kennard were made in the early afternoon, while those in Loch Derculich were taken in the late evening).

*Loch Skiach* (see Plate XXVI.).—Loch Skiach, situated in Strath-tay, containing large trout as well as pike, flows into Little Loch Skiach (which was not sounded) by a short burn with a slight fall, and thence by the Pitleoch burn into the Ballinloan burn shortly before it joins the river Bran. It is surrounded by low, rounded, heather-clad hills with scattered boulders, and the shores are of clean shingle with boulders. It is very irregular in outline, the longer axis being nearly north and south, and the bottom is also irregular. It is over three-quarters of a mile in length, and nearly half a mile in maximum breadth, the mean breadth being nearly one-fifth of a mile, or 25 per cent. of the length. Its waters cover an area of about 98 acres, or over one-seventh of a square mile, and it drains an area six times greater—an area of nearly one square mile. Eighty-five soundings were taken in Loch Skiach, the maximum depth observed being 55 feet. The volume of water is estimated at 77,185,000 cubic feet, and the mean depth at 18 feet, or 33 per cent. of the maximum depth. The length of the loch is 75 times the maximum depth, and 228 times the mean depth. Near the middle a ridge crosses the loch from south-east to north-west, on which the depth is less than 20 feet; this ridge separates the two deep basins, of which the southerly one is the deeper, the maximum depth of 55 feet having been recorded about a quarter of a mile from the southern end of the loch, while the greatest depth recorded in the northern basin was 45 feet in two places. The two 25-foot basins are each under a quarter of a mile in length. Near the middle of the loch the slope of the bottom is very steep in places—for instance, a sounding of 33 feet was taken off the eastern shore at a distance of about 100 feet, giving a slope of 1 in 3, and a sounding of 26 feet about the same distance off the western shore gives a slope of 1 in 3·8. The area of the lake-floor covered by less than 25 feet of water is about 77 acres, or 79 per cent. of the total area of the loch; that covered by water between 25 and 50 feet in depth is about 20 acres, or 20 per cent.; while that covered by more than 50 feet of water is only about  $1\frac{1}{4}$  acres, or 1 per cent. Loch Skiach was surveyed on June 12, 1903, and the level of the surface of the water was determined by levelling from bench-mark as being 1385·7 feet above the sea.

*Temperature Observations.*—The temperature of the surface water on commencing the survey at 9 a.m. on June 12, 1903, was 59°·0 Fahr. Later in the day serial temperatures were taken in the deepest part of the loch, with the following results:—

Surface ... ..	60°·0 Fahr.
10 feet ... ..	59°·0 "
15 " ... ..	55°·3 "
20 " ... ..	49°·2 "
30 " ... ..	49°·0 "
45 " ... ..	48°·0 "
55 " ... ..	47°·5 "

The range in the temperature of the water from surface to bottom was thus 12°·5; between the surface and a depth of 10 feet the fall was only 1°, but between the depths of 10 and 20 feet the fall of temperature amounted to nearly 10°—3°·7 between 10 and 15 feet, and 6°·1 between 15 and 20 feet. These readings are all higher than those taken in Lochs Kennard and Derculich about a fortnight earlier in the season.

*Loch Broom* (see Plate XXVII.).—Loch Broom, a fine trout loch, but strictly preserved, lies to the east of the river Tummel, into which it flows by the Lochbroom burn to the north of Ballinluig, before the river Tummel joins the river Tay. It is nearly three-quarters of a mile in length, and over one-third of a mile in maximum breadth, the mean breadth being nearly one-fifth of a mile. Its waters cover an area of about 86 acres, or over one-eighth of a square mile, and it drains an area of 3½ square miles—an area 26 times greater than the area of the loch. Over 60 soundings were taken in Loch Broom, the maximum depth observed being 9 feet. The volume of water contained in the loch is estimated at 18,813,000 cubic feet, and the mean depth at 5 feet, or 56 per cent. of the maximum depth. The length of the loch is 422 times the maximum depth, and 757 times the mean depth.

Loch Broom is very shallow, being simply a large bog-hole, or depression in the moorland, with shores of yellow sandy debris covered by peat, and all heather clad. The outflow is over a dam about 5 feet high, so that the greater part of the loch must be artificial. Where the depth is less than 5 feet the bog-bean is everywhere seen, and there are numerous islets—some of peat, others chiefly of bog-bean—on several of which gulls nest. The deeper water (over 5 feet) lies to the east and north of the islets, the maximum depth of 9 feet having been observed in several places towards the eastern shore; along the western shore and around the islets the bottom is covered by less than 5 feet of water, but at the outflow, where the waters of the loch pass into Lochbroom burn, two soundings of 5 feet were taken. The area of the lake-floor covered by less than 5 feet of water is about 38 acres, or 44 per cent. of the entire area of the loch, while that covered by more than 5 feet of water

is about 48 acres, or 56 per cent. Loch Broom was surveyed on June 11, 1903, but the elevation above the sea could not be determined. Drift-marks were observed 3 feet above the level of the water on the date surveyed.

The temperature of the surface water on commencing the survey at noon on June 11, 1903, was 60°·0 Fahr., and two readings in open water—one at the surface and one at a depth of 8 feet—gave in each case 60°·8.

*Loch Essan* (see Plate XXVII.).—Loch Essan (or Easain), a hill loch lying to the north of Loch Dochart, containing dark-coloured trout of rare quality, but strictly preserved, flows by the Allt Essan into the river Dochart after it leaves Loch Iubhair. It is nearly half a mile in length, and over one-fifth of a mile in maximum breadth, the mean breadth being about one-ninth of a mile. Its waters cover an area of about 32 acres, and it drains an area of over 1½ square miles—an area 32 times greater than the area of the loch. Over 40 soundings were taken in Loch Essan, the maximum depth observed being 18 feet. The volume of water is estimated at 9,664,000 cubic feet, and the mean depth at nearly 7 feet, or 38 per cent. of the maximum depth. The length of the loch is 135 times the maximum depth, and 356 times the mean depth. The loch trends in an east and west direction, and is very irregular in outline. The bottom is also irregular, forming three small basins with depths exceeding 10 feet, the westernmost being the deepest, the maximum depth of 18 feet having been observed about one-sixth of a mile from the west end of the loch. To the east of this western deep basin, and near the centre of the loch, lies a heap of stones around which soundings of 6 feet were taken. A little farther to the east lies the central 10-foot basin, based on a sounding of 11 feet. To the east of the central basin there is a constriction in the outline of the loch in which soundings of 7 and 8 feet were taken, and on approaching the east end the loch widens out, and the bottom sinks to form the third (eastern) 10-foot basin, the maximum depth in which is 16 feet. To the south of this eastern basin is a small island, the passage between the island and the shore being obstructed by weeds, and weeds are also abundant along the northern shore. The area of the lake-floor covered by less than 10 feet of water is about 26 acres, or 81 per cent. of the total area of the loch, while that covered by more than 10 feet of water is about 6 acres, or 19 per cent. Loch Essan was surveyed on June 16, 1903, the elevation of the surface of the water being estimated at about 1440 feet above sea-level.

*Lochan Breaclauch* (see Plate XXVII.).—Lochan Breaclauch (or Loch-an-Breacklauch), a hill loch containing fine trout, flows into Loch Tay near its south-west end by the Allt na Breaclauch. It is peculiar



Allt na Breaclauch. It trends in a north and south direction, and is extremely simple in outline and conformation; it is oblong in outline, and of nearly uniform width throughout. It is nearly three-quarters of a mile in length, and over one-eighth of a mile in maximum breadth, the mean breadth being one-tenth of a mile, or 14 per cent. of the length. Its waters cover an area of about  $47\frac{1}{2}$  acres, and it drains an area 16 times greater, or about  $1\frac{1}{8}$  square miles. Over 40 soundings were taken, the maximum depth observed being 39 feet. The volume of water is estimated at 22,682,000 cubic feet, and the mean depth at 11 feet, or 28 per cent. of the maximum depth. The length of the loch is 99 times the maximum depth, and 350 times the mean depth. The northern portion of the loch is shallow, and water deepening gradually on proceeding southwards until the maximum depth is encountered about one-eighth of a mile from the southern end, thence the water shallows rapidly towards the south end. The 10-foot basin is about half a mile in length, extending from near the south end to within one-sixth of a mile from the north end. The 25-foot basin is contained in the southern half of the loch, and is about a quarter of a mile in length. The area of the lake-floor covered by less than 10 feet of water is over 29 acres, or 62 per cent. of the entire area of the loch, while that covered by more than 10 feet of water is over 18 acres, or 38 per cent., of which 8 per cent. exceeds 25 feet in depth. Lochan na Lairige was surveyed on June 16, 1903; the surface of the water was estimated at about 1595 feet above the level of the sea.

*Lochs Daimh and Giorra.*—Lochs Daimh and Giorra, situated in the wilds of Glenlyon, amid grand and mountainous scenery, are good trouting lochs, but strictly preserved. Loch Daimh flows into Loch Giorra by a short river, and the outflow from both lochs is carried into the river Lyon by the Allt Conait. To the south, on the flanks of Stuchd an Lochain, lies the small Lochan nan Cat, at an elevation of over 2000 feet above the sea, which flows into the river between Lochs Daimh and Giorra. It being reported that this little lochan was frozen over a few days before the date of the survey of Lochs Daimh and Giorra, it was visited in the hope of taking soundings through holes in the ice, but the ice had disappeared. It was apparently shallow all round the shore, except where there are screes from the cliffs, and, if at all deep, it must be over a very limited area. The temperature of the water was  $53^{\circ}0$  Fahr., while a reading taken close under the crags beside the snow gave  $49^{\circ}8$ .

*Loch Daimh* (see Plate XXVII.).—Loch Daimh (or Damh) trends in an east-and-west direction, being widest and deepest towards the west end, narrowing and shallowing towards the east end. It is nearly a mile in length, and nearly one-third of a mile in maximum breadth, the mean breadth being nearly one-fifth of a mile, or 19 per cent. of

the length. Its waters cover an area of about 111 acres, or over one-sixth of a square mile, and it drains an area nearly 30 times greater, or over 5 square miles. Nearly 60 soundings were taken, the maximum depth observed being 95 feet. The volume of water is estimated at 189,623,000 cubic feet, and the mean depth at 39 feet, or 41 per cent. of the maximum depth. The length of the loch is 53 times the maximum depth and 130 times the mean depth. The loch is of simple conformation, and, on the whole, comparatively deep, only half a dozen soundings under 10 feet being recorded close to the shore. Off the northern shore, towards the west end, the slope of the bottom is very steep, soundings of 31 feet and 44 feet having been taken about 80 and 100 feet from the shore respectively; this is equal to a slope of 1 in 2·3 to 2·6. The eastern end, and south-eastern portion of the loch around the island, are comparatively shallow. The 25-foot basin is about three-quarters of a mile in length, stretching from quite close to the west end to within one-sixth of a mile from the east end. The 50-foot basin is nearly half a mile in length, and the 75-foot basin, occupying the western half of the loch, is over one-third of a mile in length. The maximum depth of 95 feet was observed in two places approximately near the centre of the wide western portion of the loch. The area of the lake-floor covered by less than 25 feet of water is about 50½ acres, or over 45 per cent. of the total area of the loch; that covered by water between 25 and 50 feet in depth is about 21½ acres, or over 19 per cent.; that covered by water between 50 and 75 feet in depth is about 19 acres, or 17 per cent.; and that covered by more than 75 feet of water is about 20½ acres, or over 18 per cent. of the entire area of the loch. The flat-bottomed character of the deep western portion of the loch is well brought out by a comparison of the last two percentages, while the high percentage of the bottom covered by less than 25 feet of water is due to the comparatively large shallow area in the south-eastern and eastern part of the loch. Loch Daimh was surveyed on May 26, 1903, but the level of the surface of the water above the sea could not be determined.

*Temperature Observations.*—The temperature of the surface water on commencing the survey at 9.30 a.m. on May 26, 1903, was 51°·0 Fahr., and a series of temperatures taken in the deepest part of the loch gave the following results:—

Surface	...	...	...	...	...	...	...	50°·3	Fahr.
10 feet	...	...	...	...	...	...	...	47°·0	„
25 „	...	...	...	...	...	...	...	44°·0	„
50 „	...	...	...	...	...	...	...	43°·5	„
90 „	..	...	...	...	...	...	...	43°·0	„

The range in the temperature of the water from surface to bottom was thus 7°·3. The fall of temperature from the surface to a depth of 10 feet amounted to 3°·3, and that between the depths of 10 and 25 feet amounted to 3°·0, and below 25 feet the fall amounted to 1°·0.

*Loch Giorra* (see Plate XXVII.).—Loch Giorra (or Girre) trends almost east and west; there is a slight bend near the middle of the loch, the eastern half trending north-west and south-east. It is over four-fifths of a mile in length, with a maximum breadth of over a quarter of a mile, the mean breadth being about one-sixth of a mile, or 20 per cent. of the length. Its waters cover an area of about  $88\frac{1}{2}$  acres, or less than one-seventh of a square mile, and it drains directly an area of over  $5\frac{1}{2}$  square miles, but, since it receives the outflow from Loch Daimh, its total drainage area is over  $10\frac{3}{4}$  square miles—an area 78 times greater than the area of the loch. Fifty-five soundings were taken in Loch Giorra, the maximum depth observed being 49 feet. The volume of water is estimated at 83,686,000 cubic feet, and the mean depth at nearly 22 feet, or 44 per cent. of the maximum depth. The length of the loch is 88 times the maximum depth, and 200 times the mean depth.

The floor of Loch Giorra is rather irregular. The deepest part is in the western half, the maximum depth of 49 feet having been observed about one-sixth of a mile from the west end. The 25-foot basin in this part of the loch is about two-fifths of a mile in length, and towards the east end there is a second 25-foot basin about one-fifth of a mile in length, in which the maximum depth is 40 feet. These two basins are separated by a remarkable rise of the bottom, on which depths of 15 and 18 feet were recorded, surrounded on all sides by deeper water. The area of the lake-floor covered by less than 20 feet of water is nearly 43 acres, or over 48 per cent. of the total area of the loch; that covered by water between 20 and 40 feet in depth is nearly 38 acres, or about  $42\frac{1}{2}$  per cent.; while that covered by more than 40 feet of water is over 8 acres, or over 9 per cent. Loch Giorra was surveyed on the same day as Loch Daimh (May 26, 1903); its elevation above the sea could not be determined.

*Temperature Observations.*—A series of temperatures taken in the deepest part of the loch gave the following results:—

Surface ... ..	50° 0 Fahr.
10 feet ... ..	48° 0 „
25 „ ... ..	46° 8 „
45 „ ... ..	46° 0 „

A comparison of these temperatures with those taken in Loch Daimh later in the day shows that, while the surface temperature in each loch was nearly identical, the temperature of the water beneath the surface was lower in the deeper loch: thus at 10 feet the temperature in Loch Daimh was 1° 0 lower than in Loch Giorra, at 25 feet it was 2° 8 lower, and at 50 feet it was 2° 5 lower than at 45 feet in Loch Giorra.

*Loch Bhac* (see Plate XXVIII.).—Loch Bhac (Bhaic, or Vach) lies to the north of Loch Tummel, and flows by the Allt Bhaic into the river

Garry between Struan and Blair Atholl. It contains fine trout, but the fishing is strictly preserved. It is surrounded by low, heather-clad hills, which slope gradually up from the shores of the loch. There are few weeds, and the bottom is sandy, or (in parts) gravelly. Loch Bhac trends in a north-east and south-west direction, and is extremely simple in outline and in conformation. It is over one-third of a mile in length, and one-sixth of a mile in maximum breadth, the mean breadth being over one-eighth of a mile, or 33 per cent. of the length. Its waters cover an area of about 31 acres, or one-twentieth of a square mile, and it drains an area thirty-six times greater, or nearly 2 square miles. About 30 soundings were taken, the maximum depth observed being 42 feet. The volume of water contained in the loch is estimated at 22,104,000 cubic feet, and the mean depth at  $16\frac{1}{2}$  feet, or 39 per cent. of the maximum depth. The length of the loch is 48 times the maximum depth, and 122 times the mean depth. Loch Bhac forms a simple basin, the bottom sloping gradually down on all sides to the deepest part, which is approximately centrally placed, but rather nearer to the southern end and to the eastern shore, where the slope of the bottom is steeper than at the northern end and off the western shore. The area of the lake-floor covered by less than 10 feet of water is about 16 acres, or 51 per cent. of the entire area of the loch; that covered by water between 10 and 25 feet in depth is about 8 acres, or 25 per cent.; and that covered by more than 25 feet of water is about 7 acres, or 24 per cent. of the total area of the loch. Loch Bhac was surveyed on July 6, 1903, but the elevation of its surface above the sea could not be determined from bench-mark, though from a spot-level at the north end of the loch it is apparently slightly under 1070 feet. The water rises and falls very little, the range being probably less than 1 foot. On commencing the survey at 6.15 p.m., the temperature of the surface water was  $53^{\circ}0$  Fahr., and in the centre of the loch a little later readings at the surface, at 25 feet, and at 40 feet gave identical results,  $45^{\circ}0$ .

*Loch Con* (see Plate XXVIII.)—Loch Con (Chon, or Choin) lies to the east of Loch Garry, and flows by the Allt Choin into Erochy water, which joins the river Garry at Struan. It was formerly a good trout loch, but now contains many pike, which are supposed to have been maliciously introduced. Its gradually sloping shores are heather-clad, with few large boulders. There are trees on the islands and on the promontory at the west end. The outflowing burn goes through a large flat mass of moraine debris, which extends far down the burn. The loch trends in an east and west direction, and is extremely irregular in outline, being almost divided into two portions by a narrow constriction near the middle. It is nearly a mile in length, and over a quarter of a mile in maximum breadth, the mean breadth being over one-tenth of a mile, or  $11\frac{1}{2}$  per cent. of the length. Its waters cover an area of about

65 acres, or one-tenth of a square mile, and it drains an area of over  $3\frac{1}{2}$  square miles—an area 37 times greater than the area of the loch. Over 60 soundings were taken, the maximum depth observed being 9 feet. The volume of water contained in the loch is estimated at 9,818,000 cubic feet, and the mean depth at  $3\frac{1}{2}$  feet, or 39 per cent. of the maximum depth. The length of the loch is 550 times the maximum depth and 1430 times the mean depth. Loch Con is very shallow, and the central constriction cuts it into two basins, the deepest water being found near the east end, where two soundings of 9 feet were taken, while a sounding of 8 feet was taken in the basin to the north-west of the constriction. The area of the lake-floor covered by less than 5 feet of water is about 51 acres, or 78 per cent. of the total area of the loch. Loch Con was surveyed on July 4, 1903, but the level above the sea could not be determined with certainty because of the disparity between the spot-levels around the loch. The loch was about its lowest on the date of the survey, and drift-marks were observed about 3 feet above the water. The temperature of the surface water on commencing the survey at 3 p.m. was  $54^{\circ}3$  Fahr., and at 5 p.m. readings at the surface and at a depth of 8 feet both gave  $55^{\circ}0$ .

*Loch Tilt* (see Plate XXVIII).—Loch Tilt, at the head of the glen of that name, consists in reality of two lochs, a broad burn flowing from the larger (northern) loch to the smaller loch, which is about one foot lower and full of weeds. The larger loch is nearly half-filled with weeds (*Equisetum*), and the bottom is stony where free from weeds. The shore is stony, and the loch is surrounded by an almost flat terrace of peat with stones, with high, rounded, heather-clad hills on the west side. Loch Tilt is over one-third of a mile in length, and one-fifth of a mile in maximum breadth, the mean breadth being about one-thirteenth of a mile, or 22 per cent. of the length. Its waters cover an area of about 17 acres, and it drains an area twenty-one times greater—an area of nearly two-thirds of a square mile. Over 20 soundings were taken, the maximum depth observed being 5 feet. The volume of water is estimated at 1,839,000 cubic feet, and the mean depth at  $2\frac{1}{2}$  feet, or 50 per cent. of the maximum depth. Loch Tilt is shallow, the great majority of the soundings giving depths of 3 and 4 feet, only two soundings of 2 feet and two soundings of 5 feet being recorded. The deeper water occurs off the eastern shore, one sounding of 5 feet having been taken about 60 feet from that shore, giving a gradient of 1 in 12. Weeds are abundant off the south-western shore, and in the northern angle of the loch, where there are many large stones in the water. Loch Tilt was surveyed on July 9, 1903, and the level of the surface was determined, by levelling from bench-mark, as being 1653.5 feet above the sea. The water in the loch was low, and drift-marks were

observed about a foot above the water. The surface temperature at 6 a.m. on the date of the survey was 54°·0.

*Loch Moraig* (see Plate XXVIII.).—Loch Moraig is an artificial loch, having been originally an old snipe marsh banked up on the south; it flows by a short stream (the Allt Chluain) into the river Garry, between Blair Atholl and Killiecrankie. It is well stocked with fine trout, but the fishing is strictly preserved. The surrounding grassy hills slope gently up from the loch. It trends in a north and south direction, and is very irregular in outline, being widest at the southern end, while the northern end is narrow and filled with weeds. It is over half a mile in length, and over a quarter of a mile in maximum breadth, the mean breadth being over one-tenth of a mile, or 19 per cent. of the length. Its waters cover an area of 37 acres, or about one-seventeenth of a square mile, and it drains an area of over 2 square miles—an area thirty-five times greater than the area of the loch. About 40 soundings were taken, the maximum depth observed being 14 feet. The volume of water contained in the loch is estimated at 8,921,000 cubic feet, and the mean depth at 5½ feet, or 40 per cent. of the maximum depth. The length of the loch is 207 times the maximum depth, and 524 times the mean depth. Loch Moraig is on the whole shallow, only four soundings exceeding 10 feet being recorded. The deepest water was found at the southern end near the outflow, the maximum depth of 14 feet being taken about 60 feet from the southern shore, giving a slope of 1 in 4·3; in this place soundings of 12 and 11 feet were also taken, and in the northern half of the loch an isolated sounding of 10 feet was recorded. The area of the lake-floor covered by less than 10 feet of water is about 34 acres, or 92 per cent. of the total area of the loch. Loch Moraig was surveyed on July 7, 1903, but the elevation above the sea was not determined; from spot-levels the elevation is probably about 1105 feet. On the date of the survey the water in the loch was high owing to recent rains, and the embankment was only a foot or two above the loch, so that the water could rise only a very little higher.

*Temperature Observations.*—On commencing the survey at 11 a.m., the temperature of the surface water was 52°·0 Fahr. Temperatures taken in the deepest part of the loch gave the following results:—

Surface ... ..	52°·2 Fahr.
8 feet ... ..	51°·8 „
14 „ ... ..	51°·4 „

*Loch Loch* (see Plate XXVIII.).—Loch Loch, a good trout loch, and containing char also, is situated amid wild mountainous scenery, the hills on both sides being very steep—Ben-y-gloe on the west, and the precipitous crags of Craig an Loch on the east. Mounds of gravelly morainic debris occupy the greater part of both shores, forming the

prominent points. It flows northward by the An Lochain into the river Tilt, which also receives the waters from Loch Tilt at the head of the glen. It trends almost due north and south, and is a long narrow loch, or rather two lochs, there being a very narrow constriction near the middle dividing it into two portions; the two lochs were quite distinct on the date of the survey, with a difference in level of about half a foot. It is about  $1\frac{1}{4}$  miles in length, the southern portion being half a mile, and the northern portion three-quarters of a mile in length, and about one-sixth of a mile in maximum breadth, the mean breadth being about one-tenth of a mile, or 8 per cent. of the length. Its waters cover an area of about 81 acres, or one-eighth of a square mile, and it drains an area of about  $2\frac{1}{2}$  square miles, an area nineteen times greater than that of the loch. One hundred soundings were taken, the maximum depth observed being 81 feet. The volume of water contained in the loch is estimated at 103,197,000 cubic feet, and the mean depth at over 29 feet, or 36 per cent. of the maximum depth. The length of the loch is 80 times the maximum depth and 222 times the mean depth. Loch Loch is peculiar in outline and in conformation. Besides the principal central constriction, which cuts the loch into two approximate halves, there are three minor constrictions, each accompanied by a shoaling of the bottom; the most important of these divides the southern half of the loch into two basins, the more southerly of which has a maximum depth of 40 feet, while the maximum depth in the second basin is 53 feet. But the greatest depth of the loch is found in the northern half, about one-fifth of a mile above the central constriction, where the loch is widest. Here the maximum depth of the loch (81 feet) occurs, approximately centrally placed, but rather nearer the western than the eastern shore, and here the slope of the bottom is very steep, a sounding of 80 feet having been taken about 200 feet off the western shore, giving a gradient of 1 in  $2\frac{1}{2}$ , while a sounding of 75 feet was taken about the same distance off the eastern shore. From the position of maximum depth the water shoals, and the loch narrows, gradually towards the northern end. The area of the lake-floor covered by less than 25 feet of water is about 45 acres, or 55 per cent. of the total area of the loch; that covered by water between 25 and 50 feet in depth is about 21 acres, or 26 per cent.; that covered by water between 50 and 75 feet in depth is about 10 acres, or 13 per cent., and that covered by more than 75 feet of water is about 5 acres, or 6 per cent. of the entire area of the loch. Loch Loch was surveyed on July 9, 1903, but the elevation above the sea could not be determined from bench-mark; from a spot-level of 1480 feet a short distance up the inflowing burn, the elevation is probably about 1450 feet. There was no evidence that the loch rises more than a foot higher than on the date surveyed.

*Temperature Observations.*—Serial temperatures were taken in the two halves of the loch: (1) in 40 feet of water near the southern end

of the loch, and (2) in the deepest part of the northern portion of the loch, with the following results:—

				Southern half.	Northern half.
Surface	...	...	...	52·5	51·7
5 feet	...	...	...	51·7	...
10 "	...	...	...	51·2	...
20 "	...	...	...	51·2	...
25 "	...	...	...	...	50·8
40 "	...	...	...	51·0	...
50 "	...	...	...	...	50·0
75 "	...	...	...	...	49·5

These observations indicate a lower temperature throughout the deeper water in the northern half, as compared with the shallower water in the southern half of the loch; the range of temperature in the 40 feet of water near the southern end amounts to 1°·5, as compared with a range of 2°·2 in the 75 feet of water in the northern portion of the loch.

*Loch nan Eun* (see Plate XXVIII.).—Loch nan Eun (or na-Nean), a beautiful but lonely little loch at the head of Glen Taitneach (or the Pleasant Glen) amid extremely wild scenery, is well stocked with trout said to be as fine as in any river or loch in Scotland. It flows into the Shee water at the head of Glenshee. It is surrounded by high hills with rounded tops, and grey with bare rock or screes. Its shores are peaty, with many small stones and a few large ones. Loch nan Eun trends in a north-east and south-west direction, and is very peculiar in outline, consisting of a subcircular body with a broad arm, in which are two comparatively large islands, and a short narrow arm extending towards the north-east. It is nearly half a mile in length, and nearly a quarter of a mile in maximum breadth, the mean breadth being one-eighth of a mile, or 28 per cent. of the length. Its waters cover an area of about 37 acres, and it drains an area five times greater, or about one-third of a square mile. Over 50 soundings were taken, the maximum depth observed being 50 feet. The volume of water is estimated at about 34,459,000 cubic feet, and the mean depth at 21½ feet, or 43 per cent. of the maximum depth. The length of the loch is 47 times the maximum depth, and 110 times the mean depth. Loch nan Eun is comparatively deep, considering its superficial area, and the soundings reveal some interesting irregularities of the bottom; for instance, the line of soundings taken across the widest and deepest part of the loch from west to east shows that the bottom sinks gradually off the western shore to 15, then 46, and then 50 feet (the maximum depth of the loch, situated about 300 feet from the western shore), thence rising rapidly to 29 feet, sinking gradually to 32 and 33 feet, then rising sharply again to 12 feet, and finally sinking to 26 feet at a distance of about 50

feet from the eastern shore. The last sounding indicates a very steep slope in this position, equal to 1 in 1·9, and off the western shore further north a similar steep gradient is indicated by a sounding of 36 feet taken about 100 feet from the shore, equal to 1 in 2·8. The soundings reveal, further, an ill-defined shallow ridge, running in a north and south direction across the wide portion of the loch, covered by less than 30 feet of water, with deeper water on both sides. The area of the lake-floor covered by less than 25 feet of water is about 23 acres, or 64 per cent. of the entire area of the loch. Loch nan Eun was surveyed on July 2, 1903; its elevation above the sea could not be determined from bench-mark, but, estimated from spot-levels, its elevation must be about 2575 feet. There is evidently very little variation in the level of the surface of the water, since no drift-mark indicating a higher level could be seen, and a fall of a few inches would cease to feed the outflowing burn, which forms a waterfall a few yards from the loch, the top of the fall being at nearly the same level as the loch.

*Temperature Observations.*—The temperature of the surface water on commencing the survey at 10.30 a.m. was 50°·0, and a series of temperatures taken at noon in the deepest part of the loch gave the following results:—

Surface	...	...	...	...	...	...	...	50°·8	Fahr.
25 feet	...	...	...	...	...	...	...	50°·5	„
45	„	...	...	...	...	...	...	49°·8	„

Lochs Craiglush, Lowes, Butterstone, Clunie, Drumellie, Rae, Fingask, White, Black, and the Stormont lochs form a connected series of lochs all draining into the Lunan burn, which flows into the river Isla shortly before its junction with the river Tay; they all contain pike and perch, and trout also are taken in Lochs Craiglush, Lowes, and Drumellie. The group nearest the source of the Lunan burn consists of Lochs Craiglush, Lowes, and Butterstone.

*Loch of Craiglush* (see Plate XXIX.).—The Loch of Craiglush is situated in Drumbuie wood near Dunkeld, and is almost surrounded by trees. Its shores are weedy, and where the Lunan burn enters there is a large grassy flat formed of material brought down by the stream. It trends in a north-east and south-west direction, and is over half a mile in length, with a maximum breadth of over a quarter of a mile, the mean breadth being nearly one-fifth of a mile, or 32 per cent. of the length. Its waters cover an area of about 70 acres, or over one-tenth of a square mile, and it drains an area of about  $5\frac{3}{4}$  square miles—an area 52 times greater than the area of the loch. Over 50 soundings were taken, the maximum depth observed being 44 feet. The volume of water contained in the loch is estimated at 49,079,000 cubic feet, and the mean depth at 16 feet, or 37 per cent. of the maximum depth. The

length of the loch is 70 times the maximum depth, and 190 times the mean depth. The Loch of Craiglush forms a simple basin, the bottom sloping gradually down on all sides towards the deepest part without any pronounced irregularities. The maximum depth of 44 feet was observed in two places opposite the entrance of the Lunan burn, approximately in the centre of the loch, but nearer the western shore and the southern end. The area of the lake-floor covered by less than 20 feet of water is about 51 acres, or 73 per cent. of the total area of the loch; that covered by water between 20 and 40 feet in depth is nearly 15 acres, or 21 per cent.; and that covered by more than 40 feet of water is over 4 acres, or 6 per cent. of the entire area of the loch. Loch Craiglush was surveyed on June 2, 1903, and the height of the surface of the water above sea-level was determined by levelling from benchmark as being 327.6 feet, the same as Loch of Lowes, into which it flows.

*Temperature Observations.*—Temperature observations taken in the deepest part of the loch at 7.45 a.m. gave the following results:—

Surface	...	...	...	...	...	...	61°.2	Fahr.
5 feet	...	...	...	...	...	...	61°.3	„
8	„	...	...	...	...	...	61°.2	„
9	„	...	...	...	...	...	57°.4	„
10	„	...	...	...	...	...	54°.5	„
20	„	...	...	...	...	...	52°.0	„
30	„	...	...	...	...	...	50°.0	„
42	„	...	...	...	...	...	49°.0	„

This series shows a rapid fall in the temperature between 8 and 10 feet, amounting to 6°.7 (a fall of 3°.8 between 8 and 9 feet, and of 2°.9 between 9 and 10 feet), the extreme range of temperature from surface to bottom amounting to 12°.2.

*Loch of Lowes* (see Plate XXIX.).—The Loch of Lowes, like the Loch of Craiglush, is surrounded by trees; its shores are mostly composed of stony debris, and weeds are abundant off the south-western shore where the artificial channel from the Loch of Craiglush enters. It trends in a north-east and south-west direction, and is  $1\frac{1}{2}$  miles in length, with a maximum breadth of over half a mile, the mean breadth being more than a quarter of a mile, or 24 per cent. of the length. Its waters cover an area of about 218 acres, or over one-third of a square mile, and it drains directly an area of nearly 2 square miles, but since it receives the outflow from the Loch of Craiglush its total drainage area is about  $7\frac{2}{3}$  square miles, an area nearly 23 times greater than the area of the loch. Over 60 soundings were taken, the maximum depth observed being 53 feet. The volume of water contained in the loch is estimated at 193,973,000 cubic feet, and the mean depth at nearly  $20\frac{1}{2}$  feet, or 39 per cent. of the maximum depth. The length of the loch is 138 times

the maximum depth, and 360 times the mean depth. The Loch of Lowes forms on the whole a simple basin, but with here and there minor undulations of the bottom. The maximum depth of 53 feet was observed approximately in the centre of the loch, but a short distance to the north of it a sounding of 42 feet was taken apparently surrounded on all sides by shallower water, and to the west a depth of 7 feet was observed with deeper water all round. Generally speaking, the slope of the bottom is gentle, there being no evidence of any steep gradients. The area of the lake-floor covered by less than 20 feet of water is about 120 acres, or 55 per cent. of the total area of the loch; that covered by water between 20 and 40 feet in depth is about 79 acres, or 26 per cent.; and that covered by more than 40 feet of water is about 19 acres, or 9 per cent. of the entire area of the loch. The Loch of Lowes was surveyed on June 2, 1903, the same day as the Loch of Craiglush, and the elevation of the two lochs above the sea was found by levelling to be identical, viz., 327·6 feet. When levelled by the Ordnance Survey officers on July 13, 1899, the elevation was found to be 327·9 feet above the sea.

*Temperature Observations.*—Temperature observations taken in the deepest part of the loch at 1.15 p.m. gave the following results:—

Surface	...	...	...	...	...	...	...	60°·0	Fahr.
10 feet	...	...	...	...	...	...	...	59°·5	„
13 „	...	...	...	...	...	...	...	57°·0	„
15 „	...	...	...	...	...	...	...	52°·2	„
20 „	...	...	...	...	...	...	...	51°·0	„
30 „	...	...	...	...	...	...	...	50°·2	„
40 „	...	...	...	...	...	...	...	50°·0	„
50 „	...	...	...	...	...	...	...	50°·0	„

This series shows a range of 10° in the temperature throughout the 50 feet of water, the greatest fall being one of 4°·8 between 13 and 15 feet. Compared with the temperatures taken in the Loch of Craiglush earlier in the day, this series shows a smaller range (the temperature at the surface being lower and at the bottom higher, notwithstanding the greater depth), and the position of the greatest fall in the temperature was observed at a greater depth, viz., between 10 and 15 feet, as compared with between 8 and 10 feet in the Loch of Craiglush.

*Loch of Butterstone* (see Plate XXIX.).—The Loch of Butterstone (or Butterston) is, like the two neighbouring lochs, to a large extent surrounded by trees; its shores are sandy or weedy, and many coots nest among the weeds. It is almost circular in outline, the greatest diameter (or length) from north-east to south-west being about three-fifths of a mile, while the maximum breadth from north-west to south-east is about half a mile, the mean breadth being over a quarter of a mile, or 50 per cent. of the length. Its waters cover an area of about 108 acres,

or one-sixth of a square mile, and it drains directly an area of over two-thirds of a square mile, but since it receives the outflow from Lochs Craiglush and Lowes, its total drainage area is about  $8\frac{1}{2}$  square miles—an area 49 times greater than the area of the loch. Over 50 soundings were taken, the maximum depth observed being 25 feet. The volume of water contained in the loch is estimated at 53,238,000 cubic feet, and the mean depth at  $11\frac{1}{4}$  feet, or 45 per cent. of the maximum depth. The length of the loch is 122 times the maximum depth and 271 times the mean depth. The Loch of Butterstone forms a simple basin, the maximum depth of 25 feet being observed approximately in the centre of the loch, but nearer the western and southern shores. The deeper water approaches much closer to the western than to the eastern shore, off which the shallow water extends some distance into the loch, especially opposite the point at the outflow, where the 10-foot contour-line makes a great bend inward; this bend affects also the 20-foot contour-line, so that the 20-foot basin becomes somewhat crescent-shaped. The area of the lake-floor covered by less than 10 feet of water is about  $52\frac{1}{2}$  acres, or  $48\frac{1}{2}$  per cent. of the entire area of the loch; that covered by water between 10 and 20 feet in depth is about  $39\frac{1}{2}$  acres, or  $36\frac{1}{2}$  per cent.; and that covered by more than 20 feet of water is about 16 acres, or 15 per cent. of the total area of the loch. The Loch of Butterstone was surveyed on June 1, 1903, and the surface of the water was found by levelling from bench-mark to be 314·4 feet above sea-level. The Ordnance Survey officers determined the level on July 31, 1899, as being 314·8 feet above the sea.

*Temperature Observations.*—Temperature observations were taken in the deepest part of the loch in the afternoon of June 1, 1903, with the following results:—

Surface	...	...	...	...	...	...	63°·0	Fahr.
5 feet	...	...	...	...	...	...	62°·8	„
8 „	...	...	...	...	...	...	62°·5	„
10 „	...	...	...	...	...	...	57°·0	„
25 „	...	...	...	...	...	...	53°·0	„

This series shows a range from surface to bottom of  $10^{\circ}$ , the greatest fall being one of  $5^{\circ}\cdot5$  between 8 and 10 feet. The water was warmer at all depths than in Lochs Craiglush and Lowes at corresponding depths; the greatest decrease of temperature was observed at the same depth as in Loch Craiglush; the range of temperature was the same as that in Loch Lowes, although there is only half the depth of water.

*Loch of Clunie* (see Plate XXX.).—The Loch of Clunie lies in a well-wooded valley, and is surrounded by cultivated ground, except at Forneth woods. The castle on the island in the loch, which seems to be artificial, is said to have been the birthplace of the Admirable Crichton. On this island a pair of herons built their nest in 1903, but nest and

young were destroyed by excursionists. Near the middle of the north side of the loch, and about 100 yards from the shore, is a mound of stones (two of which were above the water on the date of the survey), said to have been put down to indicate a sandbank. The Lunan burn at the exit of the loch is a long weedy stretch with no perceptible current, the fall to the Loch of Drumellie being only 10 feet in a mile. The Loch of Clunie is triangular in outline, with the apex pointing south. The diameter from east to west and from north to south is nearly equal, the length from east to west being rather less than two-thirds of a mile, while the maximum breadth is slightly less, the mean breadth being one-third of a mile, or 55 per cent. of the length. Its waters cover an area of 134 acres, or over one-fifth of a square mile, and it drains directly an area of nearly 8 square miles, but since it receives the outflow from the Lochs of Butterstone, Lowes, and Craighush, its total drainage area is over  $16\frac{1}{4}$  square miles—an area nearly 78 times greater than the area of the loch. Over 80 soundings were taken, the maximum depth observed being 69 feet. The volume of water contained in the loch is estimated at 170,265,000 cubic feet, and the mean depth at 29 feet, or 42 per cent. of the maximum depth. The length of the loch is 47 times the maximum depth, and 112 times the mean depth. The Loch of Clunie forms, generally speaking, a simple basin, but with a few minor undulations of the bottom. The 25-foot basin corresponds approximately with the outline of the loch, but the 50-foot basin is somewhat irregular in outline, owing to two elevations of the lake-floor: (1) Near the north-east angle of the loch, where a sounding of 24 feet was taken, with depths of 33 and 35 feet on one side and depths of 52 and 69 feet on the other; and (2) a short distance to the west, where a depth of 45 feet was observed, with 52 feet on one side and 60 feet on the other. These two elevations give rise to a peculiar constriction in the outline of the 50-foot basin, and the shallower elevation is the more striking because of its close proximity to the deepest part of the loch, the maximum depth of 69 feet having been found comparatively close to the eastern shore. A moderately steep slope was observed off the northern shore, opposite the east lodge of Forneth House, where a depth of 14 feet was found about 60 feet from the shore, equal to a gradient of 1 in 4·3. The area of the lake-floor covered by less than 25 feet of water is about 68 acres, or 51 per cent. of the total area of the loch; that covered by water between 25 and 50 feet in depth is about 39 acres, or 29 per cent.; and that covered by more than 50 feet of water is about 27 acres, or 20 per cent. of the entire area of the loch. The Loch of Clunie was surveyed on June 4, 1903, and the elevation of the lake-surface above the sea was determined, by levelling from bench-mark, as being 156·55 feet; when levelled by the Ordnance Survey officers on September 12, 1899, the elevation was found to be 156·3 feet.

*Temperature Observations.*—Temperature observations taken at 6.30 p.m. in the deepest part of the loch gave the following results:—

Surface	...	...	...	...	...	...	62°·3	Fahr.
5 feet	...	...	...	...	...	...	62°·0	„
10 „	...	...	...	...	...	...	54°·2	„
15 „	...	...	...	...	...	...	52°·4	„
25 „	...	...	...	...	...	...	49°·0	„
50 „	...	...	...	...	...	...	47°·4	„
65 „	...	...	...	...	...	...	47°·2	„

This series shows a range of temperature from surface to bottom amounting to 15°·1, the greatest fall being one of 7°·8 between 5 and 10 feet, there being a further fall of 3°·4 between 15 and 25 feet.

*Loch of Drumellie* (see Plate XXX.).—The Loch of Drumellie (or Marlee Loch) lies about a mile to the east of the Loch of Clunie, and is surrounded by cultivated ground, the fields sloping gently up on all sides. Its shores are stony or weedy; and the narrow portion leading to the outflow is quite choked up with weeds, except for an artificial channel about 4 feet deep leading to the landing-stage, where the burn flows out over a weir. Large yellow masses of decaying vegetable matter were floating everywhere. The loch is about seven-eighths of a mile in length, with a maximum breadth of nearly half a mile, the mean breadth being nearly one-third of a mile, or 37 per cent. of the length. Its waters cover an area of about 175 acres, or over a quarter of a square mile, and it drains directly an area of over 6½ square miles, but since it receives the outflow from the Loch of Clunie and from Rae Loch, its total drainage area is about 23¼ square miles—an area 86 times greater than the area of the loch. Over 70 soundings were taken, the maximum depth observed being 58 feet. The volume of water contained in the loch is estimated at 221,902,000 cubic feet, and the mean depth at 29 feet, or 50 per cent. of the maximum depth. The length of the loch is 78 times the maximum depth and 156 times the mean depth. The Loch of Drumellie forms a flat-bottomed basin, the bottom sinking in two places below the 50-foot line, with shallower water between. The south-eastern 50-foot basin is based upon two soundings of 51 feet, while in the north-western one the maximum depth of 58 feet was observed, situated less than a quarter of a mile from the west end of the loch. The average slope of the bottom is gentle, the steepest slope observed being about midway along the southern shore, where a sounding of 20 feet was taken about 100 feet from the shore, giving a slope of 1 in 5. The area of the lake-floor covered by less than 25 feet of water is about 72 acres, or 41 per cent. of the total area of the loch; that covered by water between 25 and 50 feet in depth is about 83 acres, or 47 per cent.; and that covered by more than 50 feet of water is about 20 acres, or 12 per cent. of the entire area of the loch.

The fact that the area between the 25- and 50-foot contour-lines is greater than the area between the shore and the 25-foot line proves the flat-bottomed nature of the basin, as well as the fact that the mean depth is fully half the maximum depth. The Loch of Drumellie was surveyed on the same day as the Loch of Clunie, June 4, 1903; the elevation above the sea was determined by levelling from bench-mark as being 146·7 feet. The Ordnance Survey officers found the level of the lake-surface to be 147 feet above the sea on September 19, 1899.

*Temperature Observations.*—Temperature observations taken in the deepest part of the loch at 11.30 a.m. gave the following results:—

Surface	...	...	...	...	...	...	...	60°·2	Fahr.
10 feet	...	...	...	...	...	...	...	59°·0	„
15	„	..	...	...	...	...	...	53°·7	„
20	„	...	...	...	...	...	...	50°·7	„
30	„	...	...	...	...	...	...	49°·5	„
40	„	...	...	...	...	...	...	49°·2	„
58	„	...	...	...	...	...	...	48°·7	„

This series shows a range of temperature from surface to bottom of 11°·5, the greatest fall being one of 5°·3 between 10 and 15 feet, with a further fall of 3° between 15 and 20 feet. Compared with the temperatures taken in the Loch of Clunie in the evening of the same day, this series shows a much smaller range of temperature, the surface temperature being 2° lower and the bottom temperature 1°·5 higher, although the difference in depth is only 7 feet; the position of greatest fall in the temperature is nearer the surface in the Loch of Clunie, and the amount of fall is greater.

*Rae Loch* (see Plate XXX.).—Rae Loch (or Ardblair Loch) lies a quarter of a mile to the east of the Loch of Drumellie, into which it flows, and about a mile to the west of Blairgowrie. It is surrounded by low fields and wooded country, and its shores are all weedy, while the western portion of the loch is quite filled with weeds. The water formerly stood at a higher level, and frequently flooded the road on the north side; it was consequently lowered about 10 feet by a cutting, which has since, however, become choked up. It is under half a mile in length, less than one-fifth of a mile in maximum breadth, the mean breadth being about one-ninth of a mile, or 25 per cent. of the length. Its waters cover an area of about 30 acres, and it drains an area seven times greater—an area of over one-third of a square mile. Over 30 soundings were taken, the maximum depth observed being 16 feet. The volume of water is estimated at 8,727,000 cubic feet, and the mean depth at 6½ feet, or 31 per cent. of the maximum depth. The deeper water occurs near the eastern end, off which the slope is steep; at one point a sounding of 10 feet was taken only 20 feet from the shore, giving a gradient of 1 in 2. The area of the lake-floor covered by less than

10 feet of water is about 24 acres, or 80 per cent. of the total area of the loch. Rae Loch was surveyed on June 23, 1903, and the level of the lake-surface above the sea was determined, by levelling from bench-mark, as 195·2 feet.

*Temperature Observations.*—Temperatures taken in the deepest part gave the following results:—

Surface	...	..	...	...	...	...	60°·8	Fahr.
5 feet	...	...	..	...	...	...	60°·5	„
10	„	...	...	..	...	...	57°·9	„
15	„	..	...	...	...	...	57°·1	„

The range of temperature throughout the 15 feet of water was 3°·7, there being a fall of 2°·6 between 5 and 10 feet.

*Fingask Loch* (see Plate XXX.)—Fingask Loch lies about three-quarters of a mile to the south-east of Rae Loch, and  $1\frac{1}{4}$  miles to the south-west of Blairgowrie. It is surrounded by low cultivated ground, and weeds occur in the north-western angle of the loch and near the shore in other places, but not in any great abundance. It receives the outflow from White Loch by a mill lade, and it flows into the Lunan burn by a short sluggish stream. It is over one-third of a mile in length from north-west to south-east, with a maximum breadth of a quarter of a mile, the mean breadth being about one-seventh of a mile, or 41 per cent. of the length. Its waters cover an area of over 32 acres, and it drains directly an area of about one-sixth of a square mile, but, since it receives the outflow from the White Loch, its total drainage area is over a quarter of a square mile—an area  $4\frac{1}{2}$  times greater than the area of the loch. Nearly 40 soundings were taken, the maximum depth observed being 48 feet. The volume of water is estimated at 32,182,000 cubic feet, and the mean depth at nearly 23 feet, or 48 per cent. of the maximum depth. Fingask Loch forms a simple basin, the bottom sloping down gradually on all sides to the deepest part, which is, approximately, centrally placed. The north-western angle is shallow and obstructed by weeds, but the remainder of the loch is comparatively deep, and forms a sub-circular basin. The slope of the bottom is in places moderately steep, as, for instance, off the northern shore, where a sounding of 20 feet was taken about 80 feet from the shore, giving a gradient of 1 in 4. The area of the lake-floor covered by less than 10 feet of water is about 9 acres, or  $27\frac{1}{2}$  per cent. of the total area of the loch; that covered by water between 10 and 25 feet in depth is about  $8\frac{1}{2}$  acres, or  $26\frac{1}{2}$  per cent.; that covered by more than 25 feet of water is about 15 acres, or 46 per cent. of the entire area of the loch. This last percentage indicates the flat-bottomed character of the basin. Fingask Loch was surveyed on June 19, 1903, and its elevation above the sea was determined by levelling from the White Loch (which was surveyed on the same day) as being 140·6 feet.

*Temperature Observations.*—Temperature observations taken in the deepest part of the loch in the afternoon of June 19, 1903, gave the following results:—

Surface	...	...	...	...	...	...	...	58°·8	Fahr.
10 feet	...	...	...	...	...	...	...	57°·6	„
20	„	...	...	...	...	...	...	55°·3	„
30	„	...	...	...	...	...	...	49°·4	„
45	„	...	...	...	...	...	...	48°·7	„

This series shows a range of temperature from surface to bottom of about 10°, there being a fall of about 6° between 20 and 30 feet.

*White Loch* (see Plate XXX.).—The White Loch lies immediately to the east of Fingask Loch, into which it flows by an artificial mill-lade, and the water has apparently been raised several feet by damming, in order to supply the mill. At the east end of the loch, in the direction of the Black Loch, a copious burn flows out of the bank into the White Loch, but there is no evidence that it comes from the Black Loch, and the local people think the burn has its source in a spring. The eastern portion of the loch, called the Eie Loch, is separated from the larger and deeper portion by a narrow constriction; it is shallow, and almost filled with weeds, with a central depression 15 feet in depth. Tradition says this was once a separate loch, and that the connection was cut, the depth in the constriction being 2 feet. The loch is surrounded by gently sloping fields and wooded ground. It is about one-third of a mile in length, with a maximum breadth of one-seventh of a mile, the mean breadth being one-fourteenth of a mile, or 20 per cent. of the length, and its waters cover an area of about 15 acres. Over 40 soundings were taken, the maximum depth observed being 32 feet. The volume of water is estimated at 8,425,000 cubic feet, and the mean depth at 13 feet, or 41 per cent. of the maximum depth. The length of the loch is 56 times the maximum depth and 138 times the mean depth. The western portion of the White Loch forms a simple basin, the bottom sloping gently down on all sides to the deepest part, which is approximately centrally placed. There is no evidence of any pronounced irregularity of the lake-floor, nor of any steep slope. The area of the lake-floor covered by less than 10 feet of water is about 8 acres, or 52 per cent. of the total area of the loch; that covered by water between 10 and 25 feet in depth is over 4 acres, or 29 per cent.; and that covered by more than 25 feet of water is about 3 acres, or 19 per cent. White Loch was surveyed on the same day as Fingask Loch (June 19, 1903), and its elevation above the sea was determined, by levelling from bench-mark, as being 153·7 feet.

*Temperature Observations.*—Temperatures taken in the deepest part of the loch gave the following results:—

Surface ... ..	59°·0 Fabr.
10 feet ... ..	58°·0 „
20 „ ... ..	52°·5 „
30 „ ... ..	50°·2 „

This series shows a range of 8°·8 in the temperature of the water from surface to bottom, there being a fall of 5°·5 between 10 and 20 feet. Compared with the temperatures taken in Fingask Loch on the same day, this series indicates that the temperature of the upper layers of water was comparable in both lochs, but at 20 feet the temperature was nearly 3° lower than at that depth in the larger loch, the position of the great fall in the temperature being nearer the surface in the smaller loch.

*Black Loch* (see Plate XXX.).—The Black Loch lies immediately to the east of the White Loch, the main road from Perth to Blairgowrie passing between them. Neither inflow nor outflow was observed, but if the water were to rise 6 or 8 feet it might overflow by the channel under the road into the White Loch. It is almost surrounded by woods, and the shores are weedy. It is over a quarter of a mile in length, nearly one-tenth of a mile in maximum breadth, and its waters cover an area of about 8 acres. Nearly 30 soundings were taken, and the maximum depth observed was 7 feet. The volume of water is estimated at 1,611,000 cubic feet, and the mean depth at  $4\frac{3}{4}$  feet, or 68 per cent. of the maximum depth. The loch is almost of uniform depth, only three of the soundings being under 5 feet, and these were near the east end, so that the great body of water is from 5 to 6 feet in depth, the area of the lake-floor covered by more than 5 feet of water being about 5 acres, or 64 per cent. of the total area of the loch. It was surveyed on June 23, 1903, by means of a portable boat lent by Mr. Anderson, carried over from Druidsmere, and the elevation above the sea was determined, by levelling from bench-mark, as being 162·8 feet.

*Temperature Observations.*—The temperature of the surface water in the main body of the loch was 60°·1, while in the eastern portion it was 59°·0. The water in the eastern basin was clearer as well as colder, as though there might be a spring there. Temperatures taken in the deepest part of the loch gave the following results:—

Surface ... ..	60°·1 Fabr.
3 feet ... ..	60°·0 „
4 „ ... ..	59°·8 „
5 „ ... ..	58°·5 „
6 „ ... ..	57°·1 „

showing a range of 3°·0 throughout the 6 feet of water.

To the south-west of the Black Loch lies Hare Myre, which was visited on June 22, 1903, but could not be sounded because no boat was available. The keeper said it was all shallow, and that the oars when

rowing stirred up the mud everywhere, the depth probably not exceeding 2 feet. More than two-thirds of the superficial area is overgrown with weeds, there being a very little open water of a black colour. Neither inflow nor outflow was seen, but a drain was cut at some remote time to conduct the water to the south-west, where it joined the burn flowing from Stormont Loch to the Lunan burn. The loch does not now rise to overflow, and the water is stagnant, but looks clearer than that in the Stormont Loch.

The term Stormont Lochs is sometimes applied to the group of small lochs in this neighbourhood, including Loch Bog (or Stormont Loch), Monk Myre, Hare Myre, Black, White, Fingask, and Rae. Myriads of water-fowl breed on these lochs, and ducks of several species were nesting on the artificial island in Stormont Loch at the time of the survey.

*Stormont Loch* (see Plate XXX.).—Stormont Loch (or Loch Bog) lies immediately to the east of Hare Myre. It is a stagnant bog in a flat country, surrounded by woods and fields, and it receives no water except rains. It rarely rises high enough to overflow, but in February, 1903, it did so, the outflow being artificial and leading to the Lunan burn. The water is turbid, light brown in colour, and dense with animals—so much so that the tow-nets could only be used for a very short time. About half the area of the loch is unapproachable on account of weeds, and the other half is very uniform in depth (2 to 3 feet), and free from weeds. The keepers say that the mud on the bottom is of great depth, 18-foot poles having been sunk in it, and that it has accumulated greatly of late years. It is said that within the memory of old men now living there was a depth of 17 feet near where the boat-house was built (of which the remains are still visible). Stormont Loch is about two-thirds of a mile in length, and one-third of a mile in maximum breadth, the mean breadth being over one-sixth of a mile, or 27 per cent. of the length. Its waters cover an area of about  $74\frac{1}{2}$  acres, and the maximum depth of 3 feet was observed in several places near the eastern shore. The volume of water is estimated at 4,867,000 cubic feet. It was surveyed on June 22, 1903, and its elevation above the sea was determined by levelling from bench-mark as 168·1 feet, which is identical with the level when visited by the Ordnance Survey officers on June 26, 1900. The temperature of the surface water at 1 p.m. on June 22, 1903, was 64°·0.

*Monk Myre* (see Plate XXX.).—Monk Myre lies about half a mile to the east of the Stormont Loch, but it flows in the opposite direction by the Monkmyre burn into the river Ericht; there are no inflowing burns. It is surrounded by flat grassy country, and is divided into two portions by a narrow constriction, through which it is now impossible to

take a boat. The smaller western portion is mostly overgrown by weeds, with a very little open water, and never entirely freezes over, owing probably to the existence of numerous springs. Monk Myre is over half a mile in length, with a maximum breadth of over one-seventh of a mile, the mean breadth being about one-thirteenth of a mile, or 14 per cent. of the length, and its waters cover an area of about 25 acres. Over 30 soundings were taken, and the maximum depth observed was 12 feet. The volume of water is estimated at 5,552,000 cubic feet, and the mean depth at 5 feet, or 42 per cent. of the maximum depth. The loch is a shallow basin with rather uneven floor; the deepest part is towards the northern shore, where neighbouring soundings of 10 and 12 feet were taken, the remaining soundings being under 10 feet. The area of the lake-floor covered by less than 10 feet of water is equal to 98½ per cent. of the total area. Monk Myre was surveyed on June 20, 1903, but its elevation above the sea could not be ascertained. Temperatures taken at 7 a.m. gave 55°·8 at the surface and at a depth of 10 feet.

Long Loch and Pitlyal Loch form the headwaters of the Dighty burn, which flows eastward and enters the estuary of the Tay at Monifieth; a burn flows from Long Loch to Pitlyal Loch.

*Long Loch* (see Plate XXX.).—The Long Loch is bordered on the west by steep, grassy hills, while the eastern shore is low and wooded. No burns of any size enter the loch, but there are many springs on the hillside to the west. It contains pike and perch. The outflow is artificial, by dam and sluice; but at the time of the survey the water was very low, and very little water was flowing out at the sluice. The dotted line on the map shows approximately the shore-line on the date of the survey, and the water would have to rise 4½ feet to reach the overflow. Long Loch trends in a north-east and south-west direction, and is very peculiar in outline, presenting a close resemblance to a dog's body and head without legs, the portion represented by the dog's nose being filled with weeds. It is nearly three-quarters of a mile in length, with a maximum breadth of over a quarter of a mile, the mean breadth being one-sixth of a mile, or 24 per cent. of the length. Its waters cover an area of about 74 acres. Over 50 soundings were taken, the maximum depth observed being 42 feet. The volume of water contained in the loch is estimated at 31,893,000 cubic feet, and the mean depth at 10 feet, or 24 per cent. of the maximum depth. The length of the loch is 88 times the maximum depth, and 373 times the mean depth. Generally speaking, the loch forms a simple basin, with a few minor undulations of the bottom, and the slope is steeper off the western than off the eastern shore. The maximum depth of 42 feet was observed near the centre of the loch, but considerably nearer the western than the eastern shore. In this locality the slope is moderately steep, a sounding of 12 feet being recorded about 50 feet from the shore, giving

a gradient of 1 in 4·2. The area of the lake-floor covered by less than 10 feet of water is about 52 acres, or 70 per cent. of the total area of the loch; that covered by water between 10 and 25 feet in depth is about 18 acres, or 25 per cent.; and that covered by more than 25 feet of water is about 4 acres, or 5 per cent. of the entire area of the loch. Loch Long was surveyed on June 24, 1903, and its elevation above the sea was determined, by levelling from bench-mark, as 724·0 feet.

*Temperature Observations.*—Temperatures taken in the deepest part of the loch gave the following results:—

Surface	...	...	...	...	...	...	...	58°·4	Fahr.
10 feet	...	...	...	...	...	...	...	57°·0	„
15 „	...	...	...	...	...	...	...	55°·4	„
20 „	...	...	...	...	...	...	...	54°·0	„
40 „	...	...	...	...	...	...	...	53°·2	„

This series shows a range of temperature throughout the 40 feet of water of 5°·2, there being a fall of 3° between 10 and 20 feet.

*Pitlyal Loch* (see Plate XXX.).—Pitlyal Loch (or Round Loch, or Thripley Loch) lies about a quarter of a mile to the south-east of Long Loch, and is surrounded by gently sloping cultivated fields. There is a fringe of weeds all round the shore. Grebe and coots were seen, and there were swans on the small islet with bushes about 100 feet north-west of the boathouse. The outflow to the Dighty burn is by artificial dam and sluice; the water may rise 2 to 3 feet above its level on the date of the survey. The loch is well described by its name “Round Loch,” for it is subcircular in outline, though rather longer from north to south than from east to west. It is over one-fifth of a mile in length, with a maximum breadth of about one-seventh of a mile, the mean breadth being about one-ninth of a mile, or 52 per cent. of the length, and its waters cover an area of about 15 acres. Thirty soundings were taken, the maximum depth observed being 19 feet. The volume of water is estimated at 5,347,000 cubic feet, and the mean depth at 8½ feet, or 44 per cent. of the maximum depth. Pitlyal Loch forms a simple basin, but the deeper water is found towards the western shore, so that the slope of the bottom is steeper off that shore than off the eastern shore; a sounding of 11 feet was taken about 100 feet from the western shore, and the maximum depth of 19 feet was recorded about 150 feet from that shore. The area of the lake-floor covered by less than 10 feet of water is nearly 10 acres, or 65 per cent. of the total area of the loch. Pitlyal Loch was surveyed on the same day as Long Loch (June 24, 1903), and its elevation above the sea was determined by levelling from bench-mark as being 606·5 feet.

*Temperature Observations.*—Temperature observations gave the following results:—

Surface	...	...	...	...	...	...	59°·0	Fahr.
10 feet	...	...	...	...	...	...	59°·0	„
11 „	...	...	...	...	...	...	58°·8	„
12 „	...	...	...	...	...	...	55°·8	„
13 „	...	...	...	...	...	...	55°·0	„

This series shows that the upper 10 feet of water had a uniform temperature, but between 11 and 12 feet there was a fall of 3°, the extreme range from surface to bottom being 4°.

*Loch Freuchie* (see Plate XXXI.).—Loch Freuchie (or Fraochie), near Amulree, is a very pretty loch amid pastoral scenery, the grassy

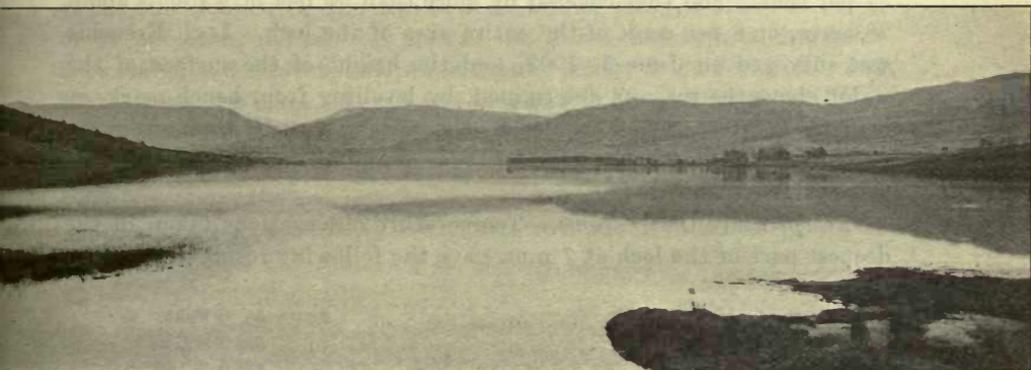


FIG. 25.—LOCH FREUCHIE, LOOKING S.E. FROM BRIDGE OVER INLET.

(*Photograph by R. Dykes.*)

shores sloping gently up on both sides, with here and there patches of wood. It was formerly a good trout loch, but in recent years it has been overrun by pike; steps have been taken, however, to keep down the pike, and the fishing is now improving. It flows by the river Bran into the river Tay at Dunkeld. Loch Freuchie trends in a north-west and south-east direction, widest in the north-western half and narrowing towards the south-east end. It is  $1\frac{3}{4}$  miles in length, with a maximum breadth of nearly half a mile, the mean breadth being about one-third of a mile, or 18 per cent. of the length. Its waters cover an area of about 348 acres, or over half a square mile, and it drains an area 55 times greater—an area of over 23 square miles. Nearly 90 soundings were taken, the maximum depth observed being 62 feet. The volume of water contained in the loch is estimated at 346,564,000 cubic feet, and the mean depth at 23 feet, or 37 per cent. of the maximum

depth. The length of the loch is 148 times the maximum depth and 402 times the mean depth. Loch Freuchie forms on the whole a simple basin, but with a few minor undulations of the bottom. The 25-foot basin is sinuous in outline, especially towards the south-east end, and is over  $1\frac{1}{2}$  miles in length, approaching close to the north-west end, but distant less than a quarter of a mile from the south-east end. The 50-foot basin, half a mile in length, is contained in the northern half of the loch, and nearer the eastern than the western shore, the maximum depth of 62 feet having been observed in two places, with soundings of 60 feet between them. Cones of alluvium have been formed at the mouths of the Turrerich burns at the northern angle of the loch, and at the entrance of the Allt a' Mhuilinn about midway along the western shore. The area of the lake-floor covered by less than 25 feet of water is about 225 acres, or 65 per cent. of the total area of the loch; that covered by water between 25 and 50 feet in depth is about 95 acres, or 27 per cent.; and that covered by more than 50 feet of water is about 28 acres, or 8 per cent. of the entire area of the loch. Loch Freuchie was surveyed on June 5, 1903, and the height of the surface of the water above the sea was determined, by levelling from bench-mark, as being 867.45 feet; when levelled by the officers of the Ordnance Survey on August 17, 1899, the elevation was found to be 870.8 feet above sea-level.

*Temperature Observations.*—Temperature observations taken in the deepest part of the loch at 7 p.m. gave the following results:—

Surface	...	...	..	...	...	...	...	58°.6	Fahr.
10 feet	...	...	..	...	...	...	...	58°.3	„
15	„	...	...	...	...	...	...	57°.6	„
25	„	...	...	...	...	...	...	53°.0	„
40	„	...	...	...	...	...	...	50°.0	„
60	„	...	...	...	..	...	...	49°.4	„

This series shows a range of temperature from surface to bottom of 9°.2, there being a fall of 4°.6 between 15 and 25 feet, and a further fall of 3°.0 between 25 and 40 feet.

*Loch Hoil* (see Plate XXXI.).—Loch Hoil (or Oyl, or Thuill) lies to the south of Aberfeldy, and flows by the Cochill burn into the river Bran. It contains trout, perch, grayling, and gudgeon. It is surrounded by low, rounded, hummocky, heather-clad hills. Its shores are stony; the bay leading to the outflow is very shallow and full of weeds. It is very irregular in outline, and over one-third of a mile in length from north-west to south-east, under one-third of a mile in maximum breadth from north-east to south-west, the mean breadth being one-seventh of a mile, or 43 per cent. of the length. Its waters cover an area of about 35 acres, and it drains an area six times greater—an area

of over one-third of a square mile. Nearly 40 soundings were taken, the maximum depth observed being 46 feet. The volume of water is estimated at 29,271,000 cubic feet, and the mean depth at 19 feet, or 42 per cent. of the maximum depth. The length of the loch is 40 times the maximum depth and 100 times the mean depth. Loch Hoil consists of a main body, which trends almost north and south, sending out an arm in an easterly direction leading to the outflow. This arm is shallow, while the body of the loch is comparatively deep; at the junction of the arm and body is a heap of stones about 200 feet from the eastern shore. The body of the loch forms a simple basin, the bottom sloping down on all sides towards the deepest part, which is approximately centrally placed, but rather nearer the northern than the southern end. The average slope of the bottom is gentle, the steepest gradient observed being one of 1 in 4·6 off the southern shore, where a sounding of 13 feet was taken 60 feet from the shore. The area of the lake-floor covered by less than 20 feet of water is about 24 acres, or 68 per cent. of the total area of the loch; that covered by water between 20 and 40 feet in depth is about 9 acres, or 26 per cent.; and that covered by more than 40 feet of water is about 2 acres, or 6 per cent. The loch was surveyed on May 28, 1903, and, from spot-levels near the loch, it was calculated that the surface of the water was about 1600 feet above the sea.

*Temperature Observations.*—Temperatures taken in the deepest part of the loch gave the following results:—

Surface ... ..	57°·0 Fahr.
10 feet ... ..	52°·0 „
20 „ ... ..	48°·0 „
40 „ ... ..	47°·0 „

This series shows a range of 10° from surface to bottom, there being a fall of 5° between the surface and 10 feet, and a further fall of 4° between 10 and 20 feet.

*Loch Fender* (see Plate XXXI.).—Loch Fender lies to the north of Loch Freuchie, and flows by the Glenfender burn into the river Bran. It contains large trout, but the fishing, which is preserved, is uncertain, sometimes yielding splendid sport, at other times none at all. It was surveyed on the same day as Loch Freuchie by means of a boat kindly supplied by Mr. Bulloch of Kinloch. The Marquis of Breadalbane sounded Loch Fender about 40 years ago from a portable boat, and found a maximum depth of about 30 yards (=90 feet); the maximum depth recorded by the Lake Survey was 78 feet. Loch Fender is thus extremely interesting on account of its great depth, considering its small dimensions. The shores are rocky all round, and the southern shore is a steep slope of bare rock, rising gradually to Creag an Loch;

at other places the shores are less steep, and surrounded by smooth, rounded, heather-covered hills. The water was very dark in colour, and, though there was apparently no great amount of inflow, there was a considerable outflow. Loch Fender is one-third of a mile in length from north-east to south-west, and one-fifth of a mile in maximum breadth, the mean breadth being over one-tenth of a mile, or 32 per cent. of the length. Its waters cover an area of over 22 acres, and it drains an area nine times greater—an area of over one-third of a square mile. Nearly 60 soundings were taken, the maximum depth observed being 78 feet. The volume of water contained in the loch is estimated at 30,998,000 cubic feet, and the mean depth at  $31\frac{3}{4}$  feet, or 41 per cent. of the maximum depth. The length of the loch is 22 times the maximum depth and 55 times the mean depth. Loch Fender forms a simple basin, the bottom sloping down on all sides to the deepest part, which is approximately centrally placed, but nearer the north-east than the south-west end, the maximum depth of 78 feet having been observed about 300 feet from the north-eastern shore. The average slope of the bottom is very steep, especially off the south-eastern shore, where were recorded soundings of 29 feet 20 feet from shore, 26 feet 30 feet from shore, and 17 feet 20 feet from shore, giving gradients of 1 in 0·7 and 1 in 1·2. Off the north-western shore the gradient is gentler, and the north-west angle, where the burn flows into the loch, is comparatively shallow and obstructed by weeds. The area of the lake-floor covered by less than 25 feet of water is about 11 acres, or 51 per cent. of the total area of the loch; that covered by water between 25 and 50 feet in depth is about 5 acres, or 21 per cent.; and that covered by more than 50 feet of water is about 6 acres, or 28 per cent. of the entire area of the loch. Loch Fender was surveyed on June 5, 1903, and, from spot-levels near the loch, it was estimated that the elevation of its surface was approximately 1888 feet above sea-level.

*Temperature Observations.*—Temperatures taken in the deepest part of the loch at 1 p.m. gave the following results:—

Surface	...	...	...	...	...	...	...	58°·0	Fahr.
5 feet	...	...	...	...	...	...	...	57°·8	„
10	„	...	...	...	...	...	...	52°·0	„
15	„	...	...	...	...	...	...	45°·0	„
25	„	...	...	...	...	...	...	44°·0	„
50	„	...	...	...	...	...	...	43°·0	„
75	„	...	...	...	...	...	...	42°·4	„

This series shows a range of temperature from surface to bottom amounting to 15°·6, there being a fall of 12°·8 between 5 and 15 feet (*i.e.* 5°·8 between 5 and 10 feet, and 7°·0 between 10 and 15 feet). The decrease of temperature in the layer of water between 10 and 15 feet is thus equal to 1°·4 per foot, whereas the fall is only 1° in the underlying layer between 15 and 25 feet.

*Loch Turret* (see Plate XXXII.).—Loch Turret, in Glen Turret, near Crieff, is used as the source of the water supply to the town of Crieff. It is a good trout loch, but strictly preserved, and is situated amid wild and beautiful scenery, the hills being steep and high on both sides, especially to the west, where crags border the loch. It flows by the Turret burn into the river Earn, and it receives the waters from the little Lochan Uaine, lying at the head of the glen, which was surveyed on the same day by request of the proprietor. Loch Turret trends in a north-west and south-east direction, and is widest towards the southern end, narrowing somewhat towards the northern end. It is over a mile in length, and over one-third of a mile in maximum breadth, the mean breadth being a quarter of a mile, or 24 per cent. of



FIG. 26.—LOCH TURRET, LOOKING N.W.

(*Photograph by R. Dykes.*)

the length. Its waters cover an area of about 164 acres, or a quarter of a square mile, and it drains an area 23 times greater—an area of nearly 6 square miles. Seventy soundings were taken, the maximum depth observed being 79 feet. The volume of water contained in the loch is estimated at 227,718,000 cubic feet, and the mean depth at 32 feet, or 40 per cent. of the maximum depth. The length of the loch is 70 times the maximum depth and 173 times the mean depth. Loch Turret forms on the whole a simple basin, the deeper water approaching nearer to the northern end and the western shore. The wide southern portion is comparatively shallow (under 20 feet), with one or two slight irregularities of the bottom, as, for instance, near the south-western angle of the loch, where soundings of 8 feet and 9 feet

were recorded, surrounded in each case by deeper water. These shallow soundings mark the position of a rocky ridge, said to cross the loch, and to be a continuation of the rocky ridge on the east shore, now used as a quarry. About midway along the eastern shore there is a slight constriction in the outline of the loch at the entrance of the Allt Bhaltair, apparently due to the material brought down by that stream, and in this position a slight shoaling of the bottom in the centre of the loch is observable, the depth being 73 feet, with two soundings of 77 feet to the north, and soundings of 77 and 79 feet to the south. The 25-foot basin is about three-quarters of a mile in length, approaching to within 100 feet from the northern end, and a quarter of a mile from the southern end. The slope of the bottom is steeper off the western than off the eastern shore; near the middle of the western shore a sounding of 40 feet was taken about 50 feet offshore, giving a gradient of 1 in 1·25. The area of the lake-floor covered by less than 25 feet of water is about 85 acres, or 52 per cent. of the total area of the loch; that covered by water between 25 and 50 feet in depth is about 36 acres, or 22 per cent.; that covered by water between 50 and 75 feet in depth is about 36 acres, or 22 per cent.; and that covered by more than 75 feet of water is about 7 acres, or 4 per cent. of the entire area of the loch. The flat-bottomed character of the deep basin is well brought out by the fact that the area between the 25- and 50-foot contour-lines is almost identical with the area between the 50- and 75-foot contours. Loch Turret was surveyed on June 9, 1903, and the elevation of the lake surface above the sea, measured from the spot-level 1145 on the east shore, was determined as being 1132 feet. The water in the loch was high on the date of the survey.

*Temperature Observations.*—The temperature of the surface water on commencing the survey at 9 a.m. was 60°·0, and a series of temperatures taken later in the deepest part of the loch gave the following results:—

Surface	...	...	...	...	...	...	60° 8 Fahr.
10 feet	...	...	...	...	...	...	59°·0 „
15 „	...	...	...	...	...	...	54°·0 „
25 „	...	...	...	...	...	...	47°·7 „
50 „	...	...	...	...	...	...	44°·8 „
75 „	...	...	...	...	...	...	44°·4 „

This series shows a range of temperature from surface to bottom amounting to 16°·4, there being a fall of 5°·0 between 10 and 15 feet, one of 6°·3 between 15 and 25 feet, and one of 3° between 25 and 50 feet; the decrease of temperature between 10 and 15 feet was thus equal to 1° per foot of depth.

*Lochan Uaine* (see Plate XXXII.).—Lochan Uaine, at the head of Glen Turret, lies in a corrie; its shores are peat, and the bottom weedy.

In the middle of the loch towards the north end is a mud islet 2 or 3 feet in length and a few inches above the water. Sir Patrick Keith Murray tried to drain the loch, but failed, and subsequently a rough dam was built at the outflow. The burn flowing from Lochan Uaine to Loch Turret passes among a series of very perfect moraine mounds. Lochan Uaine is a small shallow loch, about one-seventh of a mile in length, and covering an area of about  $4\frac{1}{2}$  acres, with a maximum depth of 10 feet. The volume of water is estimated at 678,000 cubic feet, and the mean depth at  $3\frac{1}{2}$  feet. Nearly 40 soundings were taken, but some of them have been omitted on the chart for lack of space. The deeper water occurs near the northern end, to the north-west of the mud islet; to the south-east of the islet the depth is under 5 feet. About 80 per cent. of the lake-floor is covered by less than 5 feet of water. Lochan Uaine was surveyed by request on the same day as Loch Turret, June 9, 1903; from spot-level, its elevation above the sea is about 1520 feet. The surface temperature at 2 p.m. was  $67^{\circ}0$ .

*Pond of Drummond* (see Plate XXXII.).—The Pond of Drummond, within the policies of Drummond Castle, near Crieff, is a pretty artificial loch, well stocked with trout, but strictly preserved; it flows into the river Earn. It trends east and west, and is two-thirds of a mile in length, nearly one-third of a mile in maximum breadth, the mean breadth being one-fifth of a mile, or 31 per cent. of the length. Its waters cover an area of about 91 acres, and it drains an area four times greater, or over half a square mile. Sixty soundings were taken, the maximum depth observed being 12 feet. The volume of water is estimated at 20,157,000 cubic feet, and the mean depth at 5 feet, or 43 per cent. of the maximum depth. The length of the loch is about 300 times the maximum depth, and 700 times the mean depth. The Pond of Drummond is, on the whole, very shallow; it is only in the small narrow portion at the east end that the depth exceeds 8 feet, the maximum depth of 12 feet having been found in the extreme north-eastern angle of the loch near the outflow. Nearly 99 per cent. of the lake-floor is covered by less than 10 feet of water. It was surveyed on June 18, 1903, but its elevation above the sea could not be determined, because of inability to find bench-mark. The water in the loch was very low, the wooden jetty at the boathouse being 2 feet above water. The temperature of the surface water was  $60^{\circ}0$ .

*Loch Monzievaird* (see Plate XXXII.).—Loch Monzievaird (or Ochtertyre), within the grounds of Ochtertyre, near Crieff, flows into the river Earn; it contains pike, carp, and perch, but few, if any, trout. Its shores are said to be all reclaimed moorland, wooded and high on the north side, grassy slopes with scattered trees on the south side. The large island near the north-eastern end of the loch is covered

with trees and grass, and is said by Mr. Patrick Murray to be natural; the small island to the south is artificial, composed of stones, with a submerged causeway running eastward to the shore; the island in the south-western portion of the loch is also artificial, built on piles, and is said to have been used as a prison. Loch Monzievairst trends in a north-east and south-west direction, being widest and deepest towards the south-western end; there is a central constriction which divides the loch into two basins. It is over half a mile in length, with a maximum breadth of one-fifth of a mile, the mean breadth being over one-tenth of a mile, or 19 per cent. of the length. Its waters cover an area of about 37 acres, and it drains an area of  $1\frac{2}{3}$  square miles—an area 27 times greater than the area of the loch. Over 60 soundings were taken, the maximum depth observed being 39 feet. The volume of water contained in the loch is estimated at 23,905,000 cubic feet, and the mean depth at nearly 15 feet, or 38 per cent. of the maximum depth. The length of the loch is 74 times the maximum depth, and 198 times the mean depth. The depth of water in the central constriction is 7 feet, with deeper water on both sides, the maximum depth observed in the north-eastern portion of the loch being 20 feet, while the maximum depth of the loch (39 feet) occurs in the south-western portion, comparatively near the western shore, where the Conalter burn flows in and the Downie burn flows out. The area of the lake-floor covered by less than 10 feet of water is about 15 acres, or 39 per cent. of the total area of the loch; that covered by water between 10 and 20 feet in depth is about 14 acres, or 37 per cent.; that covered by water between 20 and 30 feet in depth is about 4 acres, or 12 per cent.; and that covered by more than 30 feet of water is about 4 acres, or 12 per cent. of the entire area of the loch. Loch Monzievairst was surveyed on June 8, 1903; its elevation above the sea was not determined by levelling, but it is evidently slightly under 200 feet since the 200-foot contour almost coincides with the shore-line. The outflow is controlled by a sluice, and on the date of the survey the water in the loch was very low.

*Temperature Observations.*—Temperature observations taken in the deepest part of the loch gave the following results:—

Surface	...	...	...	...	...	...	68°·0	Fahr.
5 feet	...	...	...	...	...	...	68°·0	„
10	„	..	...	...	...	...	60°·5	„
15	„	...	...	...	...	...	53°·0	„
20	„	...	...	..	...	...	51°·0	„
36	„	...	...	...	...	...	47°·4	„

This series shows a range of temperature from surface to bottom amounting to 20°·6, there being a fall of 7°·5 between 5 and 10 feet, and a similar fall between 10 and 15 feet—a decrease of 15° in the 10 feet of water, equal to 1°·5 per foot.

*Loch Benachally* (see Plate XXXIII.).—Loch Benachally, a good trout loch in the Forest of Clunie, is used by the Blairgowrie Corporation as the source of the town's water-supply. It flows by the Lornty burn into the river Ericht, which further on joins the river Isla. Its shores are of shingle and stones, except at the north-western corner, where the material brought down by the Craigsheal burn has formed an extensive flat covered with short weeds. This flat was dry at the time of the survey, the water in the loch being very low. It is surrounded by low hills covered with heather and grass. It is almost triangular in outline, the base towards the north-west and the apex pointing south-east, and is over a mile in length, with a maximum breadth of over half a mile, the mean breadth being about a quarter of a mile, or 23 per cent. of the length. Its waters cover an area of about 163 acres, or a quarter of a square mile, and it drains an area of over 3 square miles—an area 12 times greater than the area of the loch. About 60 soundings were taken, the maximum depth observed being 64 feet. The volume of water contained in the loch is estimated at 177,566,000 cubic feet, and the mean depth at 25 feet, or 39 per cent. of the maximum depth. The length of the loch is 87 times the maximum depth, and 220 times the mean depth. Loch Benachally forms a simple basin, the bottom sloping more or less regularly on all sides down to the deepest part, which is approximately centrally placed. The slope of the bottom is in some places rather steep—for instance, off the northern shore near the north-western angle, and off the southern shore near the middle, where soundings of 22 feet were taken about 60 feet from the shore, giving a gradient in each case of 1 in 2·7. The loch is on the whole comparatively deep, very few of the soundings being under 10 feet. The area of the lake-floor covered by less than 25 feet of water is about 91 acres, or 56 per cent. of the entire area of the loch; that covered by water between 25 and 50 feet in depth is about 58 acres, or 36 per cent.; and that covered by more than 50 feet of water is about 13 acres, or 8 per cent. of the total area of the loch. Loch Benachally was surveyed on June 3, 1903, and the elevation of the surface of the water was determined, by levelling from bench-mark, as being 1004·9 feet above sea-level.

*Temperature Observations.*—Temperature observations taken in the deepest part of the loch gave the following results:—

Surface .. .. .	57°·2 Fahr.
10 feet ... .. .	55°·8 „
15 „ ... .. .	54°·3 „
20 „ ... .. .	49°·0 „
30 „ ... .. .	47°·4 „
40 „ ... .. .	47°·2 „
50 „ ... .. .	47°·0 „
60 „ ... .. .	46°·8 „

This series shows a range of temperature throughout the 60 feet of water amounting to  $10^{\circ}4$ , the greatest fall being one of  $5^{\circ}3$  between 15 and 20 feet.

*Loch Shechernich* (see Plate XXXIII.).—Loch Shechernich (or Bainie), a small loch in Glenshee, situated amid fine mountain scenery, is a good trout loch, but strictly preserved. It flows by the Allt Mòr into Shee water, thence by the Black water into the river Ericht, a tributary of the river Isla. Its shores are low and peaty, rising gradually to the surrounding heather-clad hills. Near the centre of the loch is an artificial island composed of small stones. Loch Shechernich trends in an east and west direction, and is nearly half a mile in length, and one-fifth of a mile in maximum breadth, the mean breadth being one-seventh of a mile, or 31 per cent. of the length. Its waters cover an area of about 42 acres, and it drains an area  $16\frac{1}{2}$  times greater—an area considerably over 1 square mile. Thirty soundings were taken, the maximum depth observed being 8 feet. The volume of water is estimated at 7,364,000 cubic feet, and the mean depth at 4 feet, or 50 per cent. of the maximum depth. The bottom sinks gradually from the west towards the east end, being covered by less than 6 feet of water in the western half (to the west of the central island), while the greater portion of the eastern half is covered by more than 6 feet of water, the maximum depth of 8 feet having been observed in three places comparatively close to the east end. The area of the lake-floor covered by less than 5 feet of water is over 31 acres, or 75 per cent. of the entire area of the loch. Loch Shechernich was surveyed on the same day as Loch nan Eun, July 2, 1903. The elevation above the sea could not be ascertained, but from spot-levels it is probably about 1330 feet. The water in the loch was about its lowest on the date of the survey, and apparently rises 1 to 2 feet higher. At 6 p.m. the temperature of the water at the surface and at a depth of 7 feet was in each case  $59^{\circ}2$ .

*Auchenchapel Loch* (see Plate XXXIII.).—Loch Auchenchapel (or Auchintaple), in Glenisla, near Inverharity, is an artificial loch made in 1884, and flows by a short stream (Allt na Beinne) into the river Isla; it is a good trout loch, without pike. It trends in a north and south direction, and is over one-third of a mile in length, and over a quarter of a mile in maximum breadth, the mean breadth being over one-seventh of a mile, or 40 per cent. of the length. Its waters cover an area of about 35 acres, and it drains an area  $5\frac{1}{2}$  times greater—an area of one-third of a square mile. Over 40 soundings were taken, the maximum depth observed being 17 feet. The volume of water contained in the loch is estimated at 12,669,000 cubic feet, and the mean depth at 8 feet, or 49 per cent. of the maximum depth. Auchenchapel

Loch is irregular in outline, and the conformation of the bottom is also irregular, shallow water extending out into the loch in some places, while in other places comparatively deep water approaches close to the shore. The maximum depth of 17 feet was observed near the southern end of the loch, and a sounding of 15 feet was taken near the centre of the wide portion of the loch, in close proximity to a sounding of 5 feet. The diversity in the soundings gives a sinuous character to the 10-foot contour-line. The area of the lake-floor covered by less than 10 feet of water is about 22 acres, or 62 per cent. of the total area of the loch. The loch was surveyed on July 3, 1903, but the elevation above the sea could not be determined. The water rises about 2 feet above, and falls about 1 foot below, the level on the date of the survey; there is a sluice at the outflow, but it was out of order and disused at the time of the survey. Temperatures taken at 10 a.m. in the position of the deepest sounding gave  $58^{\circ}0$  at the surface and  $57^{\circ}5$  at a depth of 16 feet.

*Loch of Lintrathen* (see Plate XXXIII.).—The Loch of Lintrathen, from which Dundee draws its water-supply, has been raised in level to the extent of 22 feet in connection therewith; the water in the loch was 14 inches below the overflow on the date of the survey, so that the 20-foot contour-line would show approximately the size and position of the original loch. It receives the drainage from a large tract of the hilly country to the north, and it flows by the Melgam water into the river Isla. It is surrounded by gently sloping cultivated ground or woods, with gravelly margin, except in the north-western angle of the loch, where the Melgam water and Inzion burn enter, which is shallow and obstructed by weeds. It is nearly  $1\frac{1}{2}$  miles in length from south-west to north-east, with a maximum breadth of three-quarters of a mile, the mean breadth being nearly half a mile, or 33 per cent. of the length. Its waters cover an area of nearly 400 acres, or considerably more than half a square mile, and it drains an area 47 times greater, or nearly 29 square miles. Nearly 120 soundings were taken, the maximum depth observed being 70 feet. The volume of water contained in the loch is estimated at 405,207,000 cubic feet, and the mean depth at  $23\frac{1}{2}$  feet, or 34 per cent. of the maximum depth. The length of the loch is 104 times the maximum depth, and 311 times the mean depth. The Loch of Lintrathen forms a simple basin, the bottom sloping down, with few irregularities, to the deepest part, which is situated in the wide south-western portion of the loch. The maximum depth of 70 feet was observed to the north of Loch Craigs, considerably nearer the southern than the northern shore, and the slope of the bottom off Loch Craigs is evidently very steep, a sounding of 26 feet having been taken close to the shore. The line of soundings taken northwards from Loch Craigs shows a slight rise of the bottom towards

the centre of the loch, where depths of 54 to 57 feet were found, with depths exceeding 60 feet to the north and south. The northern portion of the loch, beyond the narrows at Balnakeilly, is comparatively shallow. The area of the lake-floor covered by less than 25 feet of water is about 260 acres, or 66 per cent. of the total area of the loch; that covered by water between 25 and 50 feet in depth is nearly 100 acres, or 24 per cent.; and that covered by more than 50 feet of water is over 40 acres, or 10 per cent. of the entire area of the loch. It was surveyed on June 25, 1903, and the height of the surface of the water above the sea was determined, by levelling from bench-marks, as being 674·6 feet.

*Temperature Observations.*—Temperature observations taken in the deepest part of the loch gave the following results:—

Surface	...	...	...	...	...	...	...	55°·5	Fahr.
10 feet	...	...	...	...	...	...	...	55°·2	„
25 „	...	...	...	...	...	...	...	54°·0	„
50 „	...	...	...	...	...	...	...	52°·5	„
55 „	...	...	...	...	...	...	...	50°·8	„
60 „	...	...	...	...	...	...	...	48°·2	„
65 „	...	...	...	...	...	...	...	48°·0	„

This series shows a range of temperature from surface to bottom of 7°·5, the greatest fall being one of 2°·6 between 55 and 60 feet.

*Loch of Forfar* (see Plate XXXIII.).—The Loch of Forfar lies immediately to the west of the town of Forfar, surrounded by cultivated fields. It flows by the Dean water into the river Isla, the outflow being a broad ditch with no perceptible current on the date of the survey, the water in the loch being very low. It contains pike, perch, and trout. It trends almost east and west, and is over a mile in length, with a maximum breadth of nearly a quarter of a mile, the mean breadth being about one-seventh of a mile, or 14 per cent. of the length. Its waters cover an area of about 103 acres, or one-sixth of a square mile, and it drains an area 14 times greater—an area of over 2 square miles. Over 60 soundings were taken, the maximum depth observed being 29 feet. The volume of water is estimated at 51,232,000 cubic feet, and the mean depth at 11½ feet, or 39 per cent. of the maximum depth. The length of the loch is 195 times the maximum depth and 494 times the mean depth. The Loch of Forfar is peculiar in conformation, due to the peninsula of Queen Margaret's inch jutting out into the loch about midway along the northern shore. From the extremity of Queen Margaret's inch a submerged causeway runs out, on which depths of 1, 2, and 3 feet were found. The deepest water in the loch lies to the north and west of the inch and causeway, approaching quite close to the end of the causeway, where a depth of 28 feet was recorded, the maximum depth of 29 feet being found a few hundred

feet to the west. To the south and east of the inch depths of 22, 25, and 26 feet were found, separated from the deep water to the west by depths of 13 to 16 feet. The 10-foot basin is a continuous area, nearly three-quarters of a mile in length, following approximately the outline of the central portion of the loch, the two ends of the loch being comparatively shallow, and weeds are abundant off the northern shore at the east end. The area of the lake-floor covered by less than 10 feet of water is about 56 acres, or 54 per cent. of the total area of the loch; that covered by water between 10 and 25 feet in depth is about 39 acres, or 38 per cent.; and that covered by more than 25 feet of water is about 8 acres, or 8 per cent. of the entire area of the loch. The Loch of Forfar was surveyed on June 26, 1903, and its elevation above the sea was determined, by levelling from bench-mark, as being 166·3 feet; when levelled by the officers of the Ordnance Survey in 1861, the elevation was found to be 170·5 feet above sea-level.

*Temperature Observations.*—Temperatures taken in the deepest part of the loch gave the following results:—

Surface ... ..	58°·9 Fahr.
10 feet ... ..	58° 3 ,,
15 ,, ... ..	57°·7 ,,
20 ,, ... ..	56°·0 ,,
27 ,, ... ..	56°·0 ,,

This series shows a range of temperature from surface to bottom of only 2°·9, the greatest fall being one of 1°·7 between 15 and 20 feet.

The particulars regarding the different lochs within the Tay basin are collected together in the table on next page for convenience of reference and comparison. Where the elevation above the sea has not been determined by levelling from bench-mark, the approximate elevation has, where possible, been indicated within brackets.

From this table it will be seen that in the 59 lochs under consideration 6850 soundings were taken, and that the aggregate area of the water surface is about 40 square miles, so that the average number of soundings per square mile of surface is 172. The aggregate volume of water contained in the lochs is estimated at 151,353 millions of cubic feet. The area drained by these lochs is 1100 square miles, or 27½ times the area of the lochs.

Loch	Elevation of surface above the sea.		Number of soundings.	Length.	Breadth.		Mean breadth per cent. of length.	Depth.		Ratio of depth to length.	Volume, million cubic feet.	Area of loch.	Drainage area.	
	Feet.	Miles.			Miles.	Mean.		Feet.	Mean.				Square miles.	Total in square miles.
Ericht	1153.0	1.0	488	14.5	0.50	3.5	189.201	37.0	150	405	38,027	7.21	50.39	6.99
Garry	1320.0	0.3	141	2.55	0.24	9.4	49.910	44.2	119	270	846	0.61	22.34	36.62
Buidhe	981.0	0.32	39	0.32	0.16	50.0	1.500	50.0	563	1296	2	0.05	11.12	222.40
na Stainge	966.5	0.40	55	0.54	0.15	27.8	5.097	36.4	204	559	11	0.08	11.79	147.37
na h-Achlaise	962.0	0.76	112	0.82	0.35	42.7	9.580	34.2	28	452	76	0.29	1.08	3.72
Bà	957.0	1.02	315	2.15	0.43	20.0	8.098	27.0	378	1402	206	0.92	17.41	18.92
Laidon and Dubh Lochan	923.0	0.70	486	5.30	0.34	6.4	35.194	27.5	219	795	1,762	1.80	47.66	26.43
Sròn Smeur	818.2	0.56	68	0.56	0.22	14	10.310	31.2	90	287	23	0.08	1.89	23.62
Eigheach	668.0	0.21	78	0.88	0.10	11.4	6.088	21.7	166	763	16	0.09	63.42	704.66
Rannoch	513.0	1.12	808	9.70	0.76	7.8	167.460	38.1	116	306	34,387	7.37	243.57	33.05
Dochart	512.0	0.16	67	0.62	0.11	17.7	5.021	45.6	298	652	10	0.07	38.85	555.00
Iubhair	1050.0	0.32	107	1.35	0.16	11.9	24.960	38.4	110	286	147	0.21	44.61	212.43
Lyon	317.2	0.26	109	1.74	0.21	12.1	44.870	44.9	92	205	461	0.37	10.56	28.54
Earn	454.5	0.80	499	6.46	0.61	9.5	137.830	48.0	118	245	14,421	3.91	54.68	13.98
Tay	349.1	0.50	924	14.55	0.36	13.1	48.030	37.5	113	302	1,317	0.98	306.06	312.31
Derenlieh	...	0.70	59	0.59	0.27	4.8	199.076	39.2	151	386	56,550	10.19	232.06	22.77
Broom	...	0.59	62	0.72	0.19	26.0	24.717	35.3	44	126	108	0.16	1.57	10.00
Essan	1440.0	0.34	41	0.46	0.11	23.7	5.020	55.8	422	757	19	0.13	3.53	26.34
Lochan Breaclich	...	0.21	59	0.49	0.11	28.2	6.820	37.9	135	356	10	0.05	1.60	32.00
Lochan na Lairige	1595.0	0.33	43	0.73	0.14	13.7	14.088	34.4	64	187	27	0.07	1.35	19.85
Dairbh	...	0.13	56	0.96	0.31	18.8	10.970	28.1	99	351	23	0.07	1.16	15.67
Giorra	...	0.31	55	0.82	0.17	20.5	39.117	41.2	53	130	190	0.17	5.13	29.48
Scoly	...	0.26	55	0.28	0.12	21.4	21.701	44.3	88	200	84	0.14	10.78	78.10
Ordie	946.3	0.12	65	0.64	0.06	21.4	5.724	47.7	123	258	3	0.02	0.23	12.77
na Craige	1297.3	0.48	27	0.48	0.28	43.8	26.324	38.2	49	128	133	0.18	4.28	23.64
		0.13			0.08	16.5	7.420	57.1	195	342	8	0.04	0.54	14.21

Kennard	...	47	0.68	0.36	0.18	26.2	72	32.266	44.8	50	111	108	0.12	0.88	7.27
Skiach	1385.7	85	0.44	0.20	25.1	55	18.090	32.9	32.9	75	228	77	0.15	0.94	6.14
Bhac	[1070]	29	0.38	0.17	33.3	42	16.500	39.3	39.3	48	122	22	0.05	1.80	36.00
Con	...	63	0.94	0.27	11.5	9	3.474	38.6	38.6	551	1430	10	0.10	3.67	36.70
Tilt	1653.5	23	0.35	0.20	21.5	5	2.500	50.0	50.0	370	740	2	0.06	0.62	20.67
Moraig	[1105]	39	0.55	0.28	11.1	14	5.540	39.6	39.6	207	524	9	0.03	2.07	34.50
Loch	[1450]	100	1.23	0.16	8.4	81	20.225	36.1	36.1	80	222	103	0.13	2.49	19.15
nan Eun	[2575]	53	0.45	0.23	28.2	50	21.642	43.3	43.3	47	110	34	0.06	0.31	5.17
Craiglush	327.6	51	0.58	0.29	32.4	44	16.130	36.7	36.7	70	190	49	0.11	5.72	52.00
Butterstone	327.6	62	1.20	0.55	23.7	53	20.400	38.5	38.5	138	360	194	0.34	7.69	22.61
Lowes	314.4	54	0.58	0.50	50.3	25	11.289	45.2	45.2	122	271	53	0.17	8.37	49.23
Clunie	156.5	83	0.62	0.59	54.7	69	29.123	42.2	42.2	47	112	170	0.21	16.29	77.57
Drumellie	146.7	74	0.86	0.46	36.9	58	29.180	50.3	50.3	78	156	222	0.27	23.26	86.14
Rae	195.2	33	0.44	0.18	24.5	16	6.590	31.2	31.2	145	353	9	0.05	0.37	7.40
Fingask	140.6	38	0.35	0.25	41.1	48	22.835	47.6	47.6	38	81	32	0.06	0.27	4.50
White	153.7	43	0.34	0.15	20.3	32	12.622	40.6	40.6	56	138	8	0.02	0.09	4.50
Black	162.8	29	0.28	0.09	15.7	7	4.730	67.6	67.6	211	313	2	0.01	0.04	4.00
Stormont...	168.1	31	0.66	0.34	26.7	3	1.500	50.0	50.0	1162	2324	5	0.12	0.32	2.66
Monk Myre	...	32	0.52	0.15	14.4	12	5.085	42.4	42.4	229	538	6	0.04	0.25	6.25
Long	724.0	52	0.70	0.28	23.6	42	9.924	23.6	23.6	88	373	32	0.16	0.87	5.44
Pitlyal	606.5	30	0.21	0.15	52.3	19	8.320	43.8	43.8	58	133	5	0.02	1.89	94.50
Freuchie	867.5	86	1.74	0.43	18.0	62	22.834	36.8	36.8	148	402	347	0.54	23.20	54.96
Hoil	[1600]	36	0.36	0.32	42.5	46	19.030	41.5	41.5	41	99	29	0.06	0.34	5.66
Fender	[1888]	59	0.33	0.19	32.2	78	31.770	40.7	40.7	22	55	55	0.04	0.36	9.00
Turret	[1132]	70	1.04	0.37	23.7	79	31.790	40.2	40.2	70	173	228	0.26	5.91	22.72
Uaine	[1520]	37	0.14	0.11	35.4	10	3.500	35.0	35.0	74	211	0.7	0.01	0.60	60.00
Drummond Pond	...	60	0.68	0.30	21.1	12	5.094	42.5	42.5	299	704	20	0.14	0.58	4.14
Monzievaird	[200]	62	0.55	0.20	19.3	39	14.700	37.7	37.7	74	198	24	0.06	1.64	27.33
Benachally	1004.9	59	1.05	0.52	23.0	64	25.080	39.2	39.2	87	221	178	0.25	3.09	12.36
Shechnich	[1330]	30	0.46	0.20	31.1	8	4.013	50.2	50.2	304	605	7	0.07	1.15	16.42
Anenchenchapel	...	43	0.37	0.27	40.3	17	8.263	48.6	48.6	115	237	13	0.06	0.33	5.50
Lintrathen	674.6	117	1.38	0.73	32.6	70	23.423	33.5	33.5	104	311	405	0.62	28.87	46.56
Forfar	166.3	63	1.07	0.24	14.0	29	11.430	39.4	39.4	195	494	51	0.16	2.19	13.68
	6851										151,3527		39.81	1099.52	27.62

## NOTES ON THE GEOLOGY OF THE TAY BASIN.

By B. N. PEACH, LL.D., F.R.S., and J. HORNE, LL.D., F.R.S. With Geological Map (Plate XXXIV.). Published by permission of the Director of H.M. Geological Survey.

The Tay basin may be divided geologically into two parts, the boundary between the two being defined by the great fault along the Highland border which runs from Glen Artney, by Crieff, Murthly, and Blairgowrie, towards Cortachy and Stonehaven. The area north-west of this line is mainly occupied by the metamorphic rocks of the Eastern Highlands, which are pierced by masses of granite, diorite, and other igneous intrusions, the latter being of special importance in connection with the history of the glaciation of the region. In the western part of the metamorphic area, on the lofty peaks of the Black Mount forest, there is a remnant of the contemporaneous volcanic rocks of Lower Old Red Sandstone Age, which are so prominently developed in the Lorne plateau. The tract, south-east of the Highland fault, embraces the lower and smaller portion of the Tay basin. With the exception of a small patch of Carboniferous strata near Bridge of Earn, the whole of this tract is occupied by rocks of Old Red Sandstone age.

In connection with the Lake Survey, the area north-west of the Highland fault is of special interest, as it includes most of the lochs which have been sounded by the staff. The metamorphic rocks which floor the greater part of this tract are bounded on their south-east margin, for a considerable distance, by the great dislocation along the Highland border. Indeed, the fault-line in places gives rise to a prominent feature, and the change, in the geological formations on either side, is indicated by a marked difference in the topography. The age of the metamorphic rocks of the Eastern Highlands has not been definitely fixed, and the original sequence of deposition is still uncertain, but they have been arranged in certain groups, which appear in a definite order as the observer proceeds northwards from the border fault.

Apart from the crystalline schists termed the " Moine Series " by the Geological Survey, which occur in the northern part of the area, the groups of metamorphic strata met with in the Tay basin are given in the subjoined table:—

11. Quartzite and quartz-schist with pebbly conglomerate and boulder bed.
10. Blair Atholl limestone.
9. Black schist with thin limestone bands.
8. Calc-sericite schists and phyllites.

7. Garnetiferous mica-schists.
6. Loch Tay limestone.
5. Garnetiferous mica-schists of Pitlochry.
4. Hornblende-schists of clastic origin and epidote-chlorite schists (Green Beds).
3. Schistose grits (Ben Ledi grits and schists).
2. Dunkeld slates.
1. Schistose grits next the Highland fault.

The members of the metamorphic series have been injected by sheets and bosses of acid and basic igneous materials, which have shared in the folding and schistosity of the altered sediments into which they have been intruded.

The distribution of these various groups of altered sedimentary strata, and the intrusive sheets of basic igneous material (epidiorite and hornblende-schist), have had an important influence in determining the trend of the tributary valleys and their surface features. The subdivisions given in the above table form sub-parallel belts crossing the basin in an east-north-east and west-south-west direction, the outcrops of which have been affected by several powerful faults, to be referred to presently.

Beginning at the Highland border, we find immediately to the north of the marginal fault a narrow band of schistose grits, extending from the river Almond to Birnam wood on the Tay, which may represent the Leny and Aberfoil grit of the Callander district. Next in order comes a zone of slate, traceable almost continuously from the forest of Glen Artney, by Comrie, to a point south of Dunkeld, where it is exposed in various quarries. The Ben Ledi grits and schists, which, as they are followed northwards, become more schistose and highly crystalline, form a belt several miles in width, extending across the basin from the heights round Loch Earn, north-eastwards by the Almond, Strath Bran, and the Tay between Birnam Hill and Logierait, and onwards by Strath Arde to Kirkton of Glen Isla. Over much of the area where the metamorphism is not highly developed the schistose grits of this group give rise to prominent rock features.

The Ben Ledi grits are followed northwards by an important zone of epidote-chlorite schists (Green Beds), which, in their ultimate stage of alteration, merge into hornblende-schists that are almost indistinguishable from rocks of this type of igneous origin. They are usually associated with intrusive sheets of epidiorite that pass into hornblende-schists, the latter sharing in the folding and schistosity that have affected the Green Beds. Like the members of this zone in the Callander region, these epidote-chlorite schists and accompanying sills of epidiorite form prominent rock features in the landscape, which have more successfully resisted glacial erosion than the overlying zone of

garnetiferous mica-schist. On both sides of the valley of the Tay at Aberfeldy these rocks may be studied, and they appear on the moorland between the Tay and Strath Ardle, and eastwards by Kirkton of Glen Isla, either as isolated patches in the form of outliers, or as more or less continuous outcrops. Again, towards the south-west, the Green Beds reappear at intervals on the heights between Loch Tay and Loch Earn till they are abruptly truncated by the Loch Tay fault.

One of the best-defined zones in the metamorphic series of the Eastern Highlands is that of the Loch Tay limestone, with its overlying and underlying garnetiferous mica-schists. In the Tay basin the members of these groups (5, 6, 7) usually indicate a stage of high metamorphism, the beds being easily eroded by surface agencies. Save where deflected by powerful faults, their outcrops are traceable almost across the basin. From Glen Fernate, at the head of Strath Ardle, the Loch Tay limestone has been followed south-westwards, by Pitlochry, along the north slope of the Tay valley at Aberfeldy, to the heights overlooking Fortingal, where the outcrop has been deflected by the Loch Tay fault. West of this line of disruption the limestone reappears, about 4 miles further south, on both sides of Loch Tay (see geological map), whence it can be traced westwards up Glen Dochart and across Strath Fillan almost to the slopes of Ben Lui, at the south-west margin of the Tay basin. Owing to folding, the Loch Tay limestone and its associated strata reappear to the north of the line of outcrop just indicated, as, for instance, in Glen Lyon and in the valley of the Lochay north-west of Killin; and to the south of this line, it is met with at Lochearnhead and on the Braes of Balquhider. An important feature connected with this limestone is the frequent occurrence of a massive sill of epidiorite in conjunction with it.

Still further north the sub-divisions just described are succeeded by calc-sericite schists, phyllites, and black schists with thin lenticular bands of limestone (groups 8, 9), which present lithological characters that are, as a rule, readily identified. The trend of the outcrop of these zones has been affected by the north-east and south-west faults which traverse the basin, and the black schist spreads over a broad area, in certain localities, by means of sharp isoclinal folds. Taking first the most southerly outcrop of the calc-sericite schist, phyllites, and black schist, they are traceable from Ben Vrackie south-west by Faskally on the Tay, to the Loch Tay fault north of Fortingal. West of this line of disruption, they have been followed from Glen Lyon, by Ben Lawers, and across Glen Lochay to the heights above Glen Dochart, where they terminate in a synclinal fold of the underlying garnetiferous mica-schists associated with the Loch Tay limestone. Still further west they reappear and form a broad outcrop stretching from the upper part of Glen Lyon in a south-south-west direction towards Tyndrum, where they are again interrupted by a north-east and south-west fault (see geological map).

The Blair Atholl limestone has an important development in the neighbourhood of Blair Atholl, and up the valley of the Tilt towards the limit of the basin. Sharing in all the folds of the associated phyllites and black schists (group 9), its outcrop is irregular and involved. Where these zones appear, in the Tilt, in the Tay, and Strath Tummel, they generally give rise to softer outlines than the quartzite which apparently overlies them.

The Perthshire quartzite (group 11) is, perhaps, the most striking geological sub-division in the metamorphic series of the Eastern Highlands, from its greater durability and the lofty mountains to which it has given rise. Along its northern margin the rock is more or less coarse-grained, due to the presence of pebbles of quartz and felspar, but this band is repeatedly brought to the surface by means of folding. An interesting feature of this group is the presence of a conglomerate or boulder bed with rounded blocks of granite, foreign to the area, the matrix of which seems to vary with the rock in contact with it. Sometimes appearing as lenticular or boat-shaped masses surrounded by black schists, phyllite, or limestone, and again as narrow belts traceable for several miles, the quartzite is always one of the dominant features of the landscape, occasionally forming lofty peaks, as in Ben-y-Ghlo and Schichallion.

In addition to the sub-divisions of the metamorphic rocks of the Eastern Highlands which have just been described, there is a group of crystalline schists termed the "Moine series" by the Geological Survey, which have a wide distribution in the north-west part of the Tay basin. Their lithological characters are remarkably persistent over wide areas. Consisting mainly of quartzose granulitic schists or fine-grained gneisses with bands of mica-schist, they represent without doubt a highly altered series of sediments, the original clastic grains of which have been destroyed. They form nearly the whole of the area north of Loch Rannoch, up Glen Garry, and northward of Glen Tilt.

Reference has already been made to the intrusive sheets of basic igneous rock which appear in association with the Green Beds and Loch Tay limestone, but others occur in connection with the zones of calc-sericite schist and black schist. Perhaps the most remarkable example of the latter is the mass of epidiorite and hornblende-schist on Ben Vrackie north of Pitlochry, where the altered sediments have been deflected and bent round the laccolitic intrusion.

The acid igneous rocks which were injected into the sedimentary series, before the folding and development of schistosity in the latter, are best represented by the foliated granite of Ben Vuroch, north-east of Ben Vrackie. On the north-west slope of that mountain, the sediments, which still retain their original bedding, have undergone contact alteration, the calcareous shales having been converted into calc-silicate hornfels.

In the central part of the metamorphic area there is a well-defined line extending from Ben Vrackie south-west by Ben Lawers to Glen Lochay, which marks the axis of a fan-shaped arrangement of the folding of the strata. Along this line the axial planes of the folds are vertical, and on either side they are inclined towards the centre of the fan. Hence on the south-east side of this central axis there is a remarkably persistent dip of the folds towards the north-west, while on the north-west side the general inclination is towards the south-east. A fine example of the latter is to be found in the river Garry, where between Blair Atholl and Dalnaspidal the granulitic schists of the Moine series dip persistently towards the south-east for a distance of about 15 miles, and yet it is highly probable that the same bands are repeated indefinitely by means of folding. This remarkable reduplication of the strata can be clearly demonstrated in the case of the black schist, limestone, and quartzite groups, where the lithological types are clearly differentiated from each other. For a distance of 6 miles across the strike, between Ben Vrackie and Glen Tilt, these groups constantly reappear, the sill of garnetiferous hornblende-schist being indefinitely repeated with the black schist.

Reference has already been made to the system of north-east and south-west dislocations which traverse the metamorphic area. Of these, apparently the most powerful is the Loch Tay fault, which has been traced from near Blair Atholl, across Loch Tay, Loch Earn, and Loch Lubnaig, till it is truncated by the fault along the Highland border at Aberfoil. Further west, and roughly parallel with the foregoing, comes the line of disruption which extends from Loch Garry across Loch Rannoch and the valleys of the Lyon, the Lochay, and the Dochart towards the Braes of Balquhiddy. Again, from Tyndrum another dislocation has been followed north-east by Loch Lyon and the west margin of Loch Rannoch in the direction of Loch Ericht. Finally, in the north-west part of the basin there is a line of fracture running along Loch Ericht and Loch Laidon, which is roughly parallel with the Loch Tay fault. In the case of the Loch Tay, the Loch Garry, and the Loch Lyon dislocations, the downthrow has been on their western side; in other words, on that side the outcrops of the sedimentary bands and epidiorite sills have been shifted further to the south by each fault in turn.

Within the metamorphic area, as already indicated, there are various masses of igneous rock which are later than the folding and foliation of the crystalline schists, and have been referred to the newer granite intrusions of the Highlands. Of these, the most important is the large mass of diorite on the Moor of Rannoch, which stretches northwards to Loch Ericht and west towards Loch Treig, boulders of which have been carried far during the glaciation of the region. Other masses appear on both sides of Loch Ericht, in Glen Tilt, on the lofty

plateau north of that valley, and far to the south in Glen Lednoch between Comrie and Loch Tay. Several of these igneous intrusions consist partly of diorite and partly of granite, the more basic type being erupted prior to the more acid.

At the western margin of the basin on the lofty peaks of the Black Mount forest there is a terraced plateau of contemporaneous igneous rocks of Lower Old Red Sandstone age, pointing to the former extension of this volcanic series, the distribution of which is of importance in connection with the glaciation. These are pierced by plutonic rocks (granite), which have produced a certain amount of contact alteration in the lavas.

In the lower part of the basin of the Tay, which is almost wholly occupied by Old Red Sandstone, both the lower and upper divisions of that system are represented. The Lower Old Red Sandstone has by far the greater development, being divisible into a lower volcanic series and an overlying group of sandstones, conglomerates, and marls. Two great flexures cross the basin in a north-east and south-west direction, roughly parallel with the fault along the Highland border. One of these flexures forms a broad arch, exposing a great series of contemporaneous volcanic rocks in the Ochils and the Sidlaws; the other forms a great trough, in line with the valley of Strathmore, containing the highest members of this division in the basin of the Tay. The anticlinal fold is prolonged far to the north-east into Forfarshire and Kincardineshire, where sandstones and flags appear in the crest of the arch. In the Ochils the total thickness of lavas, tuffs, and agglomerates in the north limb of the fold is about 6000 feet, and they were probably deposited on a gradually sinking area; nevertheless, some of the volcanic cones may have ultimately appeared above the level of the water and become subaërial. Rising out from underneath the overlying sandstones and marls, along the Highland border, the volcanic series again appears, though in a very attenuated form, consisting of andesitic lavas, which are associated with coarse conglomerates containing pebbles of volcanic rocks. Indeed, the lavas, conglomerates, and sandstones occur on the north side of the fault at Blairgowrie, and again at Crieff, where they rest unconformably on the metamorphic rocks. The broad tract of low ground between the Sidlaws and the Highland border has been carved out of the softer sandstones and marls overlying the volcanic series. The river Isla, when it enters the area occupied by this overlying sedimentary series, is deflected towards the south-west till it joins the Tay.

The long interval which elapsed between the Lower and Upper Old Red Sandstone periods was marked by great denudation of the members of the lower division of that system. The strata were thrown into anticlinal and synclinal folds, the axes of which are roughly parallel with the trend of the fault along the Highland border. And further,

along the crest of the arch, the higher members of the lower division were worn away, and the volcanic rocks were laid bare, before the Upper Old Red Sandstone was deposited. The members of the upper division occur near Bridge of Earn, and extend beneath the estuary of the Tay and the Carse of Gowrie to near Dundee. Between Forgan-denny and Bridge of Earn, the basement beds are found resting unconformably on the denuded Lower Old Red Sandstone volcanic rocks, where fragments of the latter occur in the breccias. On both sides of the estuary of the Tay, however, the Upper Old Red Sandstone is brought into conjunction with the volcanic series of the lower division by two parallel faults. The members of the upper division are composed mainly of friable brick-red sandstones and marls, which have yielded near Errol fine specimens of the genera of fishes characteristic of this division.

Reference has already been made to the fact that a small patch of Carboniferous rocks appears about half a mile to the south of Bridge of Earn, which are brought into conjunction with the Lower Old Red volcanic rocks to the south by means of a fault. The strata consist of blue clays and shales, sandstones, and calcareous bands belonging to the Cementstone group. Small though it be, this remnant is of great importance in proving the former extension of the Carboniferous rocks over the lower part of the Tay basin, from which it has been almost wholly removed by denudation.

The existing valley system of the basin of the Tay furnishes admirable examples of the influence of geological structure in determining the direction of the water drainage. The upper part of the Tay itself, and many of the tributaries within the metamorphic area, flow approximately in the direction of the strike of the crystalline schists. The massive Ben Ledi grits, the Green Beds, the sills of epidiorite and hornblende-schist, and the Perthshire quartzite have each had a powerful influence in the development of the prominent rock features of the region. Where these occur in association with zones of mica-schist and phyllite, they have more successfully resisted erosive action, and have given rise to rocky barriers or precipitous escarpments, thereby contributing to the formation of gorges, and in some cases of rock-basins.

The evidence relating to the glaciation of the Tay basin leads to the conclusion that, during the climax of the Ice age, the region must have been covered with one continuous sheet of ice, the movement of which must to some extent have been independent of the existing valley system. Where the rocks have been able to retain the striæ, the latter have been found up to elevations of 3000 feet, showing that the highest mountains were over-riden by the ice. This stage was followed by a period of confluent glaciers, when the ice streamed over passes connecting adjoining valleys, leaving in its track lines of moraines.

Finally, there is the phase of corrie glaciers, when the glacial detritus was borne for no great distance from the local centres of dispersion.

During the maximum glaciation, the ice-shed lay round the north-west margin of the Tay basin, from the mountains beyond Rannoch Moor, by Ben Alder west of Loch Ericht, eastwards to the watershed separating Glen Garry from the tributaries of the Spey and the Dee.

Beginning in the western part of the basin, with the lofty watershed between the head of Glen Lyon and Glen Lochay, in the Mamlorn forest, striæ are found at intervals along this ridge for a distance of 3 miles, at elevations which in some cases vary from 2700 to 3000 feet, trending E.  $20^{\circ}$  to  $30^{\circ}$  S. Further east, about 3 miles north of Killin, on Creag-na-Caillich at a height of 2250 feet, the direction is about south-south-east. Again, to the west of Ben Lawers, the ice-markings point S.  $40^{\circ}$  E. about the 2000-foot level. Proceeding northwards to the dividing line between Glen Lyon and Strath Tummel, the evidence is no less remarkable, for on Schichallion, at an elevation of 3000 feet, the trend is E.  $30^{\circ}$  S. Still further north, on Beinn a' Chuallaich—a high mountain between Glen Erichdie and Kinloch Rannoch—the striæ point S.  $30^{\circ}$  E. at a height of 2700 feet. Again, on Ben Vrackie, about 3 miles north of Pitlochry—a mountain which is glaciated to the top—the trend is east-south-east. Similar conclusive evidence is obtained on the dividing ridge that stretches eastwards from Schichallion towards Pitlochry and separates Strath Tummel from the upper course of the Tay between Aberfeldy and Logierait. Part of this ridge is composed of the Perthshire quartzite, the glaciated surfaces of which show finely preserved striæ, the direction varying from E.  $20^{\circ}$  S. to E.  $45^{\circ}$  S. On one of the prominent peaks of this ridge—Ben Eagach—south of Loch Tummel, ice-markings are found on the top at a height of 2250 feet, which point E.  $35^{\circ}$  S. Further south, on the dividing ridge between Strath Bran and the valley of the Almond, on Meall nan Caoraich, the direction is E.  $30^{\circ}$  S., close to the 2000-foot contour-line. Additional instances might be given from the mountainous region within the metamorphic area, but the above examples establish the conclusion that during the maximum glaciation there must have been a movement of the *mer de glace* independent of the valley system in an east-south-east or south-easterly direction.

During the great extension of the ice, on the broad plateau of the Moor of Rannoch the ice seems to have radiated partly towards the east-south-east or south-east, and partly towards the south-west in the direction of the Tulla and Glen Orchy (see geological map).

The evidence obtained from the dispersal of the boulders is no less remarkable, for in some cases they have been carried far from their parent source, and over lofty cols. The boulders of diorite or hornblende granite from the Moor of Rannoch have been found in Strath Tummel, in Glen Lyon, in Strath Fillan, in Strath Tay, and across the

watershed into Glen Almond. Again, all along Strath Fillan, Loch Tay, and Strath Tay, boulders of the Perthshire quartzite, black schist, limestone, and calc-sericite schist have been carried several miles to the south of the various belts from which they were derived. Of course, in many of these instances, the boulders may have been distributed during the later glaciation. On the slopes of Ben More (3843 feet), which is composed of grits of the Ben Ledi group, blocks of calc-sericite schist occur that have been carried from the hills to the north-north-west in the direction of the Mamlorn forest. Confirmatory evidence is furnished by the dispersal of the stones in the boulder clay—a deposit formed during the great extension of the ice. Within the metamorphic area, sections of boulder clay occur up the Tay valley as far as Loch Tay, in the valleys of the Tummel and the Garry as far as Struan, and in Strath Bran from Amulree to Dunkeld. Outlying patches are found also at the east end of Loch Rannoch and round Loch Tummel.

After the stage of the great ice-sheet, there followed a period of confluent glaciers when the ice was still thick enough to stream over passes connecting adjoining valleys, as, for instance, over some of the cols between Glen Lyon and Glen Lochay, between Glen Lyon and Loch Tay, and between Glen Lochay and Glen Dochart, between the upper course of the Tay and Strath Bran, and between Loch Tay and Glen Almond. Again, the glacier which moved eastward from the high mountains in Black Mount forest and at the head of Glen Coe and Glen Etive was deflected southwards, part of it flowing into Glen Orchy, and part into Strath Fillan. The numerous groups of moraines, frequently showing a terraced arrangement along the hill slopes, indicate the great development of the later glaciation. Fine examples of the local dispersion of moraines are to be found in the neighbourhood of the Black Mount forest and the mountains round the head of Glen Etive and Glen Coe. The debris of Old Red Sandstone volcanic rocks have been traced in the moraines eastwards from the Black Mount forest to the drift-covered plateau at Loch Bà.

Within the Tay basin by far the larger number of the lochs lie in the midst of drift deposits, most of which are of no great size, and are comparatively shallow. In the southern part of the Moor of Rannoch, along the river Bà and its tributaries, in Allt Lochain Ghaineamhaich, and on the drift plateau, about twenty-five lochs occur in the midst of morainic drifts. Numerous examples of this type occur in other parts of the basin.

Again, several lochs, some of which are of considerable size, lie along lines of displacement, or fault-lines, for which reason they need not now be discussed. For example, Loch Ericht and Loch Laidon are situated on one line of disruption which has been traced over a considerable distance in the eastern Highlands. Loch Garry, at the head

of Glen Garry, and Loch Lyon, near the head of Glen Lyon, likewise occur along lines of fault. In each of these cases, the long axis of the loch coincides with the course of a more or less powerful dislocation, which has been traced for miles.

The following instances might be discussed in relation to the question of the glacial origin of rock basins: Loch Rannoch, Loch Tummel, Loch Tay, Loch Earn, Loch Iubhair, and Loch Dochart. Of these, the first four have been previously described by our colleague, Mr. J. S. Grant Wilson, in the *Scottish Geographical Magazine* for May, 1888, in connection with the soundings made by him in the course of the geological survey of the district. It is not necessary, therefore, to give in detail the evidence in support of the view that these lochs, with the exception of Loch Tay, have been eroded by ice-action. His soundings have been, as a rule, confirmed by Sir John Murray and his staff.

Loch Rannoch is a fine instance of a rock basin, for though, at the lower end, the river Tummel, which issues from the loch, flows along an alluvial flat for a distance of 3 miles as far as Dun Alastair, a rocky barrier appears at the latter point in the river and on the hill slopes. Near the foot of the loch, on either side of the valley, there is a prominent mass of high ground, culminating in Schichallion (3547 feet) and Beinn a' Chuallaich (2925 feet). The streams draining this high ground to the north and south have silted up the loch at the lower end, and have produced the long stretch of alluvium between Kinloch Rannoch and Dun Alastair. The longitudinal section of Loch Rannoch shows that the loch gradually deepens from the west margin towards the centre and lower end. The soundings further show that between the mouth of the Dall burn and the foot of the loch there are three small basins, each over 400 feet in depth. The deepest sounding—440 feet—is in the centre of the largest and most easterly of these three basins, and within 2 miles of Kinloch Rannoch. On referring to the geological map it will be seen that the Loch Garry fault crosses Loch Rannoch near Dall in a S.S.W. direction; and, notwithstanding the fact that the downthrow side of this fault is towards the west, yet the deepest sounding is found on the upthrow side.

Loch Tummel is another typical example of a rock basin, the rocky barrier appearing in the stream and on the hill slopes at Allean House, about a mile below the mouth of the lake. For several miles downstream, as far as Faskally, the Tummel cuts through solid rock, composed mainly of the Perthshire quartzite, with bands of black schist. This loch has had originally a greater extension westwards, for it has been silted up by alluvial matter deposited by the streams. It is about  $2\frac{1}{2}$  miles long, and the soundings show that it forms three separate basins of no great depth, the deepest sounding of the western basin being 128 feet; of the central, 119 feet; of the eastern, 99 feet.

Where these slopes and barriers appear, streams enter the lake from the south, which have given rise to cones projecting for some distance into the loch. It is probable, however, that they may be formed partly of solid rock. Judging from the evidence round the sides of Loch Tummel, the floor of that loch consists mainly of black schist, with infolds of the lower part of the quartzite.

Loch Earn may be described as the best instance of a typical rock basin within the catchment area of the Tay. Upwards of 6 miles long and about three-quarters of a mile broad, the soundings show that it is a simple basin. The deepest sounding—287 feet—occurs about half-way down the loch. The Loch Tay fault crosses the lake about a mile from the upper or western end; and along its course there is a small basin, the greatest depth of which is 240 feet. West of this fault, the floor of the loch is composed of the Loch Tay limestone and the underlying garnetiferous mica-schists; east of it, for some distance, the lake lies obliquely across the strike of the schists overlying the Green Beds and the Green Beds themselves; while at the foot of the loch the Ben Ledi grits appear as a rocky barrier crossing the valley at St. Fillans.

Lochs Iubhair and Dochart may be cited as further instances of rock basins. Originally forming one sheet of water, they have been isolated by alluvial matter brought down by the stream that drains the great corrie west of Ben More. The deepest sounding of Loch Iubhair—65 feet—is near the foot. *Roches moutonnées* appear in that lake, both about the middle and near the foot. Loch Dochart is being rapidly silted up; indeed, it must formerly have extended for 3 miles up the valley of Strath Fillan. The deepest sounding of Loch Dochart is 11 feet.

Further down Glen Dochart there is a strip of alluvium about 5 miles long, between Luib station and Easter Lix, which may probably represent a silted-up rock basin.

Loch Tay presents certain features which differentiate it from the rock basins already described. There is no rocky barrier close to the lake; the Loch Tay fault runs along the course of the lake for a distance of  $5\frac{1}{2}$  miles from Ardeonaig to Stronfearnan; the greatest depth, which is 508 feet, lies on the downthrow side of this dislocation; and finally there is a basin 12 miles long, the whole of which is below the level of the sea. The first appearance of solid rock in the bed of the Tay is north of Grandtully castle, about 8 miles below the foot of the loch, where mica-schists appear, belonging to the group of the Ben Ledi grits. For a distance of  $1\frac{1}{2}$  miles below this point to near Ballinluig village the river flows at intervals over rocky ledges. There can be no doubt that the deflection of the original valley of the Tay between Ardeonaig and Stronfearnan was due to the Loch Tay fault, whereby the Loch Tay limestone and associated schists on its western side were brought into conjunction with the intrusive igneous masses

of Tomnadashan and Beinn Bhreac. The soundings show that the deepest part of the basin, which is bounded by the 400-foot contour-line, lies along the course of this fault. Under these circumstances, Loch Tay cannot be regarded as a typical example of a rock basin.

The other rock basins, however, seem to us to furnish strong evidence in support of the theory that they have been eroded by ice-action.

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### BIOLOGY OF THE LOCHS OF THE TAY BASIN.

By JAMES MURRAY.

While it was not compatible with the bathymetrical work of the Lake Survey to study in detail the biology of the lochs, it has been customary to make collections of the plankton of each loch, a coarse and a fine net being used in each case. It is thus possible to compare only the biology of the open water of the different lochs. The number of species living in the open water is not very great, and does not vary in different lochs so much as might have been expected. The fauna of the shallower lochs is usually much richer than that of the deeper ones, owing to the occurrence in them of many species which in larger lochs would be confined to the shore region. Even thus limited, it is found that the lochs differ sufficiently from one another to render a comparative review of them of much interest. Each loch has a distinct character, which, notwithstanding a considerable amount of seasonal variation, is pretty constant.

A small number of animals and plants occur so constantly in the open water of all our lakes, large or small, that they mainly determine the character of the plankton of this pelagic region. They are so generally present that the absence of any one of them is occasion for remark. The most important of them are—*Diatomus gracilis*, *Cyclops strenuus*, *Daphnia lacustris*, *Bosmina obtusirostris*, the Rotifers *Conochilus* (two species), *Anuræa cochleare*, and *Notholca longispina*, and the Diatom *Asterionella gracillima*. These are found at all seasons. In the summer, *Holopedium*, *Leptodora*, *Bythotrephes*, and *Polyphemus* are as generally distributed.

Only less common are *Asplanchna priodonta*, *Polyarthra platyptera*, *Peridinium tabulatum*, *Ceratium hirundinella*, *Mallomonas*. Some Desmids, mostly of the genus *Staurastrum*, but including also species of *Micrasterias*, *Xanthidium*, and *Closterium*, are generally present. The Rotifers *Floscularia pelagica* and *Notops pygmaeus* are of frequent occurrence. Although all of those species may be present in most of the lochs, the varying proportions in which they occur in the plankton give rise to great differences of character in the lochs. Other species of

*Diaptomus*, *Daphnia*, and *Bosmina* are occasionally found, but the species included in the preceding list are so much more common, that when the generic name only is mentioned it will be understood that the common species is referred to.

This small association of animals and plants constitutes what may be called the lacustrine type of plankton. A not very dissimilar association is found in small ponds, but the species for the most part are different. The *Diaptomus* may be *D. castor*, the *Daphnia* *D. pulex*, the *Bosmina* *B. cornuta*; Rotifers and Algæ will be more abundant and varied, and there will probably be some Ostracodes. It might have been expected that the shallowest lochs would have had a plankton of the pond type, but it has been found that even the smallest lochs surveyed had the plankton distinctly lacustrine. A few nearly or quite stagnant lochans showed a slight approach to the pond type in the presence of *Bosmina cornuta* and *Volvox* and in the abundance of Rotifers and Algæ.

The remarkable variations of the loch trout, which have so much puzzled naturalists cannot be touched on here, but parallel cases are found among the smaller animals. *Diaptomus gracilis* varies remarkably in colour, and is usually constant for each loch, and several other Entomostraca vary greatly in size and form; chief among these is *Daphnia*. The typical lacustrine form of this genus, which will be referred to as *Daphnia lacustris*, has an evenly rounded head with a depression on the line of the forehead marking off the brow from the beak. Where this depression is obliterated the head of the animal has a very different appearance, resembling that of a parrot. The form differing most from the typical *Daphnia lacustris* is that in which the head is produced upwards into a sort of peak or helmet. For convenience, this form will be referred to as *Daphnia galeata*, though it is doubtful if the points of difference are of specific value, and intermediate varieties are found.

After *Daphnia*, the species which varies most is *Bosmina obtusirostris*. The typical lake-form has a short mucro at the posterior angle of the valves. It varies much in size and in colour, being usually hyaline, but sometimes purple, or rarely orange and purple.

During its season *Holopedium*, from its large size, is very conspicuous in those lochs in which it occurs. It is frequently so abundant that it chokes up the nets in a short time, and makes it impossible to get a fair proportion of the other animals present. It appears in some lochs as early as May, and continues till August.

Commonly a single organism, usually vegetable, will so increase in a loch as to form what the Germans call a "Wasserblut." The Algæ *Clathrocystis*, *Oscillaria*, *Botryococcus*, *Anabana*, and *Volvox* are among those which most frequently increase to this extent, but almost any of the smaller organisms, as Diatoms, Rotifers, or Protozoa, may on

occasion do so. *Asterionella*, *Notholca longispina*, *Asplanchna priodonta*, *Ceratium hirundinella*, and even on one occasion the rather uncommon Rotifer *Dinocharis Collinsii*, have been observed to form a "Wasserblut" in the shallower lochs.

The abundance of certain species in a loch on a single visit may be exceptional or temporary; the small lochs may vary greatly at different seasons. It is believed that, except for the seasonal appearance of certain species which are known to live for only a few months of the year, a loch is pretty uniform in character throughout the year. This is known to be the case with the large lochs and with some small ones.

The points to which attention will be called in reviewing the biology of the Tay lochs will be—the abundance or scarcity of life on the whole; the preponderance of one or a few species in each loch; the abundance of an animal or plant that is usually scarce; the absence or scarcity of some very common species.

The lochs of the valley of the Earn differ much in size and physical conditions, so that they might be expected also to differ much in their biology. There is one great lake, Loch Earn, two hill lochs, Turret and Uaine, the latter at a great elevation, one deep but stagnant pond, and one shallow artificial dam.

*Loch Earn.*—The only abundant organism was *Diaptomus gracilis*, which was bright red in colour. There was almost no life at the surface, the *Diaptomus* being in myriads at a depth of 40 or 50 feet. The loch was rather remarkable for the scarcity of common lacustrine species. *Bythotrephes* was somewhat frequent; *Polyphemus*, *Cyclops strenuus*, and *Bosmina obtusirostris* were present, but not plentiful. *Daphnia* was very rare, only one example being seen. Smaller organisms were almost entirely absent, except for a few examples of the two commonest pelagic Rotifers: *Anuraea cochleare* and *Notholca longispina*, and some unicellular Algæ.

*Loch Turret.*—This was one of the lochs where *Holopedium* filled the net with a slimy mass, and rendered it difficult to catch anything else. *Diaptomus gracilis*, *Daphnia* (typical *D. lacustris*), *Asterionella*, *Peridinium tabulatum* were noted.

*Lochan Uaine.*—This little shallow tarn, in a corrie at a considerable elevation, had nothing remarkable in its pelagic life. *Diaphanosoma brachyurum* was most numerous; *Diaptomus gracilis*, of a brown colour, and *Polyphemus* were common. Only a few examples of *Daphnia lacustris* and *Holopedium* were seen.

*Loch Monzievaird (or Ochertyre).*—This loch, though fairly deep, was almost stagnant at the time it was visited. As might be expected from this and from the very high surface temperature, life was abundant and varied. The collection was green from the abundance of *Volvox*. *Bosmina cornuta*, *Daphnia lacustris*, *Diaptomus gracilis* (of a brown

colour), *Ceratium hirundinella*, *Asplanchna*, *Anuræa cochleare*, *Anabæna* were among the most abundant organisms. Many others were present in smaller numbers.

*Drummond Pond*.—This is a shallow and nearly stagnant artificial pond, and many species were plentiful in the water. *Daphnia lacustris* was most numerous. Many males and females carrying ephippia were present. Other abundant species were *Ceriodaphnia* (some with ephippia), *Anuræa cochleare*, *Conochilus*, *Asplanchna*, *Notops pygmaeus*. *Volvox* was scarce. The beautiful Rhizopod *Diffugia corona* was seen.

The lochs of Strath Bran, though completely isolated one from another, and draining by different streams into the Bran, are fairly comparable one with another, being all, with the exception of Loch Freuchie, hill lochs of small size, lying at considerable elevations.

*Loch Freuchie*.—This was one of the lochs where *Holopedium* for the time being abounded to the exclusion of everything else. Only a few individuals of *Diaptomus gracilis* (brown in colour) were seen. Hardly any small organisms were noticed.

*Loch Fender*.—Life was abundant, but few species were present. The most numerous animals were *Diaptomus* (pale brown), *Notholca longispina*, *Daphnia* (parrot-shaped head), *Bosmina longispina*, and *Peridinium tabulatum*. *Holopedium* was not seen.

*Loch Hoil*.—Life was very abundant. The commonest animals were *Holopedium*, *Diaptomus gracilis*, *D. Wierzejskii* (blue, red, or red and blue), *Daphnia*, and *Asplanchna*.

*Loch na Craige*.—Animals of many species were present, but only four were plentiful—*Diaptomus gracilis* (blood-red), *Bosmina obtusirostris* (of large size), *Daphnia lacustris* (very large), and *Conochilus unicornis*.

*Loch Kennard*.—Some seven or eight species of animals were common in the loch, but *Diaptomus* predominated. *D. gracilis* and *D. Wierzejskii* were both present. Blood-red individuals of both species occurred, and *D. Wierzejskii* was also seen of the usual blue colour, or red and blue. *Holopedium*, *Notholca longispina*, and *Asplanchna priodonta*, and the somewhat rare crustacean *Latona setifera*, were numerous.

*Loch Skiach*.—The characteristic animals were *Holopedium*, *Daphnia lacustris* (very large), *Bosmina obtusirostris* (very small, purple). *Gammarus pulex* of large size, and orange colour, was found. A few examples of *Bosmina* were large and brightly coloured, orange and purple.

*Loch Tay*.—Comparing Loch Tay with Loch Rannoch, it is found that the plankton differs in several important particulars. Besides the common *Diaptomus gracilis*, there was another species, *D. Wierzejskii*,

pretty common in the loch. This is a larger species, usually dark blue in colour. It is a northern species, of general occurrence over the north and west of Scotland, but hardly known south of Loch Tay. *Daphnia* was always very scarce. Desmids of the genera *Staurastrum* and *Arthrodesmus* were more numerous than is usual in great lakes. As in Loch Rannoch, skeletons of *Clathrulina* were abundant.

*Lochs Iubhair and Dochart.*—Both these lochs, being very shallow, had, at the time they were visited, in addition to the usual pelagic species of *Diaptomus*, *Daphnia*, and *Bosmina*, several species in abundance which are not truly pelagic. *Chydorus sphaericus*, *Alonopsis elongata*, and *Alonella nana* were as numerous as the pelagic species. Rotifers and Protozoa, especially Rhizopods, were more varied than usual.

*Loch Essan.*—Life was abundant and varied. *Daphnia* was of three forms—large typical *Daphnia lacustris* with rounded head, smaller with tall helmet (*D. galeata*), and an intermediate form. *Diaptomus gracilis*, some dark brown, some hyaline, *Polyphemus*, *Diaphanosoma brachyurum*, *Bosmina obtusirostris*, and water-mites (Hydrachnidæ), which do not usually occur in the open water, were all common.

*Loch Breaclauch.*—This loch was quite unusual from the great numbers of a Rotifer, *Asplanchna priodonta*, which formed a "Wasserblut," appearing as a great slimy mass in the net. *Diaptomus gracilis* (hyaline), *Cyclops* (dark red), and *Diaphanosoma brachyurum* were seen.

*Loch na Lairige.*—The characteristic organisms were *Bosmina obtusirostris* (large dark brown, and purple) and a species of *Conochilus*. *Daphnia galeata* (with tall helmet), *Polyarthra*, and *Diaptomus gracilis* (pale, immature) were frequent. A few dark red *Diaptomus gracilis*, *Sida crystallina*, and *Bythotrephes* were also present.

*Loch Lyon.*—The biology of this loch was notable for its unusual richness. Most abundant were *Diaptomus gracilis* (pale yellow), *Bosmina obtusirostris* (with somewhat long spine), *Cyclops strenuus* (of large size), and Rotifers of many species. Larvæ of *Diaptomus* were exceedingly numerous.

*Lochs Daimh and Giorra.*—These two lochs are so nearly alike in size and so close together, being connected by a river, that they might be expected to resemble one another in their biology, but they were found to differ greatly. In Loch Daimh, *Holopedium* was abundant, but very young. *Diaptomus gracilis* (hyaline, with dark brown eggs) was numerous, and the larvæ still more so. Nothing else was found in any numbers. Loch Giorra, on the other hand, had half a dozen common species—*Diaptomus gracilis* (pale yellow), *Cyclops strenuus*, *Daphnia lacustris*, *Bosmina obtusirostris*, *Dinobryon*, and *Tabellaria* (two species). *Holopedium* was not seen.

*Loch Derculich.*—The characteristic animals were *Diaptomus* (brown), *Daphnia lacustris* (with parrot-shaped head), *Bosmina obtusirostris* (with long beak), *Notholca longispina*, and *Dinobryon*.

*Loch Scoly.*—The most abundant animals were *Daphnia lacustris*, *Diaptomus gracilis* (dark brown, mostly immature), *Conochilus volvox*, *Bosmina obtusirostris* (small), and *Peridinium tabulatum*.

*Loch Rannoch.*—The plankton of Loch Rannoch may be fairly taken as the type of all the large Scottish lochs. Almost every one of the species included in the list of the lacustrine organisms was found in it, and there was nothing in it not given in the list. Of the Entomostraca, *Bosmina* was the most abundant. Skeletons of the Rhizopod *Clathrulina elegans*, though this is not a pelagic animal, were always found in it. The biology of the littoral region of the loch has been studied with some care by Mr. D. J. Scourfield and others, but as this region has not been studied in the other lochs of the system, it is thought better not to enter into the details of it here.

*Loch Bà.*—Most of the common pelagic animals were not seen, while many species belonging rather to the shore (or littoral) fauna were numerous, as *Eurycerus lamellatus*, *Acroperus harpæ*, *Alonella nana* and *A. excisa*, *Alona affinis* and *A. guttata*, and *Chydorus sphaericus*. Many Rhizopods were observed, as well as mites and Ostracodes.

*Loch Laidon.*—Only the Entomostraca of this loch were studied by Mr. D. J. Scourfield. The species were all the same as in Loch Rannoch. No collections were made of the other groups of animals.

*Lochan Sròn Smeur.*—Notwithstanding the high elevation and the early season at which it was examined, this loch was found to be exceptionally rich in both animals and plants, particularly in Rotifers, Rhizopods, and Desmids. *Holopedium* was here seen unusually early in the season. Besides the ordinary pelagic animals, *Diaptomus*, *Daphnia*, *Bosmina*, &c., *Latona setifera* was present.

*Loch Bhac.*—The commonest animals were *Diaptomus gracilis* (red), *Bosmina obtusirostris* (with long beak), *Daphnia lacustris*, *Diaphanosoma brachyurum*. Among the Rotifers was the brilliant red and blue *Notops pygmaeus*, and the curious Desmid *Micrasterias Wallichii* was present.

*Loch Con.*—Entomostraca were few, and Algæ more numerous than usual. The commonest animal was *Bosmina obtusirostris* (small). *Diaptomus gracilis* (some large, yellow, others red). The Rotifer *Notops pygmaeus* was unusually large.

*Loch Tilt.*—In common with a few other lochs, usually lying at considerable elevations, the only common animal was *Diaptomus gracilis*, so bright red in colour that the net, when taken up, seemed filled with blood. Hardly anything else was seen.

*Loch Moraig*.—Entomostraca were here scarce, and Protozoa and Algæ abundant. The commonest organism was a form of *Ceratum hirundinella*, which was so abundant as to constitute a "Wasserblut."

*Loch Broom*.—This shallow, marshy pool, with *Menyanthes* growing almost everywhere, yet had a quite ordinary lacustrine fauna, including *Diatomus* (dark brown), *Daphnia lacustris* (very large), *Cyclops strenuus* (large hyaline), *Bythotrephes*. *Conochilus* was much the commonest animal. An unusual form of *Ceratum hirundinella*, having both the median spines long, occurred.

*Loch Ordie*.—The most abundant animals at the time this loch was visited were *Holopedium*, *Daphnia* (parrot-shaped head), and *Diatomus* (hyaline). *Bosmina* of two forms was found—*B. obtusirostris* (small) and *B. longispina*.

*Loch nan Eun*.—The highest loch in the Tay system visited. The predominant animal was *Diatomus gracilis* (blood-red); *Daphnia lacustris* (very large), *Bosmina obtusirostris*, and several species of Desmids, notably *Staurastrum arcticon*, were present in some numbers. There was a scarcity of smaller organisms.

*Loch Shechernich*.—The water was turbid from the abundance of life. The most conspicuous examples were *Diatomus* (dark red, red and yellow, red and blue, or all blue), probably *D. Wierzejskii*, *Daphnia* (parrot-shaped head), *Bosmina* (very large, purple), *Notholca longispina*, and *Polyarthra*. *Asterionella* was of a smaller size than usual. Numbers of a small yellow water-mite were seen.

*Loch Auchenchapel*.—*Ceratum hirundinella* formed a "Wasserblut" in the loch at the time it was visited. Other common animals were *Bosmina obtusirostris*, *Daphnia lacustris* (small), *Diatomus* (reddish), *Conochilus*.

*Loch of Lintrathen*.—The water was very clear, and organisms sparingly distributed. *Daphnia lacustris* (large) and *Diatomus gracilis* (hyaline) were the only animals at all common.

*Loch Benachally*.—*Holopedium* was common on the surface, but not below. *Diatomus gracilis* (brown, mostly immature) and *Daphnia lacustris* (large) were most abundant. *Bosmina* was scarce.

*Long Loch*.—Very few animals were present, the commonest being *Daphnia lacustris*, *Diatomus gracilis* (hyaline), and *Conochilus*.

*Pitlyal Loch*.—This differed from most lochs visited about the same time in the general scarcity of life, especially of Entomostraca. It was one of the few lochs in the system where *Bosmina cornuta* took the place of the common *B. obtusirostris*. There was a "Wasserblut" of a pale filamentous Alga. *Volvox* and several other Algæ occurred. Although in those various respects the biology approached the pond type, *Leptodora* was rather numerous.

*Forfar Loch*.—The water was very turbid throughout, yet the fauna was mainly lacustrine, the commonest animal being *Cyclops strenuus*.

*Daphnia lacustris* (large) was also common. The *Cyclops* was covered with parasites of many species, both animal and vegetable.

The lochs which are drained by the Lunan burn form a connected series, all of moderate size or very small and shallow, several being quite stagnant and overgrown with weeds. The most important are Lochs of the Lowes, Drumellie, and Clunie, the last being the deepest of the whole chain. *Volvox* was present in most of the lochs.

*Loch of Craiglush.*—Most of the ordinary pelagic animals were seen. *Holopedium* was abundant. *Daphnia* was tinged with pink, and some males were seen; *Diaptomus* was dull brown; *Bosmina* was small. Several small Algæ, as *Volvox*, *Pediastrum*, *Eudorina*, were common, and several Rotifers, as *Sacculus viridis* and a species of *Synchaeta*.

*Loch of the Lowes.*—The plankton resembled that of Loch Craiglush, but differed in a few points. *Holopedium* was more numerous, *Daphnia* larger and not pink, *Bythotrephes* was seen, and there were fewer Algæ and Rotifers.

*Loch of Butterstone.*—Life was abundant, and the species were almost all the same as in Loch Craiglush. There was less difference between those two lochs than between Loch Craiglush and Loch of the Lowes, which are connected by a broad canal. The *Daphnia* was pink-tinged as in Loch Craiglush, and there were some males. Another form of *Daphnia* also occurred, larger, and with a purple spot on each valve.

*Lochs Drumellie and Clunie.*—These two lochs may be treated together, as they are connected by a short burn and differ little in the character of the plankton. The *Daphnia* in both had the parrot-shaped head which results from the elimination of the depression in the forehead. *Bosmina* was not noted in either. *Volvox* was more plentiful in Loch Drumellie, and *Leptodora* was common in it and not seen in Loch Clunie.

*Rae Loch (or Ardblair Loch).*—The most common animal was *Notholca longispina*. The *Daphnia* was small, the *Diaptomus* mostly immature, and *Bosmina* was not seen. A large bizarre-shaped Infusorian with green body-contents was numerous.

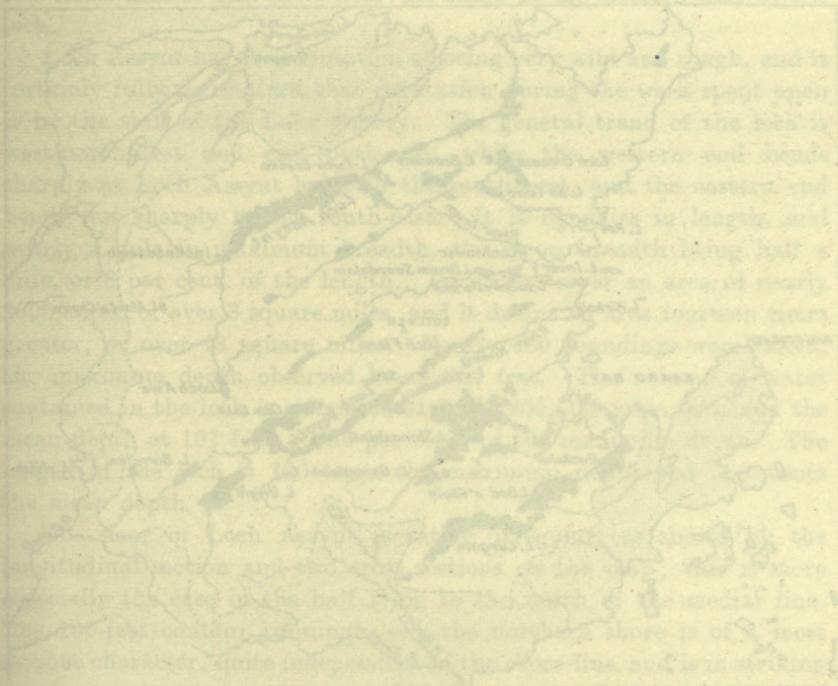
*Black Loch.*—The only common organisms were *Diaptomus* (pale red), *Daphnia* (large), *Polyphemus*, and some small Diatoms.

*White Loch and Fingask Loch.*—These two lochs, which are connected by a short burn, are very similar, *Daphnia* (large) being much the most abundant animal, a few bearing ehippia and some males being seen. *Diaptomus* was hyaline and immature. *Volvox* was more plentiful in Fingask Loch. *Leptodora* was only seen in the White Loch.

*Stormont Loch.*—The water of this stagnant pond was quite turbid and yellow in colour from the superabundance of *Daphnia*. The nets could not be drawn through the water in the usual way without getting

quite choked with animals. A single dip of the net, by which about half a gallon of water would be strained, collected enough material to fill a 2-oz. bottle. The *Daphnia* was of two forms, one small and the other much larger than usual, and many males were seen. There was little else in the loch, only *Diaptomus* (hyaline) and a species of *Anabæna* being at all plentiful.

*Monk Myre.*—*Notholca longispina* formed a "Wasserblut" here, giving the collection a reddish colour. *Diaptomus* (grey or hyaline), *Bosmina cornuta*, and *Polyphemus* were common.





passes along its northern shore. It receives the outflow from Lochs Awe, Maol a' Choire, and Leitir Easaich, and its waters are discharged by the river Inver, which, after a wild and tortuous course of over five miles, falls into Loch Inver. It is a good fishing loch, containing trout, sea-trout, salmon, and *Salmo ferox*. The ground around the western end is low, but on proceeding eastwards it becomes higher, Beinn Gharbh rising on the south shore to over 1700 feet, while on the north shore Quinag attains 2600 feet, Ghlas Bheinn 2500 feet, Beinn Uidhe 2300 feet, and farther to the south-east Coniveall and Ben More Assynt reach 3200 feet. On a promontory on the north shore about a mile from Inchnadamph stand the ruins of Ardvreck Castle, once a stronghold of the M'Leods and afterwards of the Mackenzies. There are a few small islands and islets near the shore in the western half of the loch.

Loch Assynt has the reputation of being very wild and rough, and it certainly fully maintained that reputation during the week spent upon it by the staff of the Lake Survey. The general trend of the loch is west-north-west and east-south-east, while the western end bends sharply at Loch Assynt lodge to the south-west, and the eastern end bends less sharply to the south-east. It is  $6\frac{1}{2}$  miles in length, and nearly a mile in maximum breadth, the mean breadth being half a mile, or 8 per cent. of the length. Its waters cover an area of nearly 2000 acres, or over 3 square miles, and it drains an area fourteen times greater, or over 43 square miles. Nearly 400 soundings were taken, the maximum depth observed being 282 feet. The volume of water contained in the loch is estimated at 8,730,905,000 cubic feet, and the mean depth at 101 feet, or 36 per cent. of the maximum depth. The length of the loch is 120 times the maximum depth and 330 times the mean depth.

The floor of Loch Assynt is rather irregular, as shown by the longitudinal section and two cross sections on the map; this is more especially the case in the half lying to the north of the medial line. The 100-foot contour running along the northern shore is of a most sinuous character, quite independent of the shore-line, and is in striking contrast to the same contour running along the southern shore. In the position of the cross section E—F, moreover, the 150-foot and 200-foot contours show a curious prolongation in a northerly direction, and here an isolated sounding of 210 feet was recorded separated from the 200-foot area by a sounding of 198 feet. The 50-foot, 100-foot, and 150-foot basins are continuous areas, while the area over 200 feet in depth is cut up into four portions, and that over 250 feet in depth into three portions. The 50-foot basin extends practically from one end of the loch to the other; the 100-foot basin stretches from 200 yards from the eastern end to beyond Rudh' an Alt-toir, where the loch bends sharply to the south-west, and is 5 miles in length; the 150-foot basin

extends from about a quarter of a mile from the east end to Rudh' an Alt-toir, and is  $4\frac{3}{4}$  miles in length. The four areas exceeding 200 feet in depth, proceeding from east to west, are—(1) a large eastern basin  $1\frac{1}{2}$  miles in length, extending from south-east of Ardvreck Castle to north of Garbh Dhoire; (2) a small basin lying 150 yards to the west of the first-mentioned, based on a sounding of 210 feet; (3) a large western basin  $1\frac{3}{8}$  miles in length, extending from south of the eastern islands off the north shore to north of Torr a' Chail; and (4) a small basin less than 100 yards further west, based on a sounding of 214 feet. The three 250-foot basins are all very narrow, one enclosed in the large eastern 200-foot basin,  $\frac{3}{4}$ -mile in length and with a maximum depth of 264 feet, the other two enclosed in the large western 200-foot basin, the smaller having a maximum depth of 270 feet, the larger being nearly a mile in length and including the maximum depth of the loch (282 feet), which occurs to the north of Eilean Assynt. It will be observed that the deep channel does not coincide with the central axis of the loch, but lies for the greater part of its course much nearer the southern than the northern shore; opposite Ardvreck Castle, however, it crosses over and lies nearer the northern shore in the eastern end of the loch. The numerous large bays along both shores were found to be fairly deep.

The areas of the lake-floor at different depths, and the percentages to the total area of the loch, are as follows:—

0 to 50 feet,	572 acres	29 per cent.
50 ,, 100 ,,	559 ,,	28 ,,
100 ,, 150 ,,	351 ,,	18 ,,
150 ,, 200 ,,	270 ,,	14 ,,
200 ,, 250 ,,	184 ,,	9 ,,
Over 250 ,,	46 ,,	2 ,,
	<u>1982</u> ,,	<u>100</u> ,,

More than half the entire lake-floor is covered by less than 100 feet of water, and the areas on both sides of the 50-foot contour-line are nearly equal, indicating a moderate and uniform average slope down to the depth of 100 feet, beyond which depth the slope becomes much steeper.

Loch Assynt was surveyed on September 12 to 18, 1902. On the 12th the elevation of the lake-surface above the sea was determined, by levelling from bench-mark, as being 215.1 feet; subsequently heavy rains set in, so that on the 16th the water had risen to the extent of a foot, and on the 18th to the extent of 16 inches, above the level on the 12th, and the later soundings were corrected in order to bring them into agreement with the earlier ones. When levelled by the officers of the Ordnance Survey on September 9, 1871, the surface of the water

was found to be 214·8 feet above sea-level. The highest drift-mark observed was  $4\frac{1}{2}$  feet above the level of the loch on September 12, 1902.

*Temperature Observations.*—Temperature observations taken in Loch Assynt showed very little variation in the temperature of the surface water during the week occupied by the survey, the highest reading recorded being  $55^{\circ}0$  F. at 10 a.m. on September 12, towards the east end of the loch, and the lowest  $53^{\circ}6$  at 10 a.m. on the 16th, also near the east end. Beneath the surface the fall of temperature was also small, as shown by the following serial observations taken at noon on September 16, to the north of Garbh Dhoire:—

Surface ... ..	53°·7 Fahr.
50 feet ... ..	53°·5 ”
150 ” ... ..	52°·7 ”
240 ” ... ..	52°·0 ”

The range of temperature from surface to bottom was thus only  $1^{\circ}7$ , and the extreme range observed throughout the whole body of water was only  $3^{\circ}0$ .

*Loch Leitir Easaich* (see Plate XXXV.).—Loch Leitir Easaich (or Letteressie) lies immediately to the west of, and at a slightly higher level than, Loch Assynt, into which it flows by a stream only a few yards in length. The ground around it is low. The waterfall at its western end, from which the loch derives its name, is very fine. Loch Leitir Easaich is considerably over half a mile (or about 1100 yards) in length, the maximum breadth being two-fifths of a mile (or about 700 yards), and the mean breadth about one-eighth of a mile (or about 230 yards), or 21 per cent. of the length. Its waters cover an area of about 62 acres, and it drains an area thirty-three times greater, or  $2\frac{2}{3}$  square miles. Nearly 30 soundings were taken, the maximum depth observed being 70 feet. The volume of water is estimated at 44,909,000 cubic feet, and the mean depth at 20 feet, or  $28\frac{1}{2}$  per cent. of the maximum depth. The loch is extremely irregular in outline, the main body trending north and south, with an arm running in an easterly direction towards Loch Assynt. The maximum depth observed in this arm was 31 feet, separated by shallower water from the deep basin in the main body of the loch, where there is a small area exceeding 50 feet in depth towards the western shore. The areas between the contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	36 acres	68·8 per cent.
25 ” 50 ”	22 ”	23·6 ”
Over 50 ”	4 ”	7·6 ”
	<hr/>	
	62 ”	100·0 ”
	<hr/>	

Over two-thirds of the entire area of the loch is thus covered by less than 25 feet of water. Loch Leitir Easaich was surveyed on September 18, 1902, the elevation of the water surface being 217 feet above the level of the sea, and half a foot higher than the water in Loch Assynt on the same date. After very heavy rains the two lochs must stand at the same level. The boatmen stated that the water in Loch Leitir Easaich would rise very little higher than on the date surveyed, and would fall about two feet lower than this level.

*Loch Maol a' Choire* (see Plate XXXVI.).—Loch Maol a' Choire (or Mulach-Corrie, or the Gillaroo Loch) is situated about two miles to the south-west of Inchnadamph, and flows by the Allt na Glaiice Motre into the river Traligill, which falls into the head of Loch Assynt near the entrance of the river Loanan. The loch derives one of its names from the supposed resemblance of its fish to the Gillaroo trout of Lough Melvin; in shape the trout are very deep and thick, and hence very heavy in proportion to their length. Loch Maol a' Choire trends in a north and south direction, and is about 600 yards in length by about 250 yards in maximum breadth. It covers an area of about 20 acres, and drains an area of about 512 acres—an area twenty-five times greater than that of the loch. Forty soundings were taken, the maximum depth observed being 8 feet. The volume of water is estimated at 4,452,000 cubic feet, and the mean depth at 5 feet. The loch is fairly uniform in depth, deepening gradually on proceeding from the southern end towards the north-western shore, off which two soundings of 8 feet were taken. It was surveyed on September 13, 1902; its elevation above the sea was not determined by levelling, but is between 800 and 900 feet, the ground surrounding it being covered by peat. The temperature of the water was uniform at 49°·2 on the date of the survey.

*Loch Awe* (see Plate XXXVI.).—Loch Awe is situated nearly four miles to the south of Inchnadamph, by the side of the road leading to Alltnacealgach. The ground to the south-east is peat-covered, while Canisp rises on the south-west, Cnoc an Leathaid Bhuidhe on the west, and Beinn an Fhuarain on the east. Its principal feeder, the burn flowing from Loch na Cruagaich, enters the loch at its northern end, within 30 yards of the mouth of the river Loanan, which carries the outflow into Loch Assynt. The fishing has been much improved of late years, and it is now a good salmon loch, the fish running through Loch Assynt into it. Loch Awe trends north and south, and is over four-fifths of a mile (or about 1400 yards) in length, with a maximum breadth of less than one-third of a mile (or about 530 yards), the mean breadth being about one-half of this. It covers an area of about 86 acres, and drains an area twenty-four times greater, or  $3\frac{1}{2}$  square miles. Over 60 soundings were

taken, the maximum depth observed being 7 feet. The volume of water is estimated at 17,751,000 cubic feet, and the mean depth at nearly 5 feet. Loch Awe is thus very shallow, a large part being overgrown by weeds and rushes; the maximum depth of 7 feet was observed in two places in the northern portion of the loch. It was surveyed on September 23, 1902. The elevation above the sea was determined, by levelling from bench-mark, as being 504 feet. This is almost identical with the level observed by the officers of the Ordnance Survey on September 6, 1871, viz., 504·1 feet. The temperature of the water was found to be uniform at 53°·5.

*Loch Beannach* (see Plate XXXVI).—Loch Beannach lies about two miles to the west of Loch Assynt and four miles from Lochinver. It flows into Loch Bad nan Aighean (which was not sounded), thence by a short stream into the river Inver after leaving Loch Assynt. It is most irregular in outline and in conformation, with numerous islands, the majority of which are thickly wooded and give to the loch a beautiful appearance. Loch Beannach is  $1\frac{1}{4}$  miles in length, with a maximum breadth of less than one-third of a mile (or about 530 yards), the mean breadth being about one-seventh of a mile (or about 250 yards). Its waters cover an area of about 117 acres, and it drains an area ten times greater, or nearly two square miles. Over 60 soundings were taken, the maximum depth observed being 38 feet. The volume of water is estimated at 67,348,000 cubic feet, and the mean depth at 13 feet. As already indicated, the floor of the loch is very uneven. It falls in four places below the 20-foot level, the deepest part of the loch being in the south-western portion, where three soundings exceeding 30 feet were taken, the maximum depth of 38 feet having been observed about 100 feet to the north of the small island lying off the southern shore, indicating in this position a slope of 1 in 2·6. The area of the lake-floor covered by less than 25 feet of water is about 105 acres, or 89 per cent. of the total area of the loch. Loch Beannach was surveyed on September 19, 1902. Its elevation above the sea could not be determined, but must be between 230 and 280 feet. The highest drift-mark observed was 3 feet above the level of the water on the date of the survey, and the boatman stated that the water might fall about 2 feet lower; thus a range in the level is indicated of about 5 feet. The temperature of the surface water was 52°·5, and at a depth of 30 feet 52°·0. The range of temperature throughout the body of water was thus very small.

*Loch Druim Suardalain* (see Plate XXXVI).—Loch Druim Suardalain lies about a mile to the east of Loch Inver and half a mile to the east of Loch na Doire Daraich, into which it flows by the Uidh a' Bhalgain. Its principal feeder is the Amhainn Bad na h-Achlaise,

bearing the outflow from Loch na Gainimh in the Canisp forest. The ground around the loch is low. It is three-quarters of a mile in length, and a quarter of a mile in maximum breadth, the mean breadth being one-sixth of a mile. Its waters cover an area of about 79 acres, and it drains an area 105 times greater—an area of nearly 13 square miles. Seventy-five soundings were taken, the maximum depth observed being 31 feet. The volume of water is estimated at 35,408,000 cubic feet, and the mean depth at over 10 feet. Loch Druim Suardalain is irregular in outline, with a few islands, and the conformation of the bottom is peculiar. Towards the eastern end is a small area exceeding 20 feet in depth, the deepest sounding in this position being 29 feet, but the maximum depth of the loch (31 feet) was observed quite close to the south-western shore, apparently a deep hole surrounded by much shallower water. The area of the lake-floor covered by less than 10 feet of water is about 45 acres, or 58 per cent. of the total area of the loch. The loch was surveyed on September 15, 1902, and the elevation above the sea was determined, by levelling from bench-mark, as being 134·5 feet; when levelled by the officers of the Ordnance Survey on September 19, 1871, the elevation was found to be 133·1 feet above sea-level. The temperature of the water was found to be uniform at 53°·2.

*Loch na Doire Daraich* (see Plate XXXVI).—Loch na Doire Daraich (or Loch Culag, as it is more generally called in the district) is situated about a quarter of a mile to the south-east of Loch Inver, into which it flows by the Amhainn na Culeig; its chief supply of water is derived from Loch Druim Suardalain. The surrounding ground is low, but is steeper to the south and south-west, and on the western side thickly wooded. It is very irregular in outline and conformation, and the two arms projecting southwards are to a large extent filled with weeds. The length from south-west to north-east is half a mile, and the maximum breadth a quarter of a mile, the mean breadth being one-seventh of a mile. Its waters cover an area of about 44 acres, and it drains directly an area exceeding a square mile, but since it receives the outflow from Loch Druim Suardalain, its total drainage area is about 14 square miles, an area 203 times greater than that of the loch. Over 40 soundings were taken, the maximum depth observed being 9 feet. The volume of water is estimated at 6,922,000 cubic feet, and the mean depth at 3½ feet. The loch is very shallow, but it is curious to note that the deeper soundings were taken near shore; soundings of 5 and 6 feet were recorded in four places close to the shore, an isolated sounding of 7 feet was taken at the entrance of the inflowing burn from Loch Druim Suardalain, while the maximum depth of the loch was observed close to the large promontory on the western shore. Loch na Doire Daraich was surveyed on September 20, 1902, the elevation of the lake-surface being 72·5 feet above the sea; when levelled by the officers of the

Ordnance Survey on August 26, 1870, the elevation was found to be 73·7 feet above sea-level. The boatman stated that the water may rise 2 feet above its level on September 20, 1902, and fall 3 feet lower, giving a range of 5 feet. Temperature observations gave 50°·5 at the surface, and 50°·1 at a depth of 7 feet.

## LOCHS OF THE ROE BASIN.

THE two principal lochs only in this basin, Lochs Cròcach and an Tuirc, were surveyed; the smaller ones could not be sounded from lack of boats.

*Loch Cròcach* (see Plate XXXVII.).—Loch Cròcach lies about three miles to the north of Loch Inver, and about a mile to the north-west of Loch an Tuirc, into which its waters are discharged. It is most irregular in outline and in conformation, and is studded with islands large and small; indeed the insulosity (*i.e.*, the ratio between the area of the islands and the total area of the loch) is one of its distinguishing characteristics, being probably higher than in any other loch visited by the Lake Survey, the lochs most nearly approaching it in this respect being Lochs Maree and Lomond. The islands are mostly congregated in the large western bay; they are low, heather-covered, and not wooded as in the majority of the lochs in the district. The ground around the loch is low; from 350 to 700 feet above the sea. Loch Cròcach trends north-east and south-west, and is nearly  $1\frac{1}{2}$  miles in length and over one-third of a mile (or about 700 yards) in maximum breadth, the mean breadth being about one-sixth of a mile (or rather less than half the maximum breadth). Its waters cover an area of about 160 acres (or one-quarter of a square mile), exclusive of the numerous islands, and it drains an area seven times greater, or  $1\frac{3}{4}$  square miles. Nearly 80 soundings were taken, the maximum depth observed being 71 feet. The volume of water is estimated at 147,987,000 cubic feet, and the mean depth at nearly 17 feet. Loch Cròcach is deeper than the other small lochs in this district. A large 25-foot area occupies the greater portion of the length of the loch to the north-west of the islands; a second smaller area occurs in the south-western expansion of the loch, and a third very small area lies near the south-western end of the loch, based on a sounding of 30 feet. The bottom falls in two places below the 50-foot level, the larger basin being centrally placed, between the entrance of the Uidh nan Lion and the largest of the islands, with a maximum depth of 64 feet, the smaller but deeper basin lying in the south-western expansion of the loch, the maximum depth of 71 feet having been observed quite close to the small island off the

southern shore. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	109 acres	68·3 per cent.
25 „ 50 „	45 „	28·0 „
Over 50 „	6 „	3·7 „
	<u>160 „</u>	<u>100·0 „</u>

Loch Cròcach was surveyed on September 17, 1902, but the elevation of the lake-surface above the sea could not be determined; the elevation must be between 350 and 370 feet above sea-level. The boatman stated that the water might rise 2 feet above, and fall 3 feet below, the level on the date of the survey.

*Temperature Observations.*—Temperature observations showed a greater variation than was observed in the larger and deeper Loch Assynt, as will be seen from the following serial taken at 2.30 p.m. on September 17, 1902:—

Surface ... ..	53°·7 Fahr.
40 feet ... ..	53° 2 „
70 „ ... ..	50°·8 „

This series shows a range of 3°, the greatest fall of temperature occurring in deep water below 40 feet.

*Loch an Tuirc* (see Plate XXXVII.).—Loch an Tuirc is situated about two miles north-east of Loch Inver, and over a mile to the west of Loch Beannach. It receives the outflow from Loch Cròcach, and flows by the Uidh nan Caorach into Loch an Aite Mhòir, thence through three other small lochs into Loch Roe. The ground around the loch is low, the greatest elevation being one of 400 feet to the north-west of the loch. Islands are not so numerous in this loch as in the neighbouring Lochs Beannach and Cròcach; weeds are very abundant in some parts of the loch. Loch an Tuirc trends north-east and south-west, and is irregular in outline and conformation. There is a constriction near the centre of the loch, which cuts the deeper water into two portions, and the loch narrows gradually towards the outflow at the south-west end. It is about four-fifths of a mile (or about 1400 yards) in length, with a maximum breadth of one-fifth of a mile (or over 300 yards), the mean breadth being one-tenth of a mile. Its waters cover an area of about 53 acres, and it drains directly an area of about  $1\frac{1}{4}$  square miles, but, since it receives the outflow from Loch Cròcach, its total drainage area is nearly 3 square miles. Nearly 100 soundings were taken, the maximum depth observed being 39 feet. The volume of water is estimated at about 24,787,000 cubic feet, and the mean depth at  $10\frac{1}{2}$  feet. The portion of the loch to the north-east of the central

constriction is shallow and obstructed by weeds; a small area exceeding 10 feet in depth runs along the southern shore, the maximum depth therein being 13 feet. The wide portion of the loch to the south-west of the constriction forms a regular deep basin, the maximum depth of 39 feet being found in the north-eastern part of the basin. The areas at different depths, and the percentages to the total area of the loch, are as follows:—

0 to 10 feet	35 acres	65·8 per cent.
10 „ 25 „	12 „	23·2 „
Over 25 „	6 „	11·0 „
	<u>53 „</u>	<u>100·0 „</u>

Loch an Tuirc was surveyed on September 17, 1902, but the elevation of the lake-surface above the sea could not be determined; the elevation is apparently slightly under 200 feet. Temperature observations at 3 p.m. gave identical readings of 53°·0 at the surface and at depths of 20 and 30 feet.

## LOCHS OF THE KIRKAIG BASIN.

THE lochs belonging to this basin form a connected series:—Loch Borralan flows by the Ledmore river into the Ledbeg river, which farther on joins the Na Luirgean, bearing the outflow from Loch



FIG. 28.—LOCH BORRALAN, FROM THE HOTEL; CUL MOR IN THE DISTANCE.

(Photograph by H. Anderson.)

Urigill, and together they flow into the Càrn Loch, which empties itself into Loch Veyatie, thence into Loch Fionn, and thence by the Kirkaig river into Loch Kirkaig. Lochs Veyatie, Fionn, and Borralan lie partly in Ross-shire and partly in Sutherlandshire, the boundary running down the centre of the two first-named lochs, and across the south-eastern end of Loch Borralan. All the lochs are good trout lochs, and Loch Veyatie contains also *Salmo ferax*, while char are numerous in Loch Borralan.

*Loch Borralan* (see Plate XXXVI.).—Loch Borralan (or Borrolan or Boarlan) trends north-west and south-east, and the road from Lairg to Inchnadamph runs along its north-eastern shore; Aultnacallagach Inn is situated on the road close to the loch near its south-eastern end. The ground around the loch is low except to the north, where Cnoc na Sròine rises to 1300 feet; to the south-west the ground is thickly covered with peat. The abundance of char in the loch is remarkable considering its shallowness. Weeds were seen growing on the bottom almost everywhere, and over large areas they reach to the surface. It is over a mile in length, with a maximum breadth of nearly a quarter of a mile (or about 400 yards), the mean breadth being about one-sixth of a mile (or over 300 yards). Its waters cover an area of about 118 acres, and it drains an area 34 times greater, or  $6\frac{1}{2}$  square miles. Over 60 soundings were taken, the maximum depth observed being 21 feet. The volume of water is estimated at 49,324,000 cubic feet, and the mean depth at  $9\frac{1}{2}$  feet. The maximum depth of 21 feet was observed towards the south-eastern end, opposite the entrance of the Allt nan Cealgach; in the north-western portion of the loch a maximum depth of 16 feet was found, the 10-foot contour-line being continuous almost from end to end of the loch. Loch Borralan was surveyed on September 1, 1902. The elevation of the lake-surface above the sea was determined, by levelling from bench-mark, as being 459·7 feet, which is almost identical with that observed by the Ordnance Survey officers on August 31, 1871, viz., 459·8 feet. According to the boatman, the water in the loch might fall about 4 inches lower than on the date of the survey, and in exceptional floods might rise 5 feet higher. Temperature observations at 3 p.m. gave identical readings of  $56^{\circ}\cdot7$  at the surface and at a depth of 16 feet.

*Loch Urigill* (see Plate XXXVI.).—Loch Urigill (or Urigall) lies less than a mile to the south-west of Loch Borralan. The ground around the loch is low and covered with peat. Like Loch Borralan, it trends in a north-west and south-east direction; in fact, nearly all the lochs in this district generally trend north-west and south-east, as will be seen from the small index map (Fig. 27). It is nearly two miles in length, with a maximum breadth of nearly three-quarters of a mile, the mean breadth being nearly half a mile. Its waters cover an area of about 500 acres (or over three-quarters of a square mile), and it drains an area 14 times greater, or 11 square miles. Nearly 130 soundings were taken, the maximum depth observed being 40 feet. The volume of water is estimated at 285,088,000 cubic feet, and the mean depth at 13 feet. Loch Urigill is, on the whole, very shallow, nearly 99 per cent. of the lake-floor being covered by less than 25 feet of water, and weeds are abundant in some places. The 10-foot area is continuous from close to the north-west end to near the south-east end, opposite the entrance

of the Allt nam Meur. Midway along the loch, towards the north-eastern shore, is a rise of the bottom covered by only 3 feet of water. The deepest part of the loch is near the north-west end, where there is a small central area exceeding 20 feet in depth, the maximum depth being 40 feet; this little depression is well defined by a steep gradient. Loch Urigill was surveyed on August 30, 1902. The level of the loch could not be determined; when visited by the officers of the Ordnance Survey on October 5, 1871, the elevation was found to be 514·7 feet above the sea.



FIG. 29.—LOCH URIGILL, WITH SUILVEN AND CANISP IN THE DISTANCE.

(Photograph by Mr. H. Anderson.)

*Temperature Observations.*—Temperature observations taken at 4 p.m. on August 30, 1902, gave the following results:—

Surface	...	...	...	...	...	...	57°·2	Fahr.
10 feet	...	...	...	...	...	...	56°·0	„
20 „	...	...	...	...	...	...	56°·0	„
35 „	...	...	...	...	...	...	55°·8	„

*Càm Loch* (see Plate XXXVIII.).—Càm Loch (or Loch Cama) lies about a mile to the north-west of Loch Urigill, and a mile to the west of Ledmore. It is extremely irregular in outline and in conformation, and includes one large and several small islands. The principal feeder is the stream bearing the outflow from Lochs Borralan and Urigill, which enters the loch at its south-eastern end, and here also is the exit of the loch, the Amhuinn Mhòr after a course of a few hundred yards

falling in a magnificent cascade into Loch Veyatie. The ground in the immediate vicinity of the loch is low, but to the east lies Cnoc na Sròine, and to the north-east Cnoc na Leathaid Bhuidhe, while to the west-north-west Sulven, and to the north Canisp, form remarkably fine objects, which catch the eye from every part of the loch. The length of the loch is  $2\frac{3}{4}$  miles, the maximum breadth over three-quarters of a mile, and the mean breadth over one-third of a mile. Its waters cover an area of about 647 acres, or over one square mile, and it drains directly an area of over 16 square miles, but since it receives the outflow from Lochs Borralan and Urigill its total drainage area is about

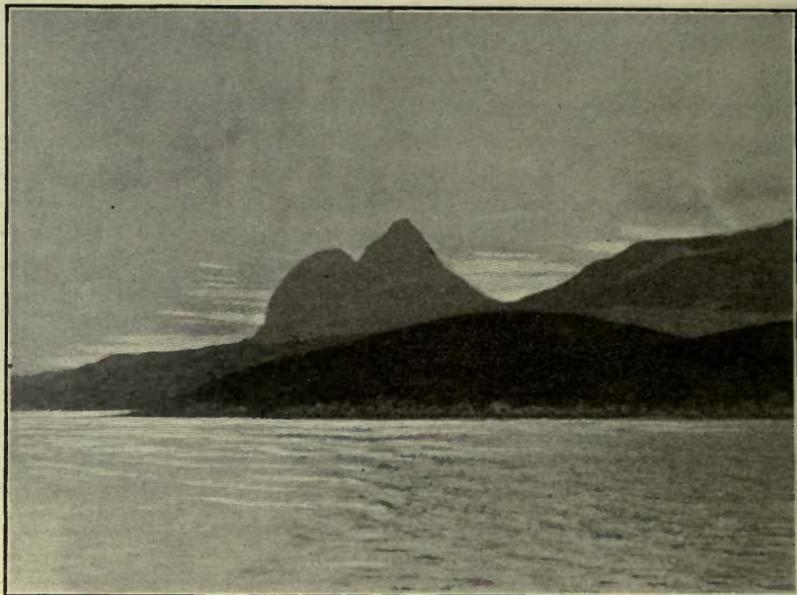


FIG. 30.—CAM LOCH, WITH SUILVEN IN THE DISTANCE.

(*Photograph by Rev. H. N. Bonar.*)

$33\frac{1}{2}$  square miles. Over 200 soundings were taken, the maximum depth observed being 122 feet. The volume of water is estimated at 1,062,543,000 cubic feet, and the mean depth at nearly 38 feet. The south-eastern portion of the loch is shallow, very few soundings exceeding 20 feet being recorded, the maximum observed being 40 feet a short distance to the east of Eilean na Gaoithe. Most of the islands are found in this part of the loch, Eilean na Gartaig being the largest, while Eilean na Gaoithe is remarkable for the long spit of sand and shingle which stretches from its northern point for a distance of nearly 100 yards; this spit is submerged when the water is high, but at the time

of the survey it rose some six inches above the surface of the water. The main basin is contained in the north-western portion of the loch, where the bottom falls in two places below the 100-foot level, separated by a slight shoaling of the water over a short interval. The larger of these two 100-foot areas near the centre of the loch is three-quarters of a mile in length, and the smaller, half a mile in length, approaches within less than half a mile from the north-west end, running comparatively close to the south-eastern shore. It is curious to note that the maximum depth observed in each of these two areas is identical (122 feet), though the two soundings are separated by an interval of about a mile; the deepest water on the rise between the two areas is 83 feet. The slope along the north-eastern shore towards the north-west end of the loch is very steep; in one place a sounding of 91 feet was taken about 20 feet from the shore, and the cliff above was almost vertical and 50 feet in height. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	320 acres	49·5 per cent.
25 „ 50 „	151 „	23·3 „
50 „ 75 „	67 „	10·4 „
75 „ 100 „	67 „	10·4 „
Over 100 „	42 „	6·4 „
	<u>647</u> „	<u>100·0</u> „

Càm Loch was surveyed on August 27 and 28, 1902. The elevation of the lake-surface above the sea could not be determined, but when levelled by the Ordnance Survey officers on October 7, 1871, it was found to be 404·8 feet above sea-level. Judging from the level of the other lochs in the district at the end of August, 1902, its level was probably about a foot lower than that quoted, and the boatman stated that he had never seen the water more than two or three inches lower; the highest drift-mark seen was 3·7 feet above the surface of the water on August 27, 1902. The temperature of the surface water was 56°·2.

*Loch Veyatie* (see Plate XXXVIII.).—Loch Veyatie lies about half a mile to the west of the village of Elphin. It receives the water from the Càm Loch at its south-eastern end, where also the Amhainn a' Chnocain enters the loch; the water is discharged at the north-western end of the loch by the Uidh Fhearna into the Fionn Loch. The ground around the loch is low, except where Cul Mor rises to a height of over 2700 feet to the south-west, and Suilven (already referred to) to the north-west. The loch is over 4 miles in length, with a maximum breadth of nearly half a mile, the mean breadth being nearly a quarter of a mile (or about 400 yards). Its waters cover an area of about 593 acres (or nearly one square mile), and it drains directly an area of over

11½ square miles, but since it receives the outflow from the Càrn Loch and from Loch a' Mhiotailt, its total drainage area is about 46½ square miles—an area 50 times greater than that of the loch. Over 200 soundings were taken, the maximum depth observed being 126 feet. The volume of water is estimated at 1,061,544,000 cubic feet (almost identical with the volume of the Càrn Loch), and the mean depth at 41 feet. The floor of Loch Veyatie is uneven, as is well shown in the sections on the map, with a few islands here and there along the shores, and some of the bays are filled with weeds. A continuous area exceeding 25 feet in depth extends nearly from one end of the loch to the other,

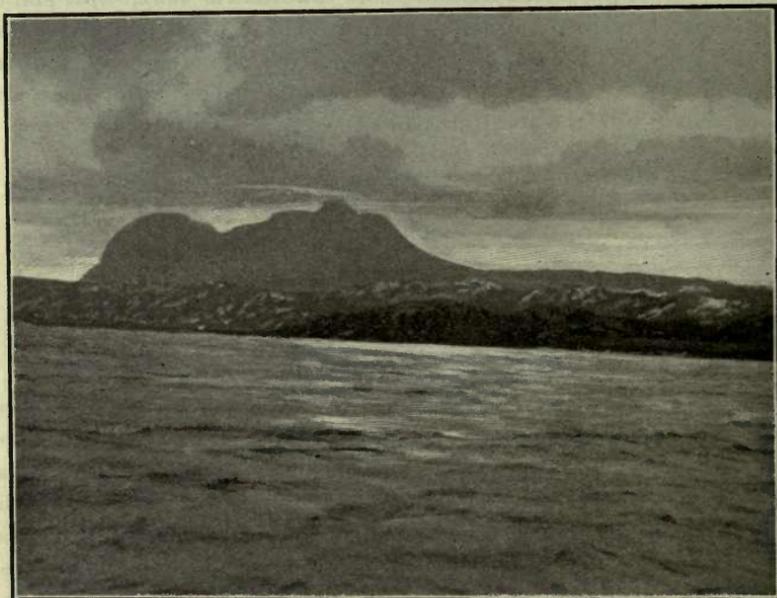


FIG. 31.—LOCH VEYATIE, WITH SUILVEN IN THE DISTANCE.

(*Photograph by Rev. H. N. Bonar.*)

with an isolated sounding of 26 feet close to the south-eastern end off the promontory between the two inflowing streams, and with a small separate area having a maximum depth of 53 feet at the north-western end. Within the large 25-foot area the bottom undulates in such a manner as to form two 50-foot areas and three 100-foot areas. Of the two 50-foot areas, the smaller but deeper one lies off the entrance to Loch a' Mhiotailt, and is three-quarters of a mile in length: it encloses the main 100-foot basin and the maximum depth of the loch (126 feet), which was observed about 220 yards from the northern shore. The larger 50-foot area lies in the south-eastern portion of the loch, and is

two miles in length ; it encloses two small 100-foot basins with maximum depths of 113 and 103 feet respectively, separated by a rise of the bottom on which the depth is 82 feet. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	230 acres	38·8 per cent.
25 „ 50 „	215 „	36·2 „
50 „ 75 „	94 „	15·9 „
75 „ 100 „	38 „	6·4 „
Over 100 „	16 „	2·7 „
	<hr/>	
	593 „	100·0 „
	<hr/>	

Thus 75 per cent. of the lake-floor is covered by less than 50 feet of water. Loch Veyatie was surveyed on August 29 and September 8, 1902. On commencing the survey on August 29, the elevation of the lake-surface was determined, by levelling from bench-mark, as being 364·8 feet above the sea ; in the interval between the two days devoted to the survey the water rose to the extent of 15 inches, then gradually fell again, and on September 8 the elevation was found to be 365·6 feet above the sea. The soundings taken on the last-mentioned date have been corrected accordingly, in order to bring them into agreement with those taken on the earlier date. The boatman stated that the water in the loch was about its lowest level on August 29, 1902, and the highest drift-mark seen was 3 feet above the surface of the water on that date. The officers of the Ordnance Survey found the level of Loch Veyatie to be 365·7 feet above the sea on September 8, 1870. Temperature observations taken at 3.30 p.m. on September 8, 1902, indicated an almost uniform temperature throughout the waters of the loch, the readings at the surface and at a depth of 50 feet being identical ( $55^{\circ}\cdot9$ ), and at a depth of 100 feet  $55^{\circ}\cdot8$ .

*Loch a' Mhiotailt* (see Plate XXXVIII.)—Loch a' Mhiotailt (pronounced Vattle) lies immediately to the south-west of Loch Veyatie ; in fact, they may almost be looked upon as one loch, for after heavy rains there is a channel about 20 feet in length, 10 feet in breadth, and 1 foot in depth connecting the lochs. When the water is low, however, the separation is complete, the barrier being formed by one of the basic dykes so numerous in this part of the gneiss: the rock is in places covered by a thin layer of sand. The ground around the loch rises steeply up to a height of 100 to 200 feet above the surface of the water, so that the loch is almost shut in, and only towards Loch Veyatie can any opening in the wall of rock be seen. Loch a' Mhiotailt is over half a mile in length from east to west, the maximum breadth exceeding a quarter of a mile, the mean breadth being about one-seventh of a mile,

or about 300 yards. Its waters cover an area of about 52 acres, and it drains an area of  $1\frac{1}{2}$  square miles. Thirty soundings were taken, the maximum depth observed being 69 feet. The volume of water is estimated at 69,264,000 cubic feet, and the mean depth at 30 feet. The loch is irregular in outline, what may be called the body of the loch sending out a broad arm at right angles. The 25-foot area follows approximately the outline of the loch, and encloses two 50-foot basins, one towards the extremity of the arm containing the maximum depth of the loch (69 feet), the other centrally placed in the body of the loch with a maximum depth of 65 feet. The greatest depth observed between the two 50-foot basins was 38 feet. The areas between the consecutive contour-lines and the percentages to the total area of the loch are as follows:—

0 to 25 feet	21 acres	40·2 per cent.
25 „ 50 „	22 „	42·7 „
Over 50 „	9 „	17·1 „
	<hr/>	<hr/>
	52 „	100·0 „
	<hr/>	<hr/>

Loch a' Mhiotailt was surveyed on September 8, 1902, when the water was at the same level as that in Loch Veyatie, viz., 365·6 feet above the sea. The soundings have been corrected in the same manner as the soundings taken in Loch Veyatie on the same date, so as to bring all the soundings into agreement with those taken in Loch Veyatie on August 29, 1902, when the surface of that loch stood at a level of 364·8 feet above the sea.

*Fionn Loch* (see Plate XXXVIII).—Fionn Loch (or Loch Fewin or Fewn) lies about three miles to the east of Enard Bay and three-quarters of a mile to the north-west of Loch Veyatie, from which it derives the greater part of its water. Besides this, however, it drains the southern slopes of Sulven, which is little more than a mile distant from the loch. The great feature of the Fionn Loch is the existence of alluvial terraces surrounding the loch. The two lowest are the most extensive, together having an average breadth of 100 yards, their heights being about 20 and 30 feet above the surface of the loch. When the water stood at this level Loch Fionn must have been connected with Loch Veyatie, the difference in their levels, as observed by the Lake Survey, being only about 8 feet. This former loch must have formed a fine sheet of water some  $7\frac{1}{2}$  miles in length, with a winding arm where is now Loch a' Mhiotailt. There is another still higher terrace seen to the north of Na Tri Lochan. The Fionn Loch discharges its waters by the Kirkaig river, which forms the renowned Falls of Kirkaig about three-quarters of a mile below the loch. Very heavy rains fell on the date of the survey and on the previous days, and in the narrow parts of the

loch, especially in the one to the south of Creag a' Choire Mhoir, the current was so strong that the greatest difficulty was experienced in rowing the boat against it, though assisted by a strong north-west wind. The loch is nearly  $2\frac{1}{2}$  miles in length, with a maximum breadth of over one-third of a mile (or about 600 yards), the mean breadth being about one-seventh of a mile (or about 250 yards). Its waters cover an area of about 209 acres (or nearly one-third of a square mile), and it drains directly an area of about  $6\frac{1}{2}$  square miles, but since it receives the outflow from Loch Veyatie and the other lochs in the basin, its total drainage area is nearly 53 square miles—an area 160 times greater than that of the loch. Over 100 soundings were taken, the maximum depth observed being 90 feet. The volume of water is estimated at 185,510,000 cubic feet, and the mean depth at  $20\frac{1}{2}$  feet. Fionn Loch is very irregular in outline, broads and narrows alternating with each other, and the contours of the bottom are correspondingly diversified. There is a long narrow tortuous area exceeding 25 feet in depth, extending from near the north-west end of the loch to north of the reedy bay where the stream from Na Tri Lochan enters, and about  $1\frac{1}{2}$  miles in length; a short distance to the south-east is a second small 25-foot area, with a maximum depth of 37 feet. The deepest water occurs in the wide part of the loch about half a mile to the south-east of the exit of the Kirkaig river, where there is a small area exceeding 75 feet in depth, the maximum depth of 90 feet having been observed about 120 yards from the south-western shore. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	153 acres	73·0 per cent.
25 „ 50 „	49 „	23·5 „
50 „ 75 „	2 „	1·0 „
Over 75 „	5 „	2·5 „
	<hr/>	
	209 „	100·0 „
	<hr/>	<hr/>

This table shows how circumscribed the deep-water area is, 97 per cent. of the lake-floor being covered by less than 50 feet of water. The Fionn Loch was surveyed on September 16, 1902. The elevation of the lake-surface was determined, by levelling from bench-mark, as being 356·9 feet above the sea; when levelled by the officers of the Ordnance Survey on October 21, 1870, the elevation was found to be 357·1 feet above sea-level. The temperature of the surface water on September 16, 1902, was 53°·0.

## LOCHS OF THE POLLY BASIN.

ONLY the two principal lochs in this basin (Lochan Gainmheich and Loch Skinaskink) were surveyed; Loch na Doire Seirbhe, Loch Lòna-h-Uamha, Loch Uidh Tarruingeach, and other smaller lochs had no boats on them at the time of the visit of the Lake Survey, and it was found impracticable to have boats transported to them. The waters of Lochan Gainmheich are discharged into Loch Skinaskink, thence by the river Polly into Loch Polly, an inlet of Enard Bay.

*Lochan Gainmheich* (see Plate XXXIX.).—Lochan Gainmheich lies about  $1\frac{1}{4}$  miles to the north of Loch Lurgain and a quarter of a mile to the south-west of Loch Skinaskink, into which its waters are discharged by the Allt Lochan Gainmheich. The eastern end of the loch lies between Cul Mor and Cul Beag, and to the west An Stac rises to over 2000 feet; Cul Beag and An Stac are connected by a ridge between Loch Lurgain and Lochan Gainmheich over 200 feet above the level of the loch, so that only towards Loch Skinaskink can an extensive view be obtained. The southern shore of Lochan Gainmheich is thickly wooded, but the northern and western shores are bare. The loch is naturally divided into a larger and deeper southern portion and a smaller and shallower northern portion, and it has been found convenient to measure these two distinct portions separately.

The *southern portion* is a mile in length from east to west, and nearly half a mile in maximum breadth, the mean breadth being over one-fifth of a mile. The area is about 135 acres, and it drains an area of nearly  $2\frac{3}{4}$  square miles. Over 50 soundings were taken, and the maximum depth observed was 120 feet. The volume of water is estimated at 245,711,000 cubic feet, and the mean depth at nearly 42 feet. This portion of Lochan Gainmheich is extremely simple in conformation, the bottom sinking down on all sides towards the deepest part, which is approximately centrally placed. The 50-foot area is about 1100 yards in length, and the 100-foot area about 400 yards in length, the maximum depth of 120 feet having been observed about 130 yards from the southern shore. The areas between the contour-lines, and the percentages to the total area, are as follows:—

0 to 50 feet	76 acres	56.5 per cent.
50 „ 100 „	45 „	33.4 „
Over 100 „	14 „	10.1 „
	<u>135 „</u>	<u>100.0 „</u>

The *northern portion* is one-third of a mile in length, with a maximum breadth of a quarter of a mile and a mean breadth of one-sixth of a mile. The area is about 40 acres, and it drains directly an area of about 5 square miles, but, including the area draining into the southern portion, the total drainage area is about  $7\frac{3}{4}$  square miles. Over 20 soundings were taken, the maximum depth observed being 59 feet. The volume of water is estimated at 43,274,000 cubic feet, and the mean depth at  $24\frac{1}{2}$  feet. The floor of this portion of Lochan Gainmheich is not so perfectly regular in conformation as that of the southern portion. There is an isolated sounding of 27 feet opposite the outflow, and within the 25-foot area the bottom is slightly undulating; the maximum depth of 59 feet was observed about 120 yards from the southern shore, and this was the only sounding exceeding 45 feet in depth.

Lochan Gainmheich was surveyed on September 10, 1902, the surface of the water being 251.5 feet above sea-level; when levelled by the Ordnance Survey officers on August 26, 1870, the elevation of the lake-surface was 251.1 feet above the sea. The highest drift-mark seen was 3.4 feet above the surface of the water on September 10, 1902.

*Temperature Observations.*—Temperature observations taken in the deepest part of the loch at 4 p.m. on September 10, 1902, gave the following results:—

Surface ... ..	55°.5 Fahr.
50 feet ... ..	55°.3 „
110 „ ... ..	54°.0 „

*Loch Skinaskink* (see Plate XXXIX.).—Loch Skinaskink (or Shianas-kaig) is a large loch lying about  $2\frac{1}{2}$  miles to the east of Enard Bay, into which it drains by the river Polly. It is one of the most interesting lochs visited by the Lake Survey, because of the extreme irregularity both of its outline and of the conformation of the lake-floor. So irregular is the outline of the loch that it has over 17 miles of shore-line. It is a splendid trout loch, but preserved, and the islands are covered with birch woods where deer are often found; the largest island is Eilean Mòr, near the centre of the loch, and there are two islands named Eilean Dubh, one near Eilean Mòr in the centre of the loch, and the other in the north-eastern arm. The ground to the west and north of the loch is low, but to the east and south rise Cul Mor (2700 feet), Cul Beag (2500 feet), and An Stac (2000 feet). There is a

sluice at the lower end of Loch Uidh Tarruingeach (through which the discharge from Loch Skinaskink passes into the river Polly) to control the outflow of the water, and by its means the average level of the loch has been raised about 3 feet. The length of Loch Skinaskink, measured from the south-eastern end near Lochan Gainmheich to the north-western arm near Loch na Moine Mòire, is over 3 miles, and the maximum breadth is over a mile, the mean breadth being two-thirds of a mile. Its waters cover an area of over 2 square miles, and it drains directly an area of nearly 8 square miles, but since it receives the outflow from Lochan Gainmheich its total drainage area is over  $15\frac{1}{2}$  square miles—an area only  $7\frac{1}{2}$  times greater than the area of the loch. Nearly 400 soundings were taken, the maximum depth observed being 216 feet. The volume of water is estimated at 3,518,305,000 cubic feet, and the mean depth at  $60\frac{1}{2}$  feet. Reference has been made to the irregularity of the floor of Loch Skinaskink, and the contour-lines on the map have a fanciful resemblance to an intricate maze. There are three main basins, which may be briefly described, viz.—(1) one embracing nearly the whole of the main body and surrounding Eilean Mòr; (2) one lying in the north-eastern arm of the loch; and (3) one lying in the north-western arm of the loch.

(1) The first basin is the largest and deepest. In it the 25-foot and 50-foot contour-lines follow approximately the outline of the shore, running into all the large bays (except that the 50-foot line does not enter the bay south of Camas nam Fiadh). The 100-foot area has a very sinuous outline, almost surrounding Eilean Mòr, and sending a large tongue into the western arm of the loch. There are two areas exceeding 150 feet in depth—one to the south of Eilean Mòr enclosing the deepest part of the loch, the other to the west and north-west of that island extending to the north of Eilean Dubh. The 200-foot area is small, based on soundings of 204 and 216 feet, the last-mentioned—the deepest sounding in the loch—lying about 350 yards to the south of Eilean Mòr. The great feature of this basin is the occurrence of two hills to the west of Eilean Mòr; the one nearest the island is covered by 38 feet of water, the depth between it and the island being 70 feet, and between it and the south-western shore exceeding 100 feet; the other is covered by 41 feet of water, the depth around it being from 100 to 150 feet.

(2) The second basin in the north-eastern arm is much smaller, and the 25-foot and 50-foot contour-lines are continuous with those of the preceding basin. The 100-foot area is centrally placed in this arm, and has a maximum depth of 137 feet. A small isolated 25-foot area lies to the north-west of Eilean Dubh in this arm, with a maximum depth of 34 feet.

(3) The third basin in the north-western arm is the smallest and shallowest of the three, and is cut off from the main basin by very

shallow water. The 25-foot contour-line follows approximately the outline of the arm, and the 50-foot area is considerable, the maximum depth being 66 feet in the eastern part of the basin.

The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 50 feet	672 acres	50·2 per cent.
50 „ 100 „	422 „	31·7 „
100 „ 150 „	171 „	12·7 „
150 „ 200 „	68 „	5·0 „
Over 200 „	5 „	0·4 „
	<hr/>	
	1338 „	100·0 „
	<hr/>	

Loch Skinaskink was surveyed on September 19 to 23, 1902. The elevation of the lake-surface above the sea on commencing the survey on September 19, 1902, was determined, by levelling from bench-mark, as being 245·1 feet; when levelled by the Ordnance Survey officers on August 13, 1870, the elevation was 242·7 feet above sea-level. The highest drift-mark seen was 3½ feet above the surface of the water.

*Temperature Observations.*—Temperature observations taken in the deepest part of the loch at 4 p.m. on September 20, 1902, gave the following results:—

Surface .. .. .	54°·2 Fahr.
10 feet ... .. .	54°·2 „
25 „ ... .. .	54°·0 „
50 „ ... .. .	54°·0 „
100 „ ... .. .	53°·3 „
125 „ ... .. .	50°·1 „
150 „ ... .. .	50°·0 „
170 „ ... .. .	49°·6 „

This series shows a range of temperature amounting to 4°·6, the greatest fall being one of 3°·2 between 100 and 125 feet.

## LOCHS OF THE GARVIE BASIN.

THE lochs in this basin form a connected series, Loch Lurgain flowing through Loch Bada na h-Achlaise (which was not sounded) into Loch Bad a' Ghail, thence by the Abhuinn Owskeich into Loch Owskeich, which flows through the little Loch Garvie into Garvie Bay, an inlet of Enard Bay. The lochs contain salmon and trout, but the fishing is preserved.

*Loch Lurgain* (see Plate XL.).—Loch Lurgain lies about two miles to the south of Loch Skinaskink, and  $3\frac{1}{2}$  miles south-east of Enard Bay. The scenery around the loch is very fine, the serrated crest of An Stac and the great pyramid-shaped mass of Cul Beag forming the high ground to the north, while to the south rise Beinn Eun and An t-Sàil. The loch is crescent-shaped, with the concave side turned towards the south. Very fine cliffs are formed in places, especially on the southern shore to the west of the large islands, where for some distance the cliffs are overhanging, and in one place there is a small cave or recess in which 20 feet of water was found. On the opposite northern shore are huge angular blocks which have slipped down from above, one on top of the other, forming fine natural chambers. Loch Lurgain is nearly 4 miles in length, the maximum breadth being over half a mile, and the mean breadth one-third of a mile. Its waters cover an area of  $1\frac{1}{4}$  square miles, and it drains an area ten times greater, or  $12\frac{1}{2}$  square miles. Nearly 200 soundings were taken, the maximum depth observed being 156 feet. The volume of water is estimated at 2,139,752,000 cubic feet, and the mean depth at 61 feet. The loch is divided into two basins by the large islands and the shallow water between them. The *eastern basin* is the larger and deeper, and quite simple in conformation. The 50-foot area is 2 miles in length, extending from the narrow part of the loch at the south-east end to north of the largest island. The 100-foot area is nearly  $1\frac{1}{2}$  miles in length, approaching to within less than a quarter of a mile from the eastern point of the largest island. The 150-foot area is small and centrally placed, and encloses the maximum depth of the loch (156 feet). In the eastern part of this basin are several rocky islets rising from deep water to 1 to 3 feet above the surface. The *western basin*

is not quite so simple in conformation as the eastern one, the 100-foot area having a central constriction in its outline with deeper water on both sides. The 50-foot area is  $1\frac{1}{2}$  miles in length, approaching to within 200 feet of the western end of the loch. The 100-foot area is nearly a mile in length, with a depth of 103 feet in the central constriction, deepening to 130 feet to the west, and 146 feet to the east, of the constriction. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 50 feet	352 acres	43·6 per cent.
50 „ 100 „	306 „	38·0 „
100 „ 150 „	145 „	18·0 „
Over 150 „	4 „	0·4 „
	<hr/> <hr/>	
	807 „	100·0 „
	<hr/> <hr/>	

Loch Lurgain was surveyed on September 5 and 9, 1902. The elevation of the lake-surface above the sea could not be determined, but when levelled by the Ordnance Survey officers on August 9, 1870, the level was found to be 173·0 feet.

*Temperature Observations.*—Temperature observations were taken in the deepest part of the loch at 3 p.m. on September 9, 1902, with the following results:—

Surface ... ..	56°·1 Fahr.
50 feet ... ..	55°·5 „
100 „ ... ..	52°·0 „
140 „ ... ..	50°·3 „

This series shows a range of temperature amounting to 5°·8, there being a fall of 3°·5 between 50 and 100 feet. The range was greater than that observed in any other loch in the district, even in Lochs Assynt, Skinaskink, and Bad a' Ghail, which are all deeper than Loch Lurgain.

*Loch Bad a' Ghail* (see Plate XLI).—Loch Bad a' Ghail (or Baddegyle) lies immediately to the north-west of Loch Lurgain, with which it is connected by the little Loch Bada na h-Achlaise, and about  $1\frac{1}{2}$  miles to the south-east of Enard Bay. The ground to the north and west is comparatively low, An Stac and An t-Sail rising to the east and south. The loch is over 2 miles in length, with a maximum breadth of three-quarters of a mile, the mean breadth being nearly half a mile. Its waters cover an area slightly exceeding one square mile, and it drains directly an area of  $4\frac{3}{4}$  square miles, but since it receives the outflow from Loch Lurgain its total drainage area is over 17 square miles. Over 150 soundings were taken, the maximum depth observed being 180 feet. The volume of water is estimated at 1,767,582,000 cubic feet, and the mean depth at 62 feet. Loch Bad a' Ghail is cut

into two deep basins by the shoaling of the bottom between the peninsula of Rudha Dubh on the southern shore and the island opposite to it towards the northern shore, but even here there is a depth near the centre of 72 feet, so that the 25-foot and 50-foot areas are continuous from end to end of the loch. The 25-foot contour-line follows approximately the outline of the loch; the 50-foot contour is extremely sinuous, in some places following the outline of the loch and in other places, especially in the central part of the loch, being far removed from the shore-line. Of the two 100-foot basins the south-eastern one is the larger and deeper, being over three-quarters of a mile in length, and widest towards the centre of the loch, narrowing on approaching the south-eastern prolongation. The maximum depth of the loch (180 feet) was observed towards the south-eastern end of this basin, and about 200 yards from the north-eastern shore. The north-western 100-foot basin is less than half a mile in length, with a maximum depth of 153 feet. Some of the lines of soundings show minor undulations of the lake-floor, and in one case towards the north-western end a sounding of 20 feet was recorded about 250 yards from the southern shore with a depth of 80 feet between it and the shore; this shallow sounding may possibly be connected with the shallow water surrounding the large island lying to the south-west. There are indications of moderately steep slopes, especially along the south-western shore, where soundings exceeding 40 feet were recorded in various places close inshore. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 50 feet	296 acres	45·1 per cent.
50 ,, 100 ,,	239 ,,	36·5 ,,
100 ,, 150 ,,	100 ,,	15·3 ,,
Over 150 ,,	21 ,,	3·1 ,,
	<u>656</u> ,,	<u>100·0</u> ,,

Loch Bad a' Ghail was surveyed on September 18, 1902; the elevation of the lake-surface above the sea could not be determined.

*Temperature Observations.*—Temperature observations taken at 5 p.m. in the deepest part of the loch gave the following results:—

Surface ..	54°·5 Fahr.
50 feet ...	54°·5 ,,
100 ,, ...	50°·5 ,,
170 ,, ...	50°·0 ,,

This series shows a constant temperature down to 50 feet, then a fall of 4° between 50 and 100 feet, the extreme range being 4°·5.

*Loch Owskeich* (see Plate XLI).—Loch Owskeich (or Oiskaig) lies about a mile to the north-west of Loch Bad a' Ghail, to which it is

connected by the Abhuinn Owskeich, and half a mile to the south of Enard Bay, into which its waters are discharged by the river Garvie. The ground around the loch is low, especially to the north and west. The loch is over  $1\frac{1}{2}$  miles in length, with a maximum breadth of three-quarters of a mile, the mean breadth being less than half a mile. Its waters cover an area of about 420 acres, or two-thirds of a square mile, and it drains directly an area of about 3 square miles, but since it receives the outflow from Lochs Bad a' Ghail and Lurgain its total drainage area is about 20 square miles—an area thirty-one times greater than that of the loch. Over 100 soundings were taken, the maximum depth observed being 153 feet. The volume of water is estimated at 845,809,000 cubic feet, and the mean depth at 47 feet. Loch Owskeich forms a simple basin, but the deep water approaches very close to the south-eastern shore, off which the slopes are steep and in striking contrast to the gentle slopes at the north-west end of the loch. A sounding of 90 feet was recorded only 100 feet, and a sounding of 120 feet only 200 feet, from the eastern shore, and the maximum depth of the loch (153 feet) was observed about 300 yards from that shore. At the opposite end of the loch the 25-foot contour-line is distant 300 yards, and the 50-foot contour half a mile, from the north-western shore. The 50-foot area is nearly a mile, and the 100-foot area nearly three-quarters of a mile, in length. In the shallower water towards the outflow one or two slight undulations of the lake-floor were observed. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 50 feet	280 acres	66·3 per cent.
50 „ 100 „	82 „	19·7 „
100 „ 150 „	57 „	13·7 „
Over 150 „	1 „	0·3 „
	<hr/> 420 „ <hr/>	<hr/> 100·0 „ <hr/>

Loch Owskeich was surveyed on September 18, 1902; the elevation of the lake-surface above the sea could not be determined, but when levelled by the Ordnance Survey officers on July 8, 1870, it was found to be 71·9 feet above sea-level.

*Temperature Observations.*—Temperature observations taken at 4 p.m. on September 18, 1902, in the deepest part of the loch gave the following results:—

Surface ..	...	54°·8 Fahr.
50 feet ...	...	54°·2 „
100 „ ...	...	53°·7 „
130 „ ..	...	50°·8 „

This series shows a range of 4°, the greatest fall being one of 2°·9 between 100 feet and the bottom.

The details regarding the lochs in the Inver, Roe, Kirkaig, Polly, and Garvie basins are collected together in the following table for convenience of reference and comparison. Where the elevation above the sea was not determined by levelling from bench-mark, the approximate elevation is given in brackets; in the case of Lochs Urigill, Càrn, Lurgain, and Owskeich, the Ordnance Survey level is given with an indication of the date when levelled.

From this table it will be seen that in the twenty lochs under consideration, 2540 soundings were taken, and that the aggregate area of the water-surface is over 12½ square miles, so that the average number of soundings per square mile of surface is 200. The aggregate volume of water contained in the lochs is estimated at about 20,355 millions of cubic feet. The area drained by these lochs is about 150½ square miles, or twelve times the area of the lochs.

The following table shows the details of the lochs under consideration, and the aggregate area of the water-surface, the aggregate volume of water contained in the lochs, and the area drained by these lochs. The area drained by these lochs is about 150½ square miles, or twelve times the area of the lochs.

Loch	Area of water-surface (sq. miles)	Volume of water (millions of cubic feet)	Area drained (sq. miles)
Inver	1.2	1,200	12
Roe	1.5	1,500	15
Kirkaig	1.8	1,800	18
Polly	2.0	2,000	20
Garvie	2.2	2,200	22
Urigill	2.5	2,500	25
Càrn	2.8	2,800	28
Lurgain	3.0	3,000	30
Owskeich	3.2	3,200	32
<b>Total</b>	<b>12.5</b>	<b>125,000</b>	<b>150.5</b>

The following table shows the details of the lochs under consideration, and the aggregate area of the water-surface, the aggregate volume of water contained in the lochs, and the area drained by these lochs. The area drained by these lochs is about 150½ square miles, or twelve times the area of the lochs.



## NOTES ON THE GEOLOGY OF THE ASSYNT DISTRICT.

By B. N. PEACH, LL.D., F.R.S., and J. HORNE, LL.D., F.R.S. With Geological Map (Plate XLII.). Published by permission of the Director of the Geological Survey.

From a geological point of view, the Assynt district is one of the most interesting in the north-west Highlands. The various rock formations which enter into the geological structure of the region are there splendidly developed, and the evidence in proof of those great terrestrial displacements of post-Cambrian date may be studied in detail in the mountainous region that runs southward from Glas Bheinn by Ben More Assynt and Breabag to the Cromalt Hills.

Beginning with the Archæan gneisses (A on map), which may be said to form the foundation-stones of that region, they are unquestionably older than the succeeding great development of Torridon Sandstone and overlying Cambrian strata. On referring to the geological map, it will be seen that they occupy a belt of ground from 6 to 9 miles broad, extending along the western coast-line between Enard Bay and Stoer, thence inland to the base of the grand escarpment of Torridon Sandstone that stretches southwards from Quinag to the Coigach mountains. These crystalline gneisses give rise to a type of scenery that is characteristic of a large part of the western seaboard of Sutherland and Ross, which seems to be typical of Archæan areas. Bare rounded knolls and bosses of grey gneiss follow each other in endless succession, and in the hollows there are numerous pools and lochs occupying rock-basins. The whole tract occupied by these crystalline gneisses is singularly destitute of drift. The rocky knolls do not rise much above one general level, which does not as a rule exceed a few hundred feet in height, save near the base of Quinag, Canisp, and Sulven, where the elevation of the old gneiss plateau is about 1000 or 1250 feet.

The Archæan rocks of the Assynt district, west of the great escarpment of Torridon Sandstone, consist largely of pyroxene gneisses and ultrabasic rocks (pyroxenites and hornblendites), which still show in a marked degree their original characters. Their behaviour in the field and their appearance under the microscope have led to the conclusion that they have affinities with plutonic igneous products. All over that district, where the original characters have not been effaced by later mechanical stresses, it is possible to trace the imperfect separation of the ferro-magnesian from the quartzo-felspathic constituents, the gradual development of mineral banding, and the net-like ramifications of acid veins (pegmatite) in the massive gneiss. Whatever be the origin of the mineral banding in these Archæan gneisses, it is

certain that they possessed this banding and were thrown into gentle folds before the intrusion of the later dykes.

On referring to the map showing the surface geology of the Assynt district, it will be seen that the Archæan area is traversed by narrow dykes of igneous material ( $B^6$  on map) trending west-north-west or north-west. In certain belts they occur in great numbers, and their intrusive character is clearly displayed. The dominant types in the Assynt district comprise ultrabasic rocks (peridotite) and basic, including dolerite and epidiorite. These dykes frequently form prominent features in the landscape, sometimes giving rise to ridges and sometimes to clefts or "slacks" in the midst of the surrounding gneiss.

A further important feature in the history of the Archæan gneiss remains to be noticed, for, after the uprise of the great series of intrusive dykes, the whole region was subjected to mechanical stresses that profoundly affected the pyroxenic gneisses and the dykes which traverse them. These lines of movement may be described as lines of shearing or disruption lines, which trend in certain definite directions, and give rise to molecular re-arrangement of the minerals and the development of newer foliation both in the gneiss and in the dykes. The gneisses are thrown into sharp folds, and are traversed by zones or belts of secondary shearing, in which the pyroxenic rocks are converted into biotite and hornblende gneisses. In like manner, the basic and ultrabasic dykes appear frequently as phacoidal masses in the shear zones, and where the latter coincide more or less with the original trend of the dykes, or cross them, then the peridotite and epidiorite intrusions are changed into talcose schist and hornblende schist respectively. A glance at the Geological Survey 1-inch maps of the Assynt district (Sheets 107 and 101) shows the great number of these lines of movement. Further reference will be made to these features in connection with the rock-basins of that district. At present it is important to remember that all these movements took place before the deposition of the Torridon Sandstone.

This undulating plateau of Archæan gneiss was originally covered by a vast pile of sandstones, conglomerates, and shales (Torridonian,  $t$  on map), which has been largely removed by denudation. The unconformability at the base of the Torridon Sandstone represents a vast interval of time, during which the old land-surface of Archæan gneiss was carved into hill and valley. On the north-west slope of Quinag a remnant of this ancient topography is still to be found, where a hill of crystalline gneiss rises to a height of 800 feet in the overlying sandstone. One of the striking features in the landscape of that region is the great western escarpment of Torridon Sandstone, reaching in places an elevation of 1000 feet above the Archæan plateau. That cliff is not continuous, for the sandstones on Quinag north of Loch Assynt cannot be traced without a break to those of Cul Mor and Cul

Beag and of the Coigach mountains beyond. Though at the base there is sometimes a local breccia that varies in character in accordance with the underlying rocks, this pile of sediment mainly consists of a succession of false-bedded grits and sandstones, with scattered pebbles derived from formations which do not now occur in the west of Sutherland and Ross. On Quinag and Beinn Gharbh the sandstones have a gentle dip to the south of east, but on Suilven the strata are horizontal, or nearly so. They attain a thickness of several thousand feet, for in the Coigach mountains they rise from the shores of Loch Broom to a height of about 2400 feet.

Overlying the Torridon Sandstone come the various subdivisions of the Cambrian formation, comprising the basal quartzite ( $a^1$  on map), pipe-rock ( $a^2$ ), fucoid beds ( $a^3$ ), serpulite grit and limestone ( $a^4$ ). The detailed mapping of that region has proved that the Cambrian strata are separated from the Torridon Sandstone by a marked unconformability. It represents an interval of time during which the Archæan floor and overlying Torridonian sediments were exposed to denudation; a vast thickness of strata was removed, and in places the Archæan gneisses were laid bare. Hence we find in the undisturbed area clear evidence of the double unconformability of the Cambrian quartzites on the Torridon Sandstone and Archæan gneiss. This important geological feature is well displayed on the north slope of Beinn Gharbh, south of Loch Assynt. The age of these sediments has been proved by the discovery of trilobites and other organisms, characteristic of the lower division of the Cambrian system, in the fucoid beds of Sutherland and Ross. Fragments of these trilobites have been found in this member of the series at Knockan and on the north shore of Loch Assynt.

On referring to the map, it will be seen that to the west of the band of limestone ( $a^4$ ) extending from Inchnadamph to Knockan, the Cambrian quartzites and fucoid beds have been traced across the sheet from Loch Gainmheich to Strath Kanaird. On the eastern slopes of Quinag, Canisp, and Cul Mor, the white quartzites form a thin cake on the underlying Torridon Sandstone, which on some of the lofty peaks is isolated by denudation. The quartzites dip at a higher angle than the sandstone, and on descending the hill slopes the former pass transgressively across bed after bed of the sandstone, and rest successively on lower members of the Torridon Sandstone.

One of the remarkable features of the Assynt district is the series of intrusive igneous rocks of later date than the Cambrian limestone and older than the post-Cambrian movements. In the undisturbed area west of the great post-Cambrian displacements, they cover considerable areas on Beinn Gharbh, south of Loch Assynt, where they appear as sills in the Torridon Sandstone or Cambrian quartzite. These sills can be traced round the western slopes of that hill, as well

as round the escarpments of Suilven and Canisp. But in the displaced masses, east of a line extending from Inchnadamph to Knockan, the intrusive rocks of this series have a much larger development and greater variety. They appear at intervals over a tract measuring 12 miles from north to south, and from 5 to 6 miles from east to west. The largest of these masses extends from Ledmore and Cnoc na Sroine eastwards by Aultnacallagach towards Cnoc Chaoruinn, and another important sheet runs north from Loch Ailsh to Loch Sail an Ruathair. But throughout the mountainous region of Glas Bheinn, Ben More Assynt, and Breabag these igneous rocks appear as sills in the various thrust-masses, restricted generally to certain definite horizons. A glance at the map will show that they occur at the base of the Cambrian quartzite, in the basal quartzite, in the pipe-rock, in the fucoid beds, and also in the limestone. The mapping of these intrusive sheets has shown the complicated character of the geological structure of that region. The petrographical characters of these igneous materials have been studied by Mr. Teall, and are of special interest. They comprise the plutonic mass of Cnoc na Sroine and Loch Borralan, and the numerous sills and dykes that traverse the Torridonian and Cambrian sediments. The former seems to have resulted from the consolidation of alkaline magmas rich in soda; at the one end of the series there is the quartz-syenite of Cnoc na Sroine, and at the other the basic augite-syenite, nepheline-syenite, and borolanite. The sills and dykes include two well-marked types—viz., hornblende-felspar rocks, and felsites with alkali felspar and ægirine.

Before proceeding to the description of the eastern or Moine schists (m on map), reference must be made to those terrestrial movements which affected that region in post-Cambrian time, whereby the Cambrian rocks were piled on each other, and huge slices of the floor of Archæan gneiss with the overlying Torridonian and Cambrian sediments were driven westwards and made to override the underlying piled-up strata. The structure is admirably shown in the horizontal section extending from Quinag to the river Cassley, placed below the map, showing the surface geology of the Assynt district. On referring to that section, it will be seen that at its western limit on Quinag, where the rocks are undisturbed, the Torridon Sandstone rests on a highly eroded platform of Archæan gneiss, being itself unconformably overlaid in turn by the Cambrian quartzites, fucoid beds, and serpulite grit (3, 4, 5, and 6 in section). In the valley of the Skiag, north of Loch Assynt, the first disruption line or thrust-plane is met with, above which lie various members of the Cambrian system, chiefly the fucoid beds, serpulite grit, and limestone, with their accompanying intrusive sheets of igneous material, all of them being driven together by minor thrusts or reversed faults or folds.

Crossing the limestone plateau at Achumore to the western base

of Glas Bheinn, we encounter the Glencoul thrust (T in section), the first of the series of powerful displacements in the Assynt region. Overlying this plane there is a mass of Archæan gneiss, covered unconformably by both divisions of the Cambrian quartzite with their characteristic igneous sills. Along the western slope of Glas Bheinn the quartzites are inverted, but the sequence can be interpreted by means of the subdivisions of the pipe-rock, based on the characters of the worm-casts from which that zone derives its name. Eastwards we find the Poll an Droighinn thrust (T' in section), and still further east, beyond Loch Cuaran, the Ben More thrust (T'' in section). By means of these displacements, additional slices of the Archæan floor with the overlying Cambrian sediments and intrusive sheets have been driven westwards like the materials above the Glencoe thrust-plane. The visitor to that district may study the relations of the Ben More thrust-plane and the materials above and below it on the southern slope of that mountain in the Beallach (pass) of Coniveall. A considerable thickness of Torridon Sandstone there intervenes between the Archæan gneiss and the Cambrian quartzites, which does not appear in the line of section further north between Quinag and the river Cassley. Indeed, on Ben More Assynt, the double unconformability of the Cambrian quartzite on the Torridon Sandstone and the Archæan gneiss is well seen. In the deep corries on the south side of Ben More Assynt, the observer finds a great development of the Lewisian gneiss with its dykes of epidiorite, forming a rocky slope about 1000 feet high, which presents many of the characteristic features of the old Archæan floor west of Quinag. Eastwards again, towards the river Cassley, beyond the Cambrian quartzites, fucoid beds, serpulite grit, and limestone, appears the Moine thrust, which brings forward a great succession of crystalline schists (Moine schists, M in section), to which reference will immediately be made.

One of the romantic features of the geology of the Assynt region is the isolation by denudation of materials overlying the Ben More thrust-plane. Two outliers of this nature occur west of Breabag, on Beinn nan Cnaimhseag and Beinn an Fhuarain, where slices of Torridon Sandstone and basal Cambrian quartzite overlie Cambrian limestone. Indeed, in the more southerly mass (see map) a small core of Archæan gneiss with an intrusive dyke of epidiorite appears in the midst of the younger formations. These outliers clearly point to the original westward extension of the materials overlying the Ben More thrust-plane having been separated from the main mass east of Breabag by prolonged denudation. It is worthy of note that, though the structure of the disturbed area in the mountainous region of Assynt is highly complicated, still by the zonal mapping of the various rock groups, the relations of the displaced materials can be satisfactorily determined.

The Moine thrust (T<sup>IV</sup> in section) is the most easterly of the great

post-Cambrian displacements that affected that region, the outcrop of which is somewhat remarkable. On referring to the geological map, it will be seen that it can be traced from Loch nan Caorach and Gorm Loch Mor east of Glas Bheinn, southwards along the eastern base of the Ben More group of mountains to Loch Ailsh, thence across the Oykeil to the Cromalt hills. Here the outcrop of the thrust-plane changes its course, and runs west along the base of these hills to Knockan, a distance of 6 miles, whence it runs southwards to Strath Kanaird. It will thus be seen that there is an extraordinary overlap of the Moine thrust-plane along the base of the Cromalt hills, for it passes transgressively across the Ben More thrust-plane and all underlying thrusts till the materials overlying it rest directly on the undisturbed Cambrian strata south of Knockan.

Near the Moine thrust the new structures resulting from the post-Cambrian movements are well developed. The lenticles of Lewisian gneiss and pegmatite are sheared and rolled out, the former passing into flaser gneiss and schist, and ultimately into a banded platy schist, while the latter show fluxion structure with felspar "eyes" like rhyolites. The Torridon Sandstone and Cambrian quartzites, the fucoid beds and intrusive igneous sheets, are likewise sheared and rolled out, the new divisional planes being more or less parallel to that of the Moine thrust. Indeed, such is the transformation effected by these movements on the crystalline rocks and overlying sediments, that it is often difficult to determine the original characters of the component members. It is noteworthy, however, that all the crushed or mylonised rocks near the Moine thrust show a characteristic striping on the divisional planes due to orientation of the constituents in the direction of movement.

The strata overlying the Moine thrust-plane and stretching eastwards down the Cassley and the river Oykeil and across the Cromalt hills are remarkably uniform in character. They consist to a large extent of flaggy quartzose schists, with partings and bands of mica-schists and occasional intrusive sheets or sills of igneous material which have a common foliation with the schists. The matrix of the quartz-schists is holo-crystalline and forms a granulitic mosaic, which is perhaps the characteristic feature of the group. Occasionally "eyes" of felspar appear in the schists, when the rocks might be described as flaser schists. There can be little doubt that the Moine schists are to a large extent, if not wholly, altered sediments, the age of which is still uncertain. Any one who has examined the Archæan rocks in the undisturbed area west of the Torridon Sandstone escarpment, has no difficulty in distinguishing the pyroxenic gneisses and intrusive dykes from the quartz-schists and mica-schists of the Moine series. These broad lithological distinctions have been of great service in interpreting the history of the glaciation of that region.

The Assynt district furnishes impressive evidence of denudation by the removal of a vast covering of Torridon Sandstone, by the persistent eastward recession of that escarpment, by the stripping off of the materials overlying the successive thrust-planes, and also by the development of the present drainage system. It is a remarkable fact that south of the mountainous region of Assynt the watershed lies to the east of Cul Mor, Cul Beag, and the Coigach mountains in the less elevated platform of the Moine schists. It is evident that the present drainage system originated at a remote geological period, when the eastern or Moine schists extended far to the west of their present limits, and were arranged in the form of a dome round the displaced masses which now form the mountainous region of Assynt. It is highly probable, also, that before the glacial period the land stood relatively higher than at present, and that the rivers on the west side of the watershed occupy consequent valleys which extended far to the west of the present coast-line.

Everywhere throughout the Assynt district, and especially in the mountainous region extending from Glas Bheinn to the Coigach area and over the plateau of Archæan gneiss, there is conclusive evidence of intense glaciation. Perhaps the most striking feature of the glacial phenomena of Assynt is the evidence pointing to the conclusion that during the maximum glaciation the ice-shed did not coincide with the existing watershed. From an examination of the striæ indicating the direction of the ice-flow, and from the distribution of boulders, it appears that the ice-parting lay to the east of the present watershed. Indeed, the ice must have accumulated to a great thickness on the less elevated plateau occupied by the Moine schists east of the Ben More Assynt range and east of the Coigach mountains.

The general movement of the ice at great elevations in this district was in a westerly direction, sometimes to the north and sometimes south of that point. For example, on Glas Bheinn, on one of the exposures of Archæan gneiss, at a height exceeding 2000 feet, the striæ point W.  $5^{\circ}$  N. Again, on Beallach an Uidhe, between Glas Bheinn and Beinn Uidhe, at an elevation of about 2000 feet, the direction is west-south-west. East of Inchnadamph, on the quartzite of Beinn an Fhurain, between the 2000- and 2250-foot contour-lines, the striæ run north of west. In the lofty pass crossing the Ben More range, that leads into Corrie Mhadaidh, at a level of 2750 feet, the direction is W.  $10^{\circ}$  S. or W.S.W. In like manner, on the long ridge of Breabag that runs northward from the Beallach of Coniveall, the average height of which is over 2000 feet, splendidly striated surfaces have been recorded which indicate an ice-movement in a westerly direction.

Passing westwards to the mountains north and south of Loch Assynt, we find similar evidence of a westerly movement during the

maximum glaciation. On Quinag, at an elevation of 1750 feet, the striæ point W.  $5^{\circ}$  N., and on Beinn Garbh near the top, about the 1500-foot contour-line, the direction varies from W.  $10^{\circ}$  S. to W.S.W. On the eastern slope of Canisp, between the 1250- and 1500-foot contour-lines, on polished surfaces of quartzite, the striæ point north of west, indicating an ice-movement up the slope in the direction of the Archæan plateau. On the flanks of Suilven, below the limit of the Torridon Sandstone, the striæ trend about west-north-west. Further south, on Cul Mor, near the 1500-foot level, on the top of the escarpment of Torridon Sandstone east of Loch Skinaskink, the direction is a few degrees south of west.

The general westerly movement of the ice across the mountainous part of Assynt, the Cromalt hills, and the Coigach district is confirmed by the dispersal of the boulders. Indeed, the evidence on this point is somewhat remarkable. For instance, on Beinn an Fhurain, which is composed of displaced members of the Cambrian formation, quartzites, fucoid beds, and serpulite grit, boulders of thrust Lewisian gneiss occur on the crest of the ridge, which have been borne westwards from the deep corries north of Ben More Assynt. The highest elevation of the thrust Lewisian gneiss in Corrie Mhadaidh is from 1750 to 2250 feet, and the striæ on the quartzite ridge of Beinn an Fhurain west of that corrie point W.  $10^{\circ}$  to  $20^{\circ}$  N. Further north, on Mullach an Leathaid Riabhaich, similar boulders of thrust Lewisian gneiss rest on the quartzite at a height of 2250 feet. On Breabag the evidence is no less remarkable, for on the quartzite ridge that runs southwards from Breabag Tarsuinn (2044 feet) about the 2000-foot level, numerous blocks of thrust gneiss and Moine schist have been recorded. Further south along the same ridge, in the direction of Meall Diamhain, on the outcrop of fucoid beds as well as on the quartzites, blocks of thrust gneiss and granulitic quartz-schist are met with. The boulders of thrust gneiss have been derived from the belt of this material that has been traced continuously from Ben More Assynt south to Sgonnan Mor, while the blocks of granulitic schists have been carried westwards from the Moine schist area, the average height of which is lower than that of the Breabag ridge. It follows, therefore, that during this westerly movement the Moine schist erratics must have been borne to levels at least 500 feet higher than the sources from which they were derived.

When we pass beyond the limit of the Ben More group of mountains to Cul Beag (2523 feet)—a mountain of Torridon Sandstone west of the Cromalt hills—the evidence is equally conclusive regarding the transport of materials in a westerly direction to higher levels. For there, at a height of 2300 feet, blocks of Moine schist rest on the Torridon Sandstone. Comparing the elevation of the Cromalt hills between Coigach and the river Oykeil with the height of these erratics on Cul Beag, it is obvious that the latter must have been raised about 600 feet

in the course of the movement. On Cul Mor, north of Cul Beag, our colleague Mr. Hinxman found a boulder of nepheline-*agirine* syenite just below the 2000-foot contour-line, which must have been derived from the Cnoc na Sroine and Aultnacallagach igneous mass (see Geological Map). No part of that mass reaches an elevation greater than 1306 feet, so that this boulder, during the westerly movement of the ice, must have been raised at least about 600 feet above its parent source.

There is hardly any trace of boulder clay within the mountainous part of Assynt. This deposit appears in some of the valleys occupied by the Moine schists, as for instance, in the catchment basins of the Cassley and the Oykell, and in the valleys of the Cromalt hills. The drift deposits consist chiefly of moraines which have indeed a wide distribution. An examination of the morainic material, and of the boulders on the mounds, points to a period of confluent glaciers when the mountainous part of Assynt, together with the Cromalt hills, Cul Mor, Cul Beag, and the Coigach mountains, became independent centres of dispersion. The feathered arrows on the geological map indicate this later movement, and show a marked contrast from the persistent westerly trend of the earlier glaciation. A glance at the map will show, for instance, how from the north-east slope of the Glas Bheinn and Ben More Assynt range the later ice spread over the moorland plateau east of Gorm Loch Mor and Fionn Loch Mor onwards in the direction of Loch Shin. This plateau is covered with moraine mounds which contain boulders and debris of Cambrian quartzite, borne from the mountains to the west on to the area occupied by the Moine schists. Again, in the valley of the Cassley that drains the great corries east of Ben More Assynt and Carn na Convaroan, boulders of Cambrian quartzite have been traced for about 15 miles down to Invercassley. Again, on the Moine schist plateau east of Loch Ailsh and south-east of Sgonnan Mor, moraines occur containing blocks of Cambrian quartzite and thrust Archæan gneiss from that area. Further, on the west side of Glas Bheinn and Ben More Assynt, in the neighbourhood of Inchnadamph, part of this confluent glacier ice streamed northwards up the Skiag valley, carrying boulders of the intrusive porphyrite of Beinn Gharbh in its train. Local ice streamed off the eastern slopes of Canisp and Beinn Gharbh, which coalesced with that radiating from Breabag. In like manner, from the eastern slopes of Cul Mor and Cul Beag, local glaciers diverged which united with that moving off the Cromalt hills, and were deflected westwards towards the Archæan plateau and northwards towards Strath Kanaird.

On referring to the geological map, it will be seen that most of the lochs lie within the area occupied by the Archæan gneiss. As the region is remarkably free of drift, the lochs lie in hollows in the solid rock, and are therefore rock-basins. Indeed, any one who visits the

area cannot fail to be struck with the number and irregular outlines of the lakes in the plateau of Archæan gneiss. While mapping that region, it was obvious that the direction of many of the lochs and of their branches had been largely influenced by the trend of lines of shearing and lines of fault, by the trend of groups of intrusive dykes, and by the presence of ultrabasic masses, which weather more readily than the pyroxenic gneiss. In view of these facts, the irregular contour of the lakes on the Archæan plateau, as proved by the soundings, is what might naturally be expected.

*Loch Assynt.*—This is the largest and by far the most important lake in the Assynt district. Round the upper end and along the north-east shore from Inchnadamph to the southern base of Quinag, it is floored by Cambrian and Torridonian strata, while the remainder rests on the Archæan gneiss plateau. It lies along an old consequent valley, the origin of which dates back to a time when the surface configuration was very different from what it is now. Originally, the lake was of larger dimensions, for at its upper end it has been silted up by the river Loanan; indeed, in that direction it must have extended at one time almost to Stonechrubie. At its lower end it must formerly have continued down to the narrows above Inveruplan—a distance of over two miles from the foot of the loch, where a rocky barrier of gneiss and intrusive dykes crosses the river Inver. From that point upwards to the present lower limit of the lake an alluvial terrace is traceable, through which the river follows a winding course. During its former extension, Loch Assynt must have been continuous with Loch Uidh na Gedaig and Loch Leitir Easaich.

The soundings show that this rock-basin is comparatively uniform. The 50-foot contour-line runs from the present lower limit of the lake to near the mouth of the river Loanan; the 100-foot contour-line, from the bend at Loch Leitir Easaich to near the schoolhouse at Inchnadamph—a distance of 5 miles; the 150-foot contour-line is continuous from a point opposite Tomore to near the schoolhouse at Inchnadamph, thus forming one basin  $4\frac{3}{4}$  miles long. Five basins are enclosed by the 200-foot contour-line, and three basins by the 250-foot line. The height of the surface of the lake above sea-level is 215 feet, and the greatest depth is 282 feet, within the Archæan area near Tobeg and Eilean Assynt. At that point the lake is 67 feet below sea-level. A glance at the bathymetrical map will show that the long axes of the deeper basins coincide with the trend of the loch between Loch Leitir Easaich and Inchnadamph, and that they lie nearer the southern shore. This feature is worthy of note, as it is a continuation of an important fault which has been traced for miles along Glen Salach in a north-west direction, in the line of which lie several lakes (see Geological Map). It must be borne in mind, however, that this line of disruption, which has produced brecciation of the Archæan gneiss and dykes along

Glen Salach, is of pre-Torridonian age, and has no connection with the later post-Cambrian movements. It developed a line of weakness, which, when stripped of the overlying Torridon Sandstone and Cambrian strata, would aid erosion either by the action of running water or land ice. Several faults enter the lake on the south side between Tobeg and Rudh' an Alttoir, which, trending in a north-east direction, are coincident with inlets at the margin. Indeed, it is not improbable that the sudden deflection of the lake between Loch Assynt Lodge and Little Assynt—its course there being south-west and north-east—may be due to faults in the same direction, entering the lake at Little Assynt.

*Loch Leitir Easaich.*—This is a shallow rock-basin on the Archæan plateau, which, as already indicated, was originally an arm of Loch Assynt. Its long axis, trending north-west, coincides in direction with that of the Glen Salach fault, but the deepest sounding—70 feet—does not lie in the line of this pre-Torridonian dislocation, but in a small basin to the south of it.

*Loch Beannach* is another shallow rock-basin on the Archæan gneiss with very irregular outlines, its greatest depth being 38 feet. Numerous rock knobs project above the surface of the water. The long arm trending north-west to Loch an Dubh Uidh coincides in direction with an epidiorite dyke and with a line of disruption, but the numerous small bays reflect the varying lithological characters of the Archæan gneiss.

*Loch Druim Suardalain* and *Loch na Doire Daraich* are two shallow rock-basins lying in the consequent valley of the Glen Canisp river (Amhainn na Clach Airidh). A chain of small lakes lies along this ancient valley, all of which are rock-basins now in course of being silted up. The greatest depth of Loch Druim Suardalain is 31 feet. Several small faults cross this lake in a north-east direction, which produce a slight displacement of the intrusive dykes, but they do not seem to have modified the floor of the loch as indicated by the soundings. Loch na Doire Daraich is only about 9 feet deep.

*Loch Cròcach* and *Loch an Tuirc* are likewise shallow rock-basins on the bare Archæan floor. The long axis of the former loch, which is about  $1\frac{1}{2}$  miles in length, lies in the line of a well-marked fault which has been traced for miles across the Archæan plateau. There can be little doubt that the straight feature of the west shore is due to this dislocation. Numerous *roches moutonnées* rise above the surface of the lake towards the east side. Again, in the case of Loch an Tuirc, a fault which shifts the intrusive dykes enters the lake at its outlet, and crosses it in a north-easterly direction. The straight feature on the south side coincides with a zone of newer shearing in the Archæan gneiss trending east and west.

*Loch Veyatie* and *Fionn Loch.*—These lakes lie in rock-basins in the

direction of an old consequent valley traversing the Archæan plateau and the Torridonian and Cambrian strata north-west of Elphin. These lakes were evidently at one time connected, for an alluvial terrace stretches up the valley from the Fionn Loch to near Loch Veyatie. The height of the surface of the Fionn Loch is 357 feet above sea-level, and the height of the alluvial terrace is 379 feet, so that the lake has been lowered by about 20 feet. The long axis of this lake coincides generally with the strike of the original banding of the Archæan gneiss, which there dips to the south-west at angles varying from  $20^{\circ}$  to  $30^{\circ}$ . Several large intrusive dykes trend obliquely up the loch, and lines of newer shearing enter the lake on the north-west side, trending north-west. Indeed, these shear lines have evidently determined the arm of the lake that runs westwards beyond the point where the river Kirkaig drains this sheet of water. Though of irregular contour, the soundings show that it is a long narrow basin, the deepest sounding being 90 feet.

In like manner, though Loch Veyatie is 4 miles long, the soundings show that it is a comparatively shallow basin, the deepest sounding being 126 feet north of Loch a' Mhiotailt and near the foot of the loch. The long axis of this lake is oblique to the strike of the early foliation of the Archæan gneiss, and several large intrusive dykes enter the foot of the lake, the direction of which coincides with that axis. The upper part of the lake is floored partly by Cambrian and partly by Torridonian strata, the lofty mountain of Cul Mor rising to a height of 2786 feet on the south side. The soundings show that there are three small basins, each over 100 feet in depth, two of which lie north-north-east of the great escarpment of Torridon Sandstone of Cul Mor, and the third near the foot, opposite an escarpment of Archæan gneiss which rises to a height of 200 feet above the level of the lake.

*Loch a' Mhiotailt* is an arm of Loch Veyatie, near the foot of the latter, and on its south side. The deepest sounding is 69 feet. The long arm of the lake has evidently been determined by faults which shift the outcrops of the intrusive dykes.

*Loch Càrn* flows into Loch Veyatie at its upper end, near Elphin. The western portion of this lake is floored by Archæan rocks, and the central and eastern portions by Torridonian and Cambrian strata. The soundings show that it is a comparatively shallow rock-basin. Much of the east part near Elphin is under 50 feet in depth, and the deepest soundings recorded at two localities further west are 122 feet. One of these localities is at the narrows, where the lake is floored by Cambrian quartzite, and the other about two-thirds of a mile from the head on the Archæan plateau. The soundings further show that near the head of the lake on the south-west side there is a narrow basin trending nearly west-north-west, enclosed by the 100-foot contour-line, the direction of which coincides with a line of pre-Torridonian shearing that has been traced for miles to the west-north-west into the Fionn

Loch. The soundings also prove that there is a steep cliff along the south shore parallel to this line of shearing, which is continued west-north-west beyond the lake towards the Fionn Loch.

Of all the lakes within the Archæan plateau, *Loch Skinaskink* presents the most irregular outlines. Still, it is obvious that its southern portion lies along a consequent valley, which rises between Cul Mor and Cul Beag. The lake is now drained by the river Polly, which, where it leaves the loch, flows over a barrier of Archæan gneiss. The longer axis of the loch south-west of Eilean Mor coincides with the trend of the early foliation of the gneiss and of certain intrusive dykes. The north-west margin of the loch has been determined by a pre-Torridonian line of fault, which shifts the outcrops of the intrusive dykes.

Numerous rocky islets rise above the level of the loch, which, together with the soundings, reflect the varying character of the Archæan gneiss and intrusive dykes. Various faults enter the loch, which in many cases have given rise to well-marked inlets. The deepest sounding is 216 feet, which occurs not far to the south of Eilean Mor, in the line of the longest axis from south-east to north-west, and where that axis is intersected by a north-east and south-west fault.

*Loch Lurgain* lies wholly within the Torridon Sandstone area, and is a true rock-basin, for at its outlet it flows over a barrier of rock into Loch Bada na h-Achlaise. The trend of the upper part obliquely crosses the strike of the Torridon Sandstone, while that of the lower is more or less parallel to it. About midway down the loch, *roches moutonnées* appear, and the soundings there vary from 20 to 56 feet. Above these islands there is a simple basin, the deepest sounding being 156 feet north-east of Beinn Eun. Below the islands the basin is comparatively simple, the greatest depth being 148 feet. At the foot of the loch, immediately in front of the rocky barrier, the basin enclosed by the 100-foot contour-line is broader than further up the lake.

*Loch Bad a' Ghail* is a true rock-basin, which, save at its lower end, where the rocky barrier is composed of Archæan gneiss, is floored by Torridon Sandstone. The soundings show that this lake forms two well-marked basins. The greatest depth of the upper one is 180 feet, which is a few feet below sea-level, and the deepest sounding of the lower basin is 153 feet. The ice-movement, as indicated by the striæ, seems to have coincided generally with the direction of this lake and Loch Lurgain. Morainic drift is met with at intervals along the shores of these lakes.

*Loch Owskeich* is likewise a rock-basin, the barrier being formed of Torridon Sandstone. The loch, save at its upper end, where there is a ridge of Archæan gneiss, is floored by Torridon Sandstone. The soundings show that this lake has been modified by a powerful north-

north-east and south-south-west fault skirting the eastern shore, whereby the Torridon Sandstone has been thrown down against the Archæan floor on the east sidé. A glance at the map will show how the contour-lines run parallel to that fault and close to the shore, and that the deepest sounding, 153 feet, is not far from the line of this dislocation.

*Loch Urigill* and *Loch Maol a' Choire* are shallow rock-basins in the Cambrian limestone, the erosion of which may be partly due to solution.

*Loch Borralan* lies along the line of a consequent valley, near the headwaters of the river Kirkaig, and probably not far from the original axis of uplift in early Palæozoic times. It is a shallow rock-basin, floored by igneous rocks which belong to the igneous mass of Cnoc na Sroine, with some drift along its margin.

From the evidence now adduced, it is obvious that the plateau of Archæan gneiss with its intrusive dykes is dotted over with lakes of various sizes, which, with the exception of the lower part of Loch Assynt, are of moderate depth. Indeed, most of them are shallow basins, which reflect the varying types of gneiss and intrusive dykes and their subsequent deformation. It is, no doubt, true that the numerous shear-lines and faults of pre-Torridonian age that traverse the Archæan plateau have determined to some extent the features of these lakes; but we are, nevertheless, of opinion that the evidence taken as a whole is in favour of the theory that they have been mainly produced by the erosive action of ice.

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#### NOTES ON THE BIOLOGY OF THE LOCHS IN THE ASSYNT DISTRICT.

By JAMES MURRAY.

Only an incomplete sketch can be given of the biology of this district, as collections of plankton were made in only twelve out of the twenty lochs surveyed. Loch Assynt is the largest loch in the district, but four others, viz., Lochs Lurgain, Skinaskink, Bad a' Ghail, and Owskeich, are moderately large and of considerable mean depth, so that they fall to be classed rather with the large lochs than with the small ones. The remainder are small or of low mean depth.

The fauna of the plankton was very uniform throughout these lochs, differing chiefly in the presence in some of them of one or other of the northern species of *Diatomus*, *D. Wierzejskii*, *D. laciniatus*, in the *Daphnia* being *D. lacustris* in some and *D. galeata* in others, and in the greater abundance of Rotifera and Rhizopods in the shallower lochs. Though the three common Scottish species of *Diatomus* were

found in the district, they were never all found together in one loch, as was commonly the case elsewhere in Sutherland. The *Daphnia* in most of the lochs was the typical *D. lacustris*. In one loch this was associated with *D. galeata*, while in three lochs *D. galeata* was alone observed. *Leptodora* was only observed in Loch Skinaskink, and *Bythotrephes* was not observed at all.

While the fauna thus offers little that is remarkable, the flora, on the other hand, is notable for the great wealth of Algæ, especially of Desmids. Over fifty species of Desmids were observed, and between thirty and forty of these sometimes occurred in one loch. Messrs. West, commenting on the Desmid flora of this part of Scotland, state that the plankton is unique in the abundance of its Desmids, and that the most conspicuous of these are of a distinctly western type, being found in Europe only along the extreme north-western coasts, while in North America they are eastern species. The southern and eastern limits of this remarkably rich area in Scotland cannot yet be fixed; in Sutherland it extends right across Scotland. An examination of many hill lochs in Perthshire and in the south of Scotland showed no such rich flora there. When the distribution of the Desmid flora is worked out, it will be of interest to observe whether the area covered by those western species coincides with that occupied by the northern Calanidæ, *Diaptomus Wierzejskii* and *D. laciniatus*, which are so generally distributed in Sutherland, though they also occur in many spots further south.

*Loch Assynt.*—The plankton of this loch closely resembles that of the larger lochs in the south, only the typically pelagic Entomostraca and Rotifera being present. It is noticeable that neither *Diaptomus Wierzejskii*, *D. laciniatus*, nor *Daphnia galeata*, species widely distributed in the district and also occurring in many of the large lochs further south, was observed here. The loch further resembles many other large lochs in the presence of numerous skeletons of *Clathrulina elegans*. The only Rotifer calling for mention is *Triarthra longiseta*, a species not usual in large lakes. Unlike the other lochs of the district, there were very few Desmids in the plankton. The quantity of plankton was very small.

*Loch Lurgain.*—The fauna comprised only the usual pelagic species, among which *Cyclops strenuus* was most abundant. The *Daphnia* was *D. galeata*. *Diaphanosoma brachyurum* was present in some numbers. The flora was remarkable for the number of Desmids, especially of the genus *Staurastrum*, including the beautiful large species, *S. longispinum* and *S. arctiscon*.

*Loch Bad a' Ghail.*—The somewhat meagre plankton was almost exactly of the type found in deep lochs, differing only in the greater abundance of Rotifera, among which were *Plæsoma*, *Gastropus*, and *Triarthra*. The commonest animal was *Cyclops strenuus*. About a

dozen species of Desmids were observed, including *Staurastrum longispinum* and *S. gracile*, var. *bulbosum*.

*Loch Owskeich*.—The fauna was much richer than that of Loch Bad a' Ghaill, with which, from position and size, it is best comparable. *Diaptomus gracilis* and *D. laciniatus* were both present. The *Daphnia* was *D. galeata*. There were many filamentous Algæ and Desmids, among which occurred *Staurastrum Braziliense*.

*Loch Skinaskink*.—The plankton was very rich, and, notwithstanding the large size and considerable mean depth of the loch, resembled that of a shallow loch in the great numbers of Rotifers, Desmids, and Protozoa. There were two species of *Diaptomus*, *D. gracilis* and *D. laciniatus*, and two of *Daphnia*, *D. lacustris* and *D. galeata*. Among the Rotifera were two species which, though pelagic, are not usual in large lakes, viz., a *Synchaeta* and a *Plæsoma*. The Desmids included *Staurastrum Braziliense* and *S. ophiura*.

*Loch Fionn*.—This loch, though long, is so narrow as to be little more than an expansion of the river. When in spate, as on the occasion of the visit of the Lake Survey, there is a decided current down the loch. As would be expected in the circumstances, life was very scarce and of few species. Two forms of *Bosmina* were present, *B. obtusirostris* and its variety *B. longispina*.

*Loch an Tuirc*.—Entomostraca were numerous, but of few species. Rotifera were scarce. Filamentous Algæ were abundant, but there were few Desmids.

*Loch Beannach*.—Organisms were not very abundant. Only the commonest pelagic Entomostraca were present. Rotifera were more numerous, including, in addition to the usual pelagic species, *Gastropus stylifer* and a species of *Plæsoma*.

*Loch na Doire Daraich*.—The very abundant fauna of this loch closely resembled that of the adjacent Loch Druim Suardalain, the most notable difference being the more numerous Rotifera. Among these were *Floscularia pelagica*, *Triarthra longiseta*, *Pterodina patina*, *Copeus cerberus*, *Dinocharis Collinsii*. Among the numerous Desmids were *Micrasterias furcata*, *M. pinnatifida*, *Staurastrum grande*, and *S. longispinum*.

*Loch Druim Suardalain*.—This shallow loch had the richest fauna found in the lochs of the district. The flora was also very rich. About a dozen species of Rotifera were seen, including *Callidina Brycei*. Over thirty species of Desmids occurred, among which were *Staurastrum grande*, *S. ophiura*, and *S. sexangulare*. There was nothing among the Entomostraca calling for remark, only the commoner pelagic and shallow-water species being observed.

*Loch Maol a' Choire*.—Crustacea were very abundant, including a species of *Gammarus*. *Diaptomus Wierzejskii* was the only Calanid observed. It was in a collection from this loch that the species was

discovered in Britain by Dr. Scott. The usual pelagic Rotifera were present. No Desmids were seen.

*Loch Awe.*—The most abundant organism was a variety of *Diaptomus Wierzejskii*. *Sida* was seen here, and in no other lake in the district, being somewhat late in the season for this species. Very few Rotifera or Algæ were noticed.

## LOCHS OF THE MORAR BASIN.

THREE lochs lying in the basin of the river Morar were surveyed—viz., Loch Morar, Loch Beoraid, and Loch an Nostarie. There are a number of other small lochs in this catchment-basin, but as there were no boats on them they could not be surveyed. Loch Morar is the principal loch in the basin, and it gives great interest to the whole area from the fact that it is not only the deepest lake in Scotland, but in the British Islands; indeed, the bottom of this loch forms the deepest hole in the continental plateau on which our islands are situated.

From the accompanying sketch-map (Fig. 32), it will be seen that Lochs Morar and Beoraid are parallel to each other, and run in an east-and-west direction. The overflow from Loch Beoraid, which lies about 3 miles to the south of Loch Morar, enters Loch Morar about its centre by the river Meoble, while the overflow from Loch an Nostarie, which lies to the north, enters Loch Morar at its western end by the river Loin.

The west end of Loch Morar is only about 500 or 600 yards from the sea, and its outflow is by the river Morar, which in its course falls over a rocky barrier, at the foot of which is a famous salmon pool.

The total drainage area of the Morar basin is calculated at 42,000 acres, or over  $65\frac{1}{2}$  square miles. The whole region is rocky and mountainous. The district has not yet been mapped by the Geological Survey, but it is believed that the whole basin lies entirely in the crystalline schists of the Moine series of the Geological Survey, the main strike being north-north-east to south-south-west. The rocks seen at the barrier at the mouth of the loch are composed of hard quartzose flagstones or siliceous Moine schists. The direction of the hills at the belt which separates Loch Morar from the sea agrees generally with the strike of the rocks. Lochs Morar and Beoraid occupy true rock-basins, but it seems almost certain that the outlet of Loch Morar was at one time to the south-west, because the col there does not rise more than 100 feet above the sea, and there is a narrow belt of comparatively flat ground running southwards towards the source of the burn called Allt Cam Carach. It will be observed,

by an examination of the depth map, that the deep water at the west end of the loch runs in the direction of this flat ground. Some deep borings along this flat ground might lead to interesting results.

Loch Morar (as well as Loch Beoraid) is a glen-lake which lies in a transverse valley—that is to say, in a valley the direction of which is independent of the geological structure of the region and crosses

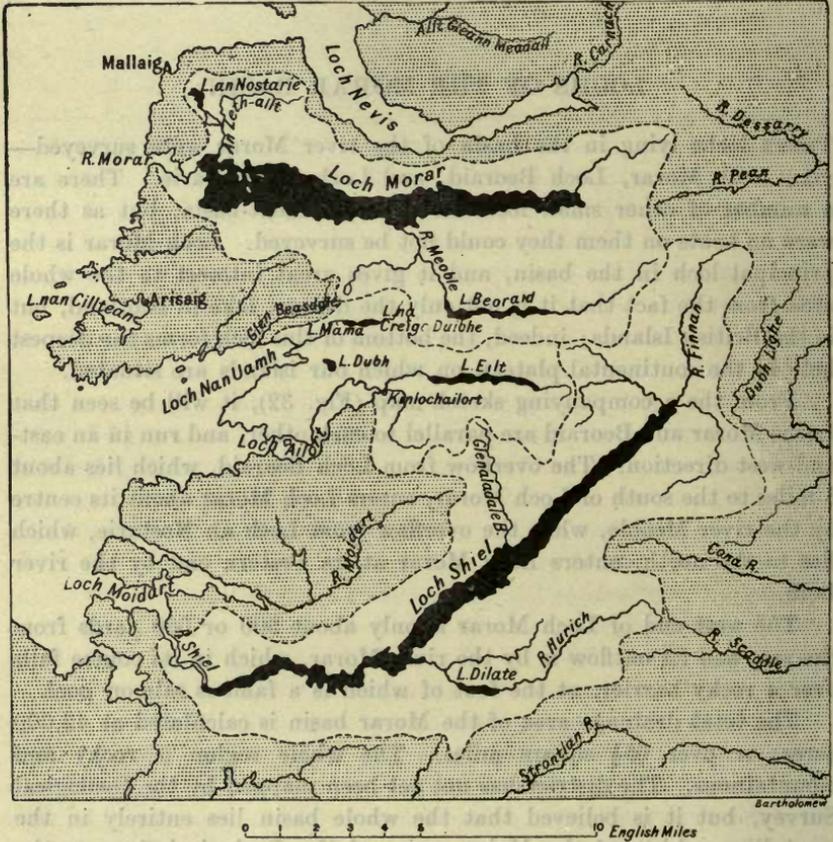


FIG. 32.—INDEX MAP OF THE MORAR, SHIEL, AILORT, AND NAN UAMH BASINS.

irregularly the strike of the rocks. This fact very probably accounts for the steep sides and the great depth to which the valley has been scooped out. Should the country be depressed about 40 feet, Loch Morar would be converted into a submerged valley and an arm of the sea like Loch Etive. By some observers it is held that the great depth of Loch Morar precludes the idea that it was scooped out by river-action or by ice.

*Loch Morar* (see Plate XLIII.).—This is a large and beautiful loch, lying amid wild and magnificent scenery on the west coast of Inverness-shire, in the south-west portion of that county, immediately to the south of Loch Nevis, which is a sea-loch running inland for 12 miles from the Sound of Sleat. The west end of Loch Morar is about 3 miles from Arisaig, and  $2\frac{1}{2}$  miles from Mallaig. Morar station, on the Mallaig branch of the West Highland Railway, is within a few hundred yards of the west end.

The loch is a little over  $11\frac{1}{2}$  miles in length, and the maximum breadth is over  $1\frac{1}{2}$  miles near the west end; the mean breadth is

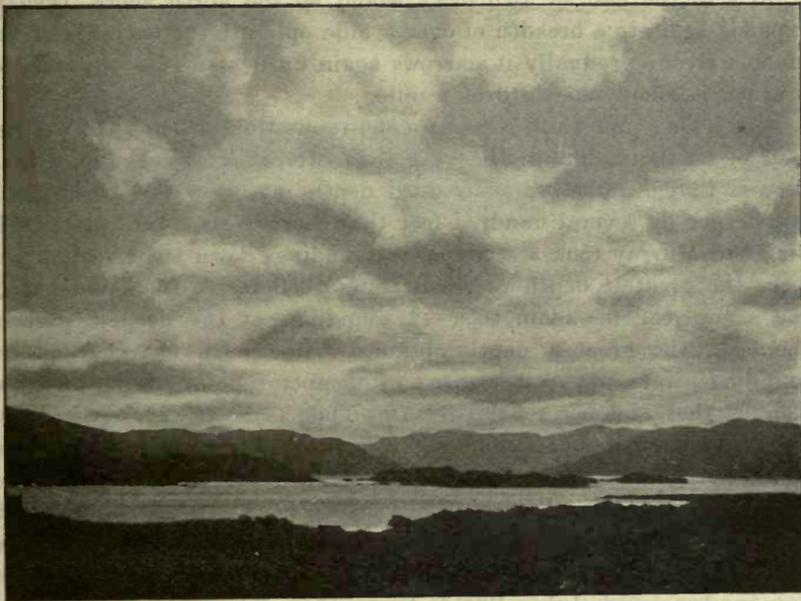


FIG. 33.—LOCH MORAR, LOOKING EAST FROM THE WEST END.

(Photograph by Mr. T. N. Johnston, M.B., C.M., F.R.S.E.)

nearly  $\frac{2}{10}$  of a mile, or about  $7\frac{1}{2}$  per cent. of the length. The area covered by the lake is 6596 acres, or nearly  $10\frac{1}{3}$  square miles.

There are several islands, more or less richly covered with vegetation, at the west end of the loch (see Fig. 33), and parts of the surrounding land, especially on the north side, are fairly well wooded, all of which greatly adds to the beauty and picturesqueness of the scenery at this part, but as one proceeds eastwards towards the head of the loch the scenery becomes wilder, the vegetation more scanty, and the mountains on both sides of the loch rise higher and more steeply. At many places on the north shore they rise precipitously from the water's edge, and around the head of the loch they reach a height of fully 3000 feet.

Loch Morar is fed by numerous small burns and streams, the largest feeder being the Meoble river, which, issuing from Loch Beoraid, falls in, after a course of about 3 miles, at "Camas Luinge," a bay on the south shore.

On the north shore, about  $4\frac{1}{2}$  miles from the head of the loch, is a large bay called "South Tarbet Bay," and here a narrow neck of land about half a mile wide separates Loch Nevis from Loch Morar. A track which runs up the north shore of Loch Morar to Tarbet on Loch Nevis, crosses this neck of land by a narrow pass which rises to a height of 200 feet. For a distance of about 6 miles from the west end, the loch gradually narrows until a breadth of two-thirds of a mile is attained a little to the east of Brinacory island on the north shore, then it expands again to a breadth of over a mile opposite the entrance of the Meoble river; gradually it narrows again until at its eastern end the breadth is about one-third of a mile.

For a long time Loch Ness bore the reputation of being the deepest loch in Scotland, but in the year 1879 Mr. J. Y. Buchanan, F.R.S., showed that Loch Morar contained depths of over 1000 feet, which was deeper by several hundred feet than Loch Ness. In April, 1887, Sir John Murray took a series of 18 soundings down the centre of the loch, the greatest depth recorded being 1050 feet. In September of the same year he again took 12 soundings at the deepest part of the loch, the greatest depth obtained being 1026 feet. All these soundings were taken by means of hempen-rope sounding-lines, as well as those taken in 1892 by Dr. Thomas Scott, who recorded a depth of 1020 feet. In June, 1896, Sir John Murray and the late Mr. Fred. P. Pullar made a bathymetrical survey of the whole loch with a wire-rope machine, but the chart they prepared was not published, as it was found that the machine employed was untrustworthy. It was therefore resolved to make a completely new survey. This was carried out in June and July, 1902. Since that date the loch has been frequently visited by members of the Lake Survey staff for the purpose of taking temperatures and making biological observations.

The surface of the loch at the time the survey was made, in June, 1902, was 30.5 feet above sea-level, and in March, 1903, the level was found to be 35 feet above the sea—a difference in level of  $4\frac{1}{2}$  feet. Altogether 1100 soundings were taken in the loch, or about 100 soundings to the square mile; the maximum depth recorded was 1017 feet. This is less than previous results, but is to be accounted for by the use of wire rope, which nearly always gives a lesser depth than the soundings with ordinary sounding-lines. The general results are set forth on the accompanying map of the loch, with various cross-sections.

Loch Morar is of simple conformation, the bottom falling on all sides down to the deepest part, but with here and there a few minor undula-

tions of the lake-floor, especially in the wider western half of the loch, where the contour-lines of depth are much more sinuous in character than in the narrower eastern half. This is most noticeable in the vicinity of the islands at the west end; the line of soundings running south from Rudha Port na Coite shows several irregularities of the lake-floor, and causes the 300-foot and 500-foot contours to twist in a peculiar manner. Proceeding eastwards, the bottom undulates in such a way as to cut up the 700-foot basin into three portions separated from each other by shallower water, and towards the north shore, opposite Camas na Togalach, a sounding of 367 feet is recorded separated from the main basin by a shoaling of the bottom covered by 229 feet of water. Farther east again, opposite Roinn a' Ghiubhais, the bottom shoals

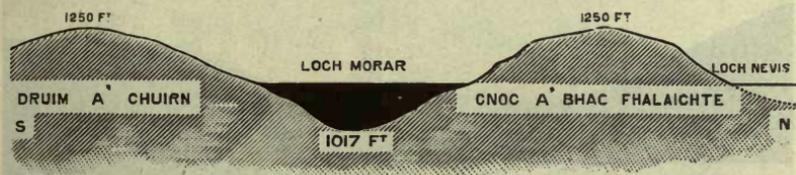


FIG. 34.—DIAGRAMMATIC SECTION ACROSS LOCH MORAR AND THE HILLS ON BOTH SIDES, SHOWING RELATION OF DEPTH TO HEIGHT. NATURAL SCALE.

slightly, so as to isolate a small area exceeding 900 feet in depth from the main 900-foot basin. Opposite the entrance of the river Meoble, on the southern shore, a sounding of 97 feet was recorded comparatively near shore, which gives rise to a prolongation of the 100-foot contour-line in that direction. Towards the east end of the loch, opposite Sròn an Drutain on the north shore, a rise of the bottom was observed covered by 74 feet of water, surrounded by depths exceeding 100 feet.

The deepest part of the loch is at the wide portion opposite the mouth of the Meoble river; here, in the centre of the loch, the maximum depth of 1017 feet was obtained, at a spot nearly midway between the two ends of the loch. The area over 1000 feet in depth is not large, extending only to a little over 4 acres. One sounding of 1002 feet was obtained about 400 yards to the north-east of this area.

The area enclosed by the 900-foot contour extends to a length of a little over 2 miles, with a maximum breadth of a quarter of a mile, situated about  $5\frac{1}{2}$  miles from the west end of the loch and 4 miles from the east end. A small detached area over 900 feet in depth, with a length of half a mile, lies about two-thirds of a mile to the west of the main 900-foot basin.

The 800-foot contour encloses an area 4 miles in length with a maximum breadth of about one-third of a mile. It extends from 4 miles from the west end of the loch to within 3 miles of the east end.

There are three depressions over 700 feet in depth. The main one is nearly 5 miles in length, with a maximum breadth of two-fifths of a mile, extending from nearly 4 miles from the west end of the loch to within  $2\frac{1}{2}$  miles of the east end. The other two depressions are small; one lies about half a mile to the west of the main depression, and is three-quarters of a mile in length; close to its western extremity lies the third depression, which has a length of about one-third of a mile.

The 600-foot contour encloses an area which is  $7\frac{1}{4}$  miles in length, extending from about 2 miles from the west end of the loch to 2 miles from the east end.



FIG. 35.—LOCH MORAR, LOOKING TOWARDS THE DEEPEST PART.

(*Photograph by Mr. J. A. Harvie-Brown, F.Z.S.*)

The 500-foot contour encloses an area extending to over  $7\frac{1}{2}$  miles in length, reaching from  $1\frac{2}{3}$  miles from the west end of the loch to about 2 miles from the east end.

The 400-foot contour encloses an area over  $8\frac{1}{2}$  miles in length, extending from  $1\frac{1}{2}$  miles from the west end to 1 mile from the east end of the loch.

The area over 300 feet in depth is  $9\frac{1}{2}$  miles in length, extending from nearly  $1\frac{1}{2}$  miles from the west end to a little over half a mile from the east end of the loch. There is a small detached area of over 300 feet in depth, about 5 acres in extent, near the north shore, a quarter of a mile to the west of Brinacory island.

The area enclosed by the 200-foot contour is nearly  $10\frac{1}{2}$  miles in length, extending from about a mile from the west end to about one-sixth of a mile from the east end of the loch.

The area enclosed by the 100-foot contour is over 11 miles in length, extending from one-fifth of a mile from the west end of the loch to a short distance from the east end.

The area covered by less than 100 feet of water is 2784 acres. The areas between the consecutive contour-lines and the percentages to the total area of the loch are as follows:—

0 to 100 feet	2784 acres	42·2 per cent.
100 „ 200 „	863 „	13·1 „
200 „ 300 „	528 „	8·0 „
300 „ 400 „	488 „	7·4 „
400 „ 500 „	331 „	5·0 „
500 „ 600 „	331 „	5·0 „
600 „ 700 „	547 „	8·3 „
700 „ 800 „	111 „	1·7 „
800 „ 900 „	530 „	8·0 „
900 „ 1000 „	79 „	1·2 „
Over 1000 „	4 „	0·1 „
	<u>6596 „</u>	<u>100·0 „</u>

These contour-lines of depth approach each other very closely in many places, showing that the slopes are very steep at these points. A little to the west of the promontory called “Rudha nam Faiseachan” on the south shore, south-east of the islands, this is very marked, the slope being as much as 1 in  $2\frac{1}{2}$ . Farther east on the south shore, off “Eilean Allmhara,” the slope is again very steep, as it also is off Brinacroy island, which lies almost opposite on the north shore.

As the surface of the loch is only 30 feet above sea-level, almost the entire bed of the loch is below the level of the sea. The area draining directly into Loch Morar is over 33,800 acres, or about 52 square miles.

The volume of water contained in the loch is estimated at 81,486,000,000 cubic feet, and the mean depth at 284 feet. Although Loch Morar is the deepest loch, Loch Ness has a volume three times as great, and its mean depth is 436 feet.

The deepest Scottish lochs next to Loch Morar are—

Loch Ness ..	...	...	...	...	...	751 feet.
„ Lomond ..	...	...	...	...	...	623 „
„ Lochy...	...	...	...	...	...	531 „
„ Ericht ..	...	...	...	...	...	512 „
„ Tay ..	...	...	...	...	...	508 „

In the sea to the west of Morar there is no depth approaching 1000 feet, with the exception of a deep spot of 834 feet (139 fathoms) between

the islands of Rum and Skye, so that to get a depth of 1000 feet one must go west of St. Kilda and Ireland, beyond the 100-fathoms line in the Atlantic ocean. There are no depths comparable to this in the North Sea, but the submarine valley known as the "Norwegian Gut," which runs round the west and south coast of Norway, is remarkably deep, depths of 1794 feet (299 fathoms) and 1710 feet (285 fathoms) having been obtained at the part called "The Sleeve."

There are seven lakes on the continent of Europe which exceed Loch Morar in maximum depth, and in the following table their maximum depths, heights of the water surface above sea-level, and depths of their floors below sea-level, are shown as compared with Loch Morar. The first four of these lakes are in Norway, the other three are well-known Italian lakes.\*

Name.	Max. depth.	Height above sea-level.	Depth below sea-level.
	F. et.	Feet.	F. et.
Hornisdalsvand ...	1594·5	167·3	1427·2
Mjösen ... ..	1482·9	396·9	1086·0
Salsvatn... ..	1460·0	42·6	1417·4
Tinnsjö ... ..	1437·0	606·9	830·1
Como ... ..	1341·8	652·9	688·9
Maggiore ... ..	1220·4	472·4	748·0
Garda ... ..	1135·1	213·2	921·9
Morar .. ..	1017·0	30·5	986·5

The Lake of Geneva, in which very important and comprehensive limnological work has been done by Prof. Forel, Dr. Ed. Sarasin, and others, has a maximum depth of 1013·8 feet, and the height of the water surface is 1220·4 feet above sea-level; the deepest part of the lake-floor does not, therefore, go below sea-level, but lies at 206·6 feet above it.

*Temperature Observations.*—A large number of observations on the temperature of the water of Loch Morar has been made in various seasons and in different years. On April 29 and September 3, 1887, Sir John Murray took several series of temperatures, ranging from the surface to the bottom. In the April observations the temperature varied from 43°·9 at the surface to 42°·0 at the bottom, a range of 1°·9, and in September the variation was from 57°·8 at the surface to 42°·1 at the bottom, a range of 15°·7. On July 2 and 3, 1902, serial temperatures were taken by the Lake Survey, and the variation was from 55°·2 at the surface to 42°·2 at the bottom, a range of 13°·0. Subsequently, on March 28, 1903, the temperature was found to be

\* The figures referring to these continental lakes are derived from "Halbfass, Die Morphometrie der Europäischen Seen," *Zeitschr. Gesellsch. Erdk. Berlin*, Jahrg. 1903, p. 592; 1904, p. 204.

practically uniform from the surface to the bottom at a depth of 1010 feet, the surface temperature being  $41^{\circ}9$ , while that at the bottom was  $41^{\circ}8$ , a range of only  $0^{\circ}1$ , and on October 23 of the same year the variation was from  $50^{\circ}2$  at the surface to  $43^{\circ}0$  at the bottom in 1000 feet, a range of  $7^{\circ}2$ . The temperature at the depth of 1000 feet has generally been regarded as fairly constant at about  $42^{\circ}0$  all the year round, with a variation of about  $0^{\circ}2$ , and this higher record of  $43^{\circ}0$  may be due to the increased amount of water draining into the loch during the wet summer of 1903. The highest surface temperature recorded was one



FIG. 36.—FALLS OF MORAR.

(*Photograph by Mr. T. N. Johnston, M.B., C.M., F.R.S.E.*)

of  $59^{\circ}2$  on June 30, 1902, off Bracora, the air temperature at the time being  $62^{\circ}8$ , with a moderate westerly breeze. This gives a total range of  $17^{\circ}4$  between the highest surface and the lowest bottom temperature recorded.

*Deposits.*—The deposits covering the floor of Loch Morar are mostly dark brown in colour, which becomes almost black in the deeper parts. A sample from 1000 feet was dark brown when wet, and greyish-black when dry, containing about 50 per cent. of black vegetable matter, about 10 per cent. of mineral particles (quartz, mica, hornblende, &c.), with a mean diameter of 0.15 millimetre, and about 40 per cent. of amorphous clayey matter, with many fine Diatoms and a few fragments





of arenaceous Foraminifera. The mica is present in extremely minute flakes, and imperceptible to the naked eye in the unwashed material. In this respect the material from Loch Morar differs from that obtained in most of the other lochs, in the samples from which the glistening mica flakes attract one's attention.

*Loch Beoraid* (see Plate XLIV.).—Loch Beoraid is a long narrow loch, lying amidst wild and rocky scenery about 3 miles to the south of Loch Morar. There were no Ordnance Survey bench-marks available in the vicinity of the loch from which the level of the water surface could be ascertained, but, from the position of the spot-levels, the height was estimated at 168 feet above the sea. The loch trends in an east-to-west direction, and is fed by numerous small burns, the largest, Allt a Ghlinne Dhuinn, flowing in at the east end. The Meoble river, which drains the loch, issues at the west end, and, after a course of 3 miles, falls into Loch Morar. There are one or two small islands at the east end of the loch, and one large one lying in the centre, almost equidistant from both ends of the loch. The length of Loch Beoraid is  $3\frac{1}{2}$  miles, and its maximum breadth about one-third of a mile; the mean breadth is one-sixth of a mile, and the area covered by water is 352 acres, or over half a square mile. The number of soundings taken was 120, the maximum depth obtained being 159 feet; the mean depth is over 72 feet. The volume of water is estimated at 1,156,000,000 cubic feet, and the drainage area extends to 7680 acres, or nearly 12 square miles.

There are two basins over 100 feet in depth; one at the west end of the loch three-quarters of a mile in length, with a maximum breadth of one-sixth of a mile, approaching to within one-eighth of a mile from that end. The maximum depth obtained in it was 147 feet, comparatively very near the outflow. The eastern basin is nearly  $1\frac{1}{4}$  miles in length, with a maximum depth of 159 feet, the area over 150 feet in depth being almost half a mile in length. The 50-foot area is continuous from end to end, passing to the south of the large central island, the depth in the channel being 53 feet. Loch Beoraid is a rock basin divided into two separate basins by a rocky ridge which crosses the loch at the large island. At the west end of the loch there is a rocky barrier, and the river Meoble in its course forms a waterfall over rocks a short distance from its exit. The loch was surveyed on July 1, 1902.

*Temperature Observations.*—The following series of temperatures was taken about a quarter of a mile from the west end of the loch:—

Surface ... ..	60°·0 Fahr.
10 feet ... ..	59°·8 „
25 „ ... ..	53°·9 „
50 „ ... ..	51°·0 „
100 „ ... ..	47°·5 „
140 „ ... ..	48°·0 „

These temperatures show a range of  $12^{\circ}5$  from the surface to 100 feet, with a small inversion of half a degree between 100 and 140 feet. About 3 p.m. the surface temperature in the centre of the loch, half a mile from the east end, with a strong westerly breeze blowing, was found to be  $61^{\circ}4$ .

*Loch an Nostarie* (see Plate XLV.).—Loch an Nostarie is a small loch lying about a mile to the north of the west end of Loch Morar, into which it drains through the little Loch a' Bhada Dharaich and the Allt an Lòin. It was surveyed on July 16, 1902, when, by levelling from an Ordnance Survey bench-mark, the level of the water surface was found to be 89.3 feet above sea-level. The loch has a length of a little over half a mile, with a maximum breadth of nearly half a mile, the mean breadth being a quarter of a mile. The area covered by water extends to 90 acres, or nearly one-seventh of a square mile. The number of soundings taken was 62, the maximum depth being 35 feet, while the mean depth is very nearly 11 feet. The volume of water contained in the loch is estimated at 44,000,000 cubic feet, and the drainage area extends to 1152 acres or  $1\frac{3}{4}$  square miles. The loch is quite simple in conformation, the deep water occupying a central position.

*Temperature Observations.*—On the date of the survey the temperature of the water was found to be almost uniform from surface to bottom, the difference between the surface temperature and that at 30 feet being only  $0^{\circ}1$  Fahr., as shown by the following series taken at 4 p.m. in the deepest part of the loch:—

Surface ... ..	59°·3 Fahr.
10 feet ... ..	59°·3 ,,
20 ,, ... ..	59°·2 ,,
30 ,, ... ..	59°·2 ,,

The details regarding the lochs in the Morar basin are given in the table on p. 208.

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#### NOTES ON THE BIOLOGY OF LOCH MORAR.

By JAMES MURRAY.

Salmon, sea-trout, and loch-trout abound in Loch Morar, and the sport is frequently very good, but the salmon as a rule are "dour" to rise. Charr and the powan, or fresh-water herring (*Coregonus*), are said to inhabit the loch.

The biology of Loch Morar offers several peculiarities as compared with most of the other large Scottish lochs. The quantity of plankton

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in millions cubic feet.	Area of loch, square miles.	Drainage area.	
				Max.	Mean.		Max. feet.	Mean. feet.	Mean percent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
Morar	30.5	1102	11.68	1.460	0.88	7.53	1017	284.0	27.9	61	217	81,486	10.30	65.63	6.37
Beoraid	168.0	120	3.43	0.32	0.16	4.70	159	72.3	45.5	114	250	1,156	0.55	11.85	21.54
Nostarie	89.3	62	0.56	0.48	0.25	44.60	35	10.95	31.3	84	270	44	0.14	1.79	12.78
		1284										82,686	10.99	65.63*	6.0

\* The drainage area of Loch Morar includes those of Lochs Beoraid and Nostarie.

is small, the larger Entomostraca especially being deficient. With this is correlated an unusual clearness of the water (a white disc was visible in June at a depth of 42 feet). The plankton hardly varies throughout the year, except that *Leptodora*, *Bythotrephes*, *Holopedium*, and a few other genera appear in the summer months only. The quantity was slightly greater in March than at other seasons. At no season has *Daphnia* been observed in the loch, and its absence has also been noted by Dr. Thomas Scott (as long ago as 1892) and by Mr. D. J. Scourfield. This is the more remarkable as *Daphnia* abounds in Loch an Nostarie, about a mile distant, and discharging into Loch Morar by a considerable stream. The only *Diaptomus* was the common *D. gracilis*; while many of the other large lochs in about the same latitude have also one or other of that group of closely related species represented in Loch Ness by *D. laticeps*. The *Bosmina* was the typical *B. longispina*, and not *B. obtusirostris*, which is the common species in the majority of the Scottish lochs. In contradistinction to the scarcity of larger organisms, many very small species were abundant. Desmids especially, of a few species, were unusually numerous in the plankton at all seasons. A remarkable variety of *Xanthidium subhastiferum* has been described by Messrs. West from material collected by the Lake Survey. In this the two spines of each side of the semi-cell, instead of lying in the same plane as the semi-cell, are placed side by side on the external angles of the wedge-shaped semi-cell.

The aquatic plants, growing in the shallow water among the islands, yielded an abundant fauna of microscopic animals, especially of Rotifera and Tardigrada. From among these there have been described two new species of Bdelloid Rotifers. A new water-bear of the genus *Echiniscus* has also been described. It is distinguished chiefly by having the dorsal plates covered by a large hexagonal reticulation in addition to the usual dots. This species was very numerous in October, and has not yet been met with elsewhere.

## LOCHS OF THE EWE BASIN.

THIRTEEN lochs draining into Loch Ewe were visited by the Lake Survey, viz., Loch Maree, Lochan Fada, Lochs Garbhaig, Coulin, Clair, Tollie, Kernsary, Ghiuragarstidh, Mhic' Ille Riabhaich, a' Bhaid-Luachraich, Sguod, an t-Slagain, and an Draine. The two last-mentioned lochs fall into the sea just outside the entrance to Loch Ewe, but it has been found convenient to include them with the lochs of the Ewe basin. The relations between the various lochs will be readily grasped by reference to the small index map of the district shown in Fig. 37. The drainage area under consideration extends from the mouth of Loch Ewe to the summit of Carn Odhar in the south, and close to the shores of Loch Fannich in the east, and is about 30 miles in length from north to south, and about 17 miles in maximum width from east to west. The total area is about 220 square miles (excluding Loch Ewe), and, as will be seen from the table at the end of this paper, about 185½ square miles drain into the lochs now to be dealt with, leaving about 35 square miles draining into the sea irrespective of these lochs. The head-waters of the basin on the south take their rise on the flanks of Beinn Liath Mhor and Carn Breac, flowing by the river Coulin into Loch Coulin, thence into Loch Clair, thence by the Allt Ghairbhe into the Kinlochewe river, at Kinlochewe, which falls into Loch Maree at its head. A short distance along the north-eastern shore Loch Maree receives the outflow from Lochan Fada by the Abhuinn an Fhasaigh, and, still further down, the outflow from Loch Garbhaig\* by the Amhainn na Fuirneis. At its foot Loch Maree receives the outflow from Loch Tollie on the west, and from Lochs Ghiuragarstidh and Kernsary on the north-east, and its waters are carried by the river Ewe into the head of Loch Ewe. The outflow from Loch Sguod falls into Loch Ewe on its western shore, and the outflow from Lochs Mhic' Ille Riabhaich and a' Bhaid-Luachraich on its eastern shore. Loch an t-Slagain flows into Slaggan bay at the entrance to Loch Ewe, and Loch an Draine flows into The Minch a short distance to the west of the entrance to Loch Ewe. A number of small lochs within the district now being dealt with could not be surveyed for lack of boats.

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\* The smaller Loch Garbhaig lying to the west of Loch Maree was not sounded.

The geology of this district is described by Drs. Peach and Horne, their important contribution being illustrated by a special geological map.

*Loch Maree* (see Plates XLVI. and XLVII.).—The loch derives its name from Saint Maelrubha, who in 671 A.D. left Bangor, and after founding one church at Applecross, founded another on Isle Maree. It is the largest sheet of fresh water in Scotland north of Loch Ness, and trends in a north-west and south-east direction.

On the north-east side of the loch, and parallel to it, runs a grand series of mountains—Beinn Airidh Charr, Meall Mheannidh, Beinn Lair, Slioch, Sgurr an Tuill Bhain, and Beinn a Mhuinidh; the slope for the first 1000 feet all along this north-eastern shore is very steep, in many places exceeding  $45^{\circ}$ . To the south-west rise Beinn Eighe, Beinn a Chearcaill, and Beinn an Eoin; the sharp ridge of the former, composed of white quartzite, forms an especially fine object from the loch to the north of the Gruidh. But the two most striking features of Loch Maree are Slioch and Isle Maree; the huge sugar-loaf form of Slioch is conspicuous from almost every part of the loch, and, though one of the smaller islands, Isle Maree, owing to the large number of trees growing upon it, stands out against the dark background of the heather-covered islands and the cliffs of the north-eastern shore.

The great feature of Loch Maree is the large number and great area of its islands. Prof. Penck, in his work on the Lake of Constance, lays great stress on the "insulosity," *i.e.*, "the proportion of the area of the islands to that of the water surface;" this in Loch Maree is 0.09, or three times as great as that of the Lake of Cheim (0.03), and nine times as great as that of the Lake of Constance (0.01). Its insulosity is also greater than that of any other large lake in Great Britain, that of Loch Lomond being 0.08, though it is surpassed in this respect by one of the small lochs in the Assynt district (Loch Cròcach, whose insulosity is 0.091).

Many of the islands were joined together when the Lake Survey visited the loch, owing to the low level of the water. A few small rocks and reefs occur out in the channel to the north of the main group of islands and removed some considerable distance from the rest. Large numbers of the Lesser Black-Backed Gull (*Larus fuscus*) breed on the larger islands, and two pairs and young of the Greater Black-Backed Gull (*Larus marinus*) were observed on two of the smaller islets. Isle Maree, Eilean Ghruidh, Eilean Subhainn, and Eilean Ruairid Bheag have been used at one time as fortresses or habitations.

The level of Loch Maree was found by the Ordnance Surveyors to be 32.1 feet above sea-level on September 15, 1870; on July 16, 1902, the surface of the water was 29.5 feet above sea-level. The loch was surveyed on July 16 to 24, 1902, and the water remained at very nearly



artificial dam depths of 37 and 35 feet were obtained, and these would seem to point to the fact that down to here the "river" is nothing more than an arm of the loch, with a current flowing along it to the outfall. That this place is the beginning of the river was evidently the opinion in past time, for it was here that the old iron-workers built their dam to obtain water for working "A Cheardach Ruardh" (The Red Smiddy).

The length of the loch as thus defined is  $13\frac{1}{2}$  miles, and the maximum breadth rather over 2 miles. The mean breadth is nine-tenths of a mile, being 7 per cent. of the length. Its waters cover an area of over 11 square miles, and the islands nearly 1 square mile. Loch Maree has a large shore development, *i.e.*, the length of the shore-line is much greater than the circumference of a circle whose area is equal to that of the loch. The shore development is 3.15, being greater than that of any other large loch in Scotland. The drainage area is 171 square miles, or 15 times the area of the loch.

Twelve hundred soundings were taken in Loch Maree, and the greatest depth obtained was 367 feet, in the middle of the loch to the south-west of Rudh' a' Ghuibhais; the bottom of the loch here is thus  $337\frac{1}{2}$  feet below sea-level. The volume of water is estimated at over 38,500 millions of cubic feet, and the mean depth at 125 feet (34 per cent. of the maximum depth). The breadth of the loch at the position of the deepest sounding is seven times the depth.

Loch Maree is divided into three main basins—(1) that extending from Isle Maree to the south-east end of the loch, which may be called the "Ghruididh basin;" (2) that lying to the south of the islands, which may be called the "Slattadale basin;" and (3) that extending from the north-east of Eilean Ruairid Mòr to the north-west end of the loch, which may be called the "Ardlair basin."

(1) The Ghruididh basin.—This basin is the largest and deepest of the three. The 200-foot area extends from a quarter of a mile to the east of Isle Maree to about half a mile from the south-east end of the loch, and has a length of  $6\frac{1}{4}$  miles, its average width being about three-quarters of a mile. The main 300-foot basin has a length of 2 miles and a mean breadth of about a quarter of a mile; it extends from south of Coppachy to north of milestone 3 miles from Kinlochewe. There is another smaller 300-foot area a little to the north-west of the main area. The 350-foot basin has a length of one mile and an average width of one-sixth of a mile; it extends from north of milestone 5 miles from Kinlochewe to north of milestone 4 miles from Kinlochewe.

The greatest depth is 367 feet, this depth being obtained in the middle of the loch to the south of Rudh' a' Ghuibhais. The deepest part of the loch thus lies between the two faults shown on the Geological Map, one of which cuts the loch a little to the south-east of the river Ghruididh on the south-west shore, and the other where the stream from

Lochan Fada enters the loch on the north-east shore. The deepest part of this whole basin occurs where the great mass of Slioch on the one side, and the heights of the Kinlochewe forest on the other, rise steeply up from the shore, and, as it were, compress the valley into its narrowest limits.

This basin has a typical "cauldron" shape, which is brought out in the section on the map, the slope on both sides down to the 350-foot contour-line being one of  $26\frac{1}{2}^{\circ}$ ; the flat portion in the middle is about 300 yards broad at the deepest place. The slope up to the 1000-foot contour-line is one of  $24\frac{1}{2}^{\circ}$  on the north-east shore, and one of  $14^{\circ}$  on the south-west shore.

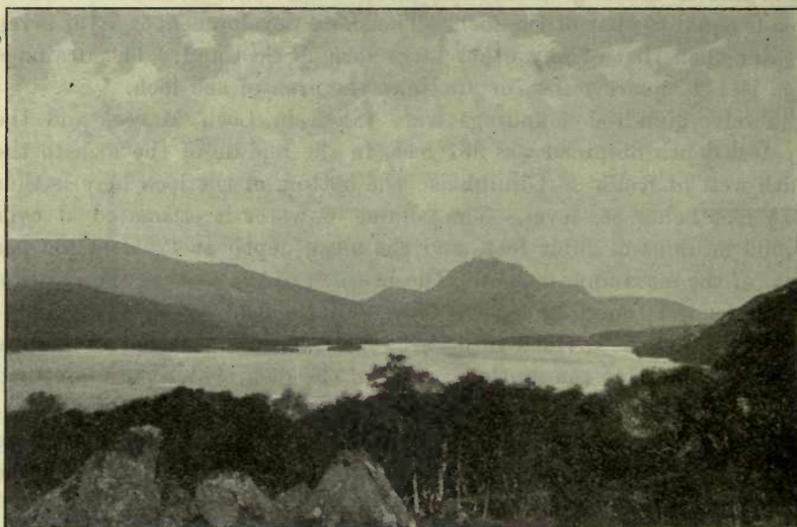


FIG. 38.—LOCH MAREE, THE ISLANDS IN THE MIDDLE DISTANCE.

(Photograph by Mr. J. A. Harvie-Brown, F.Z.S.)

It should be noted that the floor of the loch rises steeply where the second fault alluded to cuts it, that part of the loch lying to the south-east of this fault being very shallow. This feature is also seen where the same fault cuts the east end of Lochan Fada.

In Loch Maree a large number of the streams have formed very decided alluvial cones; *e.g.* the large one at the mouth of the Ghruididh river. This feature is much more marked in Loch Maree than in the majority of lochs. Other features of interest in this basin are the comparatively deep soundings in Ob nam Muc and the inlet to the south-east of this; and the curious hill on the bottom of the loch to the south of Letterewe (300 yards from the shore), the summit of which is covered by 44 feet of water.

(2) The Slattadale basin.—This basin extends from west of Eilean Ruairid Mòr to south of Eilean Subhainn. The 150-foot area has a length of 2 miles and a mean breadth of a quarter of a mile. The curve traced out by this contour to the east of the Slattadale river is very remarkable; the extension of the shallower part of the loch into the 150-foot area is in the direction of the Slattadale river, but the soundings nearer to the shore give no indication that this bank is due to the material brought down by the river. The 200-foot area extends from south of Eilean Ruairid Mòr to north of Stalla nam Manach, its length being nearly  $1\frac{1}{2}$  miles, and its average breadth about 150 yards. The greatest depth is 232 feet in the extreme north-west of the basin. In a line with the curious indentation in the 150-foot contour-line the 200-foot basin is very narrow and shallow (202 feet).

Comparatively deep soundings were obtained in all the channels extending into the islands, and it is noteworthy that the long and narrow passage between Eilean Subhainn and Garbh Eilean lies in a line with the narrow prolongation of deeper water from Rudha Chailleach into the shallow water north of the islands.

Ob na h-Innse Moire in Eilean Subhainn was cut off from the main part of the loch by a sand-bar. This was also the case with the inlet to the north-west of Ob na h-Innse Moire, but this inlet had its surface covered with weeds and boulders.

(3) The Ardlair basin.—The outline of this basin is also very irregular, and the bottom more so than in either of the other basins. The 100-foot area has a length of  $3\frac{1}{2}$  miles and a mean breadth of three-quarters of a mile. The 200-foot area has a length of  $2\frac{1}{2}$  miles and an average breadth of one-third of a mile. The length of the 250-foot basin is two-thirds of a mile and the average breadth a quarter of a mile. The greatest depth in this basin is 285 feet, occurring about 700 yards to the south-east of Rudh' Aird an Anail.

In this basin the contour-lines run very close to the north-eastern shore in the western and central parts of the basin, but spread out towards the eastern part. Again, they run very close to the shore round the western coast of Eilean Ruairid Mòr and round Rudh' Aird an Anail. They have a very sinuous outline in the eastern part of the basin.

As stated above, the floor of this basin is very irregular; several small hills rise above the general level of the bottom, as that to the south of Ardlair and that to the east of Rudh' Aird an Anail. The north-western extension of this basin, called "River Ewe," has already been noticed.

There remain for consideration the ridges between the basins and the large tract of shallow water to the north of the islands. The ridge which runs across from Eilean Ruairid Mòr to the mouth of Allt na Doire is very marked. The lowest part of the ridge is 83 feet

below the surface of Loch Maree, whilst the distance between the two 100-foot contour-lines at this place is 120 yards, and that between the two 150-foot contours is 550 yards.

The shallow water to the north of the islands is much more remarkable. A large part of this area is under 50 feet in depth, and the deepest water that occurs anywhere between Creag Tharbh and Rudha Chailleach is 79 feet, though it is along this northern channel that the great fault must run. Right in the middle of the channel, underneath Creag Tarbh, the water is only 41 feet in depth; the hills on the north shore rise steeply up to heights of over 2000 feet in places, and the slope up to the 1000-foot contour-line is at an angle of  $45^\circ$ ; hence the difference between the sub-aerial and the sub-aqueous slopes is in this place very marked. Rudha Chailleach (the witch's point) is a narrow spit of shingle stretching out to a considerable distance into the loch, with deep water close to the shore. From this point a narrow channel of deeper water projects right across the loch towards the opening between Eilean Subhainn and Garbh Eilean.

The ridge between the Slattadale and Ghruididh basins is merely a continuation of the islands. The depths on it are much less than on either of the other ridges; there is, however, a fairly deep channel, through which the steamer passes, ranging in depth from 62 feet to 28 feet; this channel is narrowest and shallowest between Isle Maree and Eilean Eachainn. To the south of Isle Maree is a large sand-flat, which in July, 1902, was covered by less than a foot of water, and on which were many boulders rising above the surface of the water.

The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 50 feet	2090 acres	29.6 per cent.
50 ,, 100 ,,	1283 ,,	18.2 ,,
100 ,, 150 ,,	1066 ,,	15.1 ,,
150 ,, 200 ,,	877 ,,	12.4 ,,
200 ,, 250 ,,	977 ,,	13.9 ,,
250 ,, 300 ,,	412 ,,	5.8 ,,
300 ,, 350 ,,	254 ,,	3.6 ,,
Over 350 ,,	99 ,,	1.4 ,,
	<u>7058</u> ,,	<u>100.0</u> ,,

It will be observed that the zone between 200 and 250 feet is larger than that between 150 and 200 feet, otherwise the areas between the contour-lines drawn in at equal intervals decrease gradually with increase of depth.

*The Small Loch on Eilean Subhainn.*—Apparently this loch has not been considered important enough to receive a name, but the fact that it had the appearance of being of some depth, whereas the other lochs on the islands on Loch Maree are overgrown with weeds or moss,

induced the Lake Survey to sound it. The trouble taken was well repaid by the curious nature of the bottom revealed by the soundings.\*

Eilean Subhainn is  $292\frac{1}{2}$  acres in area, its shore-line being very irregular. The surface of the ground is uneven, though nowhere except in the south-east corner is it very elevated; here, however, a small hill rises to a height of 84 feet above the level of Loch Maree. The greater part of the island is not more than 30 to 40 feet above Loch Maree, this rise for the most part taking place in the first 30 yards, and in some places there are vertical cliffs from 20 to 30 feet in height. In these cliffs it is seen that the island is composed of Torridon Sandstone; the rock does not appear elsewhere except around the little loch, the island being covered with peat, with a considerable number of fir trees round the shore and in the south-east corner.

The loch lies in a small hollow in the centre of the island, being situated about a quarter of a mile from the south-east shore, and one-third of a mile from the west shore of the island, and about 150 yards from the Lily Loch. Its level was determined on July 24, 1902, to be 57·4 feet above sea-level, and 27·9 feet above the surface of Loch Maree.

The loch trends in an east and west direction, and its length is a little over 250 yards; its maximum breadth is about 100 yards, and the mean breadth about 70 yards. Its waters cover an area of nearly 5 acres, and its drainage area is ten times greater, or 51 acres; the shore development is 1·62 and the insulosity 0·02. The maximum depth is 64 feet, and hence the bottom of the loch is 30 feet below the level of Loch Maree, and  $6\frac{1}{2}$  feet below sea-level. The volume of water contained in the loch is estimated at 6 millions of cubic feet, and the mean depth at  $46\frac{1}{2}$  feet.

The loch is fairly regular in outline, and has three small islands in it. The deepest part is a mere hole near the western end; on the ridge running across from the island near the north shore to the island with the tree there is only 5 feet of water, but there is a considerable depth of mud. In the eastern part of the loch depths of 12 feet were met with. Eighty-five per cent. of the total area of the loch is less than 50 feet in depth. This loch is the only one situated on an island in another loch which has been visited by the Lake Survey. It was surveyed on July 24, 1902.

*Temperature Observations.*—Many surface temperatures were taken in Loch Maree between July 16 and 24, 1902, the greatest range observed being from  $53^{\circ}\cdot3$  off Letterewe at 11 a.m. on the 21st, to  $57^{\circ}\cdot0$  at Talladale at 7 p.m. on the 22nd. The surface temperature in the south-east end of the loch was almost always higher than that in the

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\* The method of sounding out this loch is interesting: it was found impossible to transport a boat to the loch, and Mr. Garrett took soundings by hand while swimming.

north-west end, owing to the north-west winds prevailing during the time the Lake Survey was on the loch. For instance, on July 19 the temperature of the surface north-west of Rudh' Aird an Anail was  $53^{\circ}9$  at 3 p.m., and off Ardlair it was  $54^{\circ}0$  at 4 p.m., whilst at 3.15 p.m. it was  $55^{\circ}3$  to the south-east of Fhasaigh.

Five serial observations were taken on July 19 and 21, as given in the following table:—

Depth in feet.	Loch Maree, opposite Pool Crofts, July 19, 1902, 12 noon. No wind.	Loch Maree, S.W. of E. Ruairid Mòr, July 19, 1902, 6 p.m. Stiff N. breeze.	Loch Maree, opposite Letterewe, July 21, 1902, 12.45 p.m.	Loch Maree, N. of E. Ruairid Mòr, July 21, 1902, 1 p.m. Light N.W. breeze.		Loch Maree, off Rudh' a' Ghuibhais, July 21, 1902, 6 p.m. Moderate N.W. wind.
0	53.5	54.7	53.9	53.9	53.9	54.5
5	...	...	53.8	...	...	54.2
7	...	...	...	...	...	...
10	...	...	53.6	53.7	53.7	54.2
15	53.6	54.7	53.5	53.3	53.4	...
20	...	...	53.5	...	...	54.2
25	...	54.0	...	53.5	53.7	...
30	53.6	...	53.3	...		54.0
35	...	...	...	53.2	...	...
50	...	53.0	53.1	53.0	...	54.0
75	...	50.0	50.8	50.3	...	53.6
80	...	...	...	...	...	...
85	...	...	...	...	...	49.6
100	...	48.0	49.0	48.2	...	48.0
150	...	48.1	46.9	46.6	...	46.4
200	...	47.0	45.9	46.0	...	45.9
250	...	...	45.4	...	...	...
300	...	...	...	...	...	45.6
350	...	...	...	...	...	45.5

Below the surface the fall in temperature was slow down to about 50 feet, when the fall became very rapid down to 150 feet, and then slow again to the bottom. Though these are the characteristics of the three series taken on the 21st, that taken on the 19th to the south of Eilean Ruairid Mòr in the Slattadale basin does not agree with the others. In this case there was a rapid fall from 20 to 100 feet, and then a slight rise in temperature to 150 feet, and then a slow fall again to 200 feet.

The series taken to the north of Eilean Ruairid Mòr on the 21st is interesting on account of the decided inversion at 25 feet. Though these inversions of temperature have occasionally been observed, they are by no means common. In this case it was noticed that the temperature fell from  $53^{\circ}9$  at the surface to  $53^{\circ}7$  at 10 feet, and to  $53^{\circ}3$  at 15 feet, and then rose to  $53^{\circ}5$  at 25 feet, and then fell again steadily below this depth. The series down to 25 feet was repeated with the results shown in the second column under this head, which proved that the inversion, though small, was real and not due to the instrument.

*Lochan Fada* (see Plate XLVIII.).—*Lochan Fada* (*i.e.*, the long loch) is the largest of its name. It is situated about 3 miles to the north-east of the upper end of Loch Maree, and runs parallel to it for a distance of 4 miles. The scenery around *Lochan Fada* is of the most magnificent description, *Slioch* and *Beinn Lair* overlooking it on the south-west shore, and *Beinn Tharsuinn* and *A Mhaighdean* on the north-east shore. The ridge between *Lochan Fada* and *Gorm Loch Mòr* is particularly noticeable; the rise from the loch is 750 feet in 350 yards, and the top of the ridge is exactly like a knife-edge. The crags on the



FIG. 39.—LOCHAN FADA, LOOKING NORTH, SHOWING RIDGE.

(Photograph by Mr. T. N. Johnston, M.B., C.M., F.R.S.E.)

south-west shore are very bold and wild, being composed of the *Beinn Lair* sill of hornblende-schist, and extend from between *Lochan Fada* and *Loch Garbhaig* to south of *Loch Fionn*. When standing above the north-west end of the loch, the outlet to the south is not suspected; the loch appears to drain away down the continuation of the glen into *Glen Na Muic*. Doubtless at one time this was the outlet of the loch, for the col here between *Lochan Sgeireach* and *Loch Gleann na Muic* is only 13 feet above the level of *Lochan Fada*. But *Abhuinn an Fhasaigh*, having a much shorter course than *Abhuinn Gleann na Muic*, has been able to cut back much more rapidly, and perhaps all the more so since its course lies along the line of fault, which runs from

Loch Meallan an Fhudair to Loch Maree, and has tapped Lochan Fada, slightly lowering its level, thus beheading Abhuinn Gleann na Muic.

The height of the loch above sea-level was not determined by the Ordnance Survey, nor by the Lake Survey when sounded on July 25 to 28, 1902, owing to absence of bench-marks, but, judging from the spot-levels and the 1000-feet contour-line, its level must be about 1005 or 1006 feet above the sea.

The length of Lochan Fada is  $3\frac{3}{4}$  miles, and its maximum breadth nearly two-thirds of a mile; the mean breadth is over one-third of a mile. Its waters cover an area of nearly  $1\frac{1}{2}$  square miles, and it drains an area  $6\frac{1}{2}$  times greater, or over  $9\frac{1}{3}$  square miles. The maximum depth is 248 feet; this occurs in the centre of the loch off the mouth of Allt Meallan a' Chruidh. The mean depth is estimated at 102 feet, and the volume at 4091 millions of cubic feet. The breadth of the loch at the position of the deepest sounding is twelve times the depth. The shore development is 2.16, and the insulosity is *nil*; Lochan Fada, like so many of the larger lochs, has not a single island.

The bottom of Lochan Fada is very regular, the 50-foot and 100-foot areas being continuous, and extending almost from one end of the loch to the other. The main 150-foot area extends from west of Claona to the narrower part of the loch, and has a length of  $1\frac{1}{2}$  miles; there is a small 150-foot area near the south-east end of the loch. The 200-foot area extends from south-west of Claona to west of Allt na Botaig; its length is one mile, and average width 280 yards.

The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 50 feet	230 acres	25.0 per cent.
50 ,, 100 ,,	236 ,,	25.7 ,,
100 ,, 150 ,,	263 ,,	28.7 ,,
150 ,, 200 ,,	100 ,,	10.8 ,,
Over 200 ,,	90 ,,	9.8 ,,
	<u>919</u> ,,	<u>100.0</u> ,,

It is unusual to observe, on proceeding from the shore into deeper water, an increasing area between the contour-lines drawn at regular intervals, as in the case of Lochan Fada, and indicates an average steep slope near shore. A glance at the map shows that the 50-foot contour follows closely the outline of the loch, and in places approaches very close to the shore.

*Seiche*.—On July 28, beginning at 1 p.m., a well-marked seiche was observed in Lochan Fada in a sheltered bay at the south-west end of the loch; the wind was strong from the west. The amplitude was half an inch, and the period about 11.6 minutes; but this oscillation was so broken up by two other oscillations, whose periods were about  $2\frac{1}{2}$

minutes and 1 minute respectively, that the whole effect was extremely complicated, and no calculations could be made from the observations.

*Temperature Observations.*—The temperatures taken in Lochan Fada are extremely interesting, because they indicate a much lower temperature than was observed in any of the other lochs in the district at the same time of the year, as shown by the following series taken at 6.40 p.m. on July 28, 1902, to the south of Allt Meallan a' Chruidh:—

Surface ... ..	51°·1 Fahr.
10 feet ... ..	51°·1 „
20 „ ... ..	51°·1 „
50 „ ... ..	51°·0 „
75 „ ... ..	45°·8 „
100 „ ... ..	45°·0 „
150 „ ... ..	44°·3 „
220 „ ... ..	44°·1 „

This series indicates an almost constant temperature down to 50 feet, then a fall of 5°·2 between 50 and 75 feet (a fall exceeding 1°·0 per 5 feet of depth), and then a slight decrease of 1°·7 down to the bottom in 220 feet. Compared with the larger and deeper Loch Maree, the water in Lochan Fada was found to be colder at all depths than that in Loch Maree: thus the surface of Lochan Fada had a temperature about 3½° lower than was observed in the surface waters of Loch Maree a week earlier, and at the bottom of Lochan Fada, in 220 feet, the temperature was found to be about 1½° lower than at the bottom of Loch Maree in 350 feet. This is probably due to the fact that Lochan Fada is very deep, considering its area, and therefore a large volume of water has to be warmed, while only a comparatively limited area is exposed to the heating agencies.

*Loch Garbhaig* (see Plate XLVI).—Loch Garbhaig lies between Lochan Fada and Loch Maree, about half a mile from the former and 1½ miles from the latter. It drains into Loch Maree by the Amhainn na Fuirneis, which leaves the loch at its western end, and, flowing in a westerly direction, enters Loch Maree between Furness and Letterewe. The ground at the eastern end is not much elevated above the surface of the loch, the col leading over to Lochan Fada, but on the south side Slioch rises up from the shore to a height of 3200 feet, and on the north side the high ground to the east of Beinn Lair rises to over 2500 feet. The most noticeable feature of the surrounding country is its bareness. The height of the loch above the sea was not determined by levelling when surveyed on July 25, 1902, but from the contour-lines the level is probably between 1005 and 1015 feet.

Loch Garbhaig is over a mile in length, with a maximum breadth of nearly one-third of a mile, the mean breadth being one-fifth of a mile. Its waters cover an area of about 148 acres, and it drains an

area  $10\frac{1}{2}$  times greater, or nearly  $2\frac{1}{2}$  square miles. The maximum depth of 93 feet was observed about 300 yards from the eastern shore. The volume of water contained in the loch is estimated at 228 millions of cubic feet, and the mean depth at  $35\frac{1}{2}$  feet. The breadth of the loch at the position of the deepest sounding is sixteen times the depth. The shore development is 2.15, and the insulosity 0.014.

The 25-foot area is continuous, passing to the north of the large island. The 50- and 75-foot areas lie in the eastern part of the loch, though there is one sounding of 50 feet in the extreme west. The 50-foot area has a length of nearly half a mile, and extends to within 40 yards of the eastern shore, while the 75-foot area is a quarter of a mile in length. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	67 acres	45.4 per cent.
25 ,, 50 ,,	42 ,,	28.3 ,,
50 ,, 75 ,,	20 ,,	13.8 ,,
Over 75 ,,	19 ,,	12.5 ,,
	<u>148</u> ,,	<u>100.0</u> ,,

The temperature of the surface water in Loch Garbhaig at 4 p.m. on July 25, 1902, was  $54^{\circ}.9$  Fahr., or nearly  $4^{\circ}$  warmer than that observed in Lochan Fada, which lies at the same elevation; no serial temperatures were taken.

*Loch Clair* (see Plate XLIX.).—Loch Clair is situated about three miles to the south-west of Kinlochewe, at the head of Loch Maree. The ground to the north and west rises to the heights of Beinn Eighe and Sgurr Dubh, the lower ground being covered by moraines. It was surveyed on July 24, 1902, and the elevation of the water surface above the sea was determined by levelling from bench-mark as being 303.1 feet.

Loch Clair is over  $1\frac{1}{3}$  miles in length, with a maximum breadth of about 600 yards, the mean breadth being about 300 yards. Its waters cover an area of about 160 acres (a quarter of a square mile), and it drains directly an area of  $6\frac{1}{3}$  square miles, but since it receives the outflow from Loch Coulin its total drainage area is  $20\frac{1}{3}$  square miles—an area 83 times greater than that of the loch. The maximum depth is identical with that observed in Loch Garbhaig, viz., 93 feet, and occurs about 150 yards from the eastern shore off Creag na Rianaich. The volume is estimated at 287 millions of cubic feet, and the mean depth at 42 feet. The breadth of the loch at the position of the deepest sounding is sixteen times the depth. The shore development is 2.01, and the insulosity very small (0.001), there being only two small islands in the loch.

The bottom of Loch Clair is fairly regular, the deeper water being found in the wide south-eastern portion, where there is a 50-foot basin about half a mile in length, enclosing a 75-foot basin one-third of a mile in length. The 25-foot area is continuous, passing to the south of the larger island, between which and the southern shore a depth of 46 feet was found. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	58 acres	34·9 per cent.
25 „ 50 „	38 „	24·4 „
50 „ 75 „	41 „	25·9 „
Over 75 „	23 „	14·8 „
	<hr/>	<hr/>
	160 „	100·0 „
	<hr/>	<hr/>

It will be observed that the zone between 25 and 50 feet is smaller than the zone between 50 and 75 feet, indicating that the average slope is steeper in the shallower zone.

*Temperature Observations.*—A series of temperatures taken at 4 p.m. on July 24, 1902, in the deep water gave the following results:—

Surface ... ..	57°·0 Fahr.
5 feet ... ..	57°·7 „
10 „ ... ..	57°·2 „
20 „ ... ..	57°·2 „
30 „ ... ..	54°·0 „
40 „ ... ..	49°·9 „
50 „ ... ..	48°·7 „
85 „ ... ..	48°·0 „

It will be noticed that the temperature of the water between 5 and 20 feet was higher than that at the surface, the highest reading being at 5 feet. Between 20 and 30 feet a fall of 3°·2 is recorded, and between 30 and 40 feet a fall of 4°·1, a total fall of 7°·3 in 20 feet, the extreme range shown by the observations being 9°·7.

*Loch Coulin* (see Plate XLIX.).—Loch Coulin is situated 300 yards to the south-east of Loch Clair, into which it drains. Doubtless, in very recent times, they formed one loch, for the ground between them is low and alluvial. To the south-west and south-east rise Beinn Liath Mòr and Carn Breac. Loch Coulin is very much overgrown with weeds, especially in the narrow north-western portion. It was surveyed on July 24, 1902, the water surface being 304·6 feet above sea-level, or 1½ feet above the level of Loch Clair.

Loch Coulin is 1½ miles in length, with a maximum breadth of one-third of a mile, the mean breadth being about 250 yards. Its waters cover an area of 113 acres, and it drains an area 78 times greater, or 14 square miles. The maximum depth of 49 feet occurs near the centre of the broader south-eastern portion of the loch. The volume

of water is estimated at 90 million cubic feet, and the mean depth at  $18\frac{1}{4}$  feet. The breadth of the loch at the position of the deepest sounding is 31 times the depth. The shore development is 2.45, and the insulosity *nil*.

Loch Coulin is very irregular in outline, and is cut up into three basins, the north-western basin having a maximum depth of 32 feet, and the central basin a maximum of 22 feet. The main basin is confined to the broad south-eastern part of the loch, and the contour-lines approach very close to the eastern shore, off which the slope is steep. There are two isolated soundings less than 25 feet within this area, and deep water is found at the entrance of the river Coulin.



FIG. 40.—LOCH COULIN, LOOKING NORTH.

(Photograph by Mr. T. N. Johnston, M.B., C.M., F.R.S.E.)

The area covered by less than 25 feet of water is over 80 acres, or 72 per cent. of the entire area of the loch.

*Temperature Observations.*—A series of temperatures was taken in the deep part of the loch at 5 p.m. on July 24, 1902, with the following results:—

Surface	...	...	...	...	...	...	...	57°·0	Fahr.
5 feet	...	...	...	...	...	...	...	57°·0	,,
10	,,	...	...	...	...	...	...	57°·1	,,
15	,,	...	...	...	...	...	...	57°·0	,,
20	,,	...	...	...	...	...	...	55°·5	,,
30	,,	...	...	...	...	...	...	54°·8	,,
40	,,	...	...	...	...	...	...	53°·0	,,

The temperature was found to be constant from the surface to a depth of 15 feet, thence the temperature fell 4° to the bottom in 40 feet.

*Loch Tollie* (see Plate XLVII.).—Loch Tollie is situated 1¼ miles to the west of the lower end of Loch Maree, and drains into its north-western arm. The ground immediately surrounding the loch is low, though Meall Airidh Mhic Criadh to the south-west, and Creag Mhòr Thollie to the south-east, rise to over 1100 feet. The loch is roughly elliptical in outline, the major axis having an east and west direction. One of the islands near the northern shore was for some time a stronghold of the McLeods.

Loch Tollie was surveyed on July 29, 1902, the elevation of the lake-surface being 387·0 feet above sea-level; when visited by the Ordnance Survey officers on November 13, 1869, the level was found to be 387·7 feet. The water must at one time have stood at a higher level, for at the east end, where the stream leaves the loch, there are the remains of a dam (now fast disappearing), which held up the water for supplying a mill farther down the burn.

Loch Tollie is under a mile in length, with a maximum breadth of about 800 yards, the mean breadth being about 500 yards. Its waters cover an area of about 169 acres (a quarter of a square mile), and it drains an area eight times greater, or 2 square miles. The maximum depth of 86 feet was observed in the centre of the loch off the mouth of the Allt Loch Laraig. The volume of water is estimated at 244 millions of cubic feet, and the mean depth at 33 feet. The breadth of the loch at the position of the deepest sounding is 27 times the depth. The shore development is small (1·11), and the insulosity 0·002. The deeper water occurs in the western part of the loch, though the 25-feet area sends a narrow tongue into the eastern part. The 75-feet area in the centre of the loch is small, with a narrow tongue extending towards the northern shore. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	81 acres	48·0 per cent.
25 „ 50 „	43 „	25·6 „
50 „ 75 „	35 „	20·6 „
Over 75 „	10 „	5·8 „
	<hr/> <hr/> 169 „	<hr/> <hr/> 100·0 „

*Temperature Observations.*—The following series of temperatures was taken in the centre of the loch at 6 p.m. on July 29, 1902:—

Surface	...	...	...	...	...	...	...	55°·5	Fahr.
5 feet	...	...	...	...	...	...	...	55°·5	„
10	„	...	...	...	...	...	...	55°·3	„
20	„	...	...	...	...	...	...	55°·3	„
30	„	...	...	...	...	...	...	55°·2	„
50	„	...	...	...	...	...	...	55°·1	„
60	„	...	...	...	...	...	...	54°·3	„
70	„	...	...	...	...	...	...	50°·9	„

This series shows that the temperature was practically constant down to 50 feet, the fall being less than  $\frac{1}{2}^{\circ}$ , thence a fall of  $0^{\circ}\cdot 8$  between 50 and 60 feet, and then a rapid fall of  $3^{\circ}\cdot 4$  between 60 and 70 feet.

*Loch Kernsary* (see Plate XLVII.).—Loch Kernsary is situated to the north-east of Inveran, at the foot of Loch Maree, into which it drains through the little Loch Poll Uidhe a' Chrò' and the Inveran river. There was no boat passage into Poll Uidhe a' Chrò', and it was found impossible to carry the boat across. The ground around Loch Kernsary is low, except to the north, where Meall an Leathaid Dharaich rises to over 400 feet. The island near the south-western shore in the main portion of the loch is an artificial crannog, but nothing is known of its history.

Loch Kernsary was surveyed on July 25 and 26, 1902; the elevation of the water-surface above the sea was determined, by levelling from Loch Maree, as being 68·0 feet. The keeper stated that the water would rise  $2\frac{1}{2}$  feet above, and fall 1 foot below this level, but a drift-mark was observed 8·4 feet above the surface of the water.

Loch Kernsary is about  $1\frac{1}{3}$  miles in length, with a maximum breadth of nearly half a mile, the mean breadth being about 350 yards. Its waters cover an area of about 200 acres, and it drains directly an area of nearly  $7\frac{3}{4}$  square miles, but since it receives the outflow from Loch Ghiuragarstidh, its total drainage area is over  $8\frac{1}{2}$  square miles—an area  $27\frac{1}{2}$  times greater than that of the loch. The maximum depth of 93 feet was observed about 250 yards from the north-western extremity of the loch. The volume of water is estimated at 333 million cubic feet, and the mean depth at 38 feet. The breadth of the loch at the position of the deepest sounding is ten times the depth. The shore development is 2·51, and the insulosity 0·008.

The floor of Loch Kernsary is rather irregular, there being two 25-foot areas and four 50-foot areas. The main 25-foot area extends throughout the greater part of the loch, while the smaller one lies in the south-western part of the loch. Three of the 50-foot areas are enclosed by the main 25-foot area: the north-western one containing the deepest water in the loch, the central one having a maximum depth of 66 feet, and the south-eastern one a maximum depth of 69 feet, therefore falling just below sea-level; the fourth 50-foot area, based

on soundings of 51 and 53 feet, lies in the centre of the south-western part of the loch. The 75-foot area is situated in the north-western part of the loch, and sinks below sea-level, the deepest spot being 25 feet below the level of the sea.

The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	72 acres	35·8 per cent.
25 „ 50 „	69 „	34·4 „
50 „ 75 „	39 „	19·8 „
Over 75 „	20 „	10·0 „
	<hr/> <hr/> 200 „	<hr/> <hr/> 100·0 „

Thus 70 per cent. of the lake-floor is covered by less than 50 feet of water.

*Temperature Observations.*—A series of temperatures was taken in the deep part of the loch at 2.30 p.m. on July 25, 1902, with the following results:—

Surface ... ..	57°·0 Fahr.
10 feet ... ..	57°·0 „
25 „ ... ..	56°·8 „
50 „ ... ..	53°·0 „
80 „ ... ..	50°·2 „

This series shows an almost constant temperature down to 25 feet, then a rapid fall of 3°·8 between 25 and 50 feet, and a further fall of 2°·8 between 50 and 80 feet.

*Loch Ghiuragarstidh* (see Plate XLVII).—Loch Ghiuragarstidh lies about half a mile to the north of Loch Kernsary, into which it drains by the Allt Loch Ghiuragarstidh. The islands are covered by a few feet of peat and soil, and have many fir trees growing on them. The loch was surveyed on July 28, 1902; the elevation of the lake-surface was determined, by levelling from Loch Kernsary, as being 116·7 feet above mean sea-level.

Loch Ghiuragarstidh is about 1200 yards in length, with a maximum breadth of about 370 yards, the mean breadth being about 230 yards. Its waters cover an area of 58 acres, and it drains an area nearly ten times greater, or about 560 acres. The volume of water is estimated at 23 million cubic feet, and the mean depth at 9 feet. The breadth of the loch at the position of the deepest sounding is 27 times the depth. The shore development is 1·63, and the insulosity 0·028. The bottom is very irregular in the southern half of the loch, large boulders and reefs rising above the surface of the water in many places. In the northern half the lake-floor is more regular, and it is only in this part that the depth exceeds 10 feet, the maximum depth of 37 feet having been

observed in the centre of the loch near the northern end. The area of the lake-floor covered by less than 25 feet of water is about 56 acres, or 96 per cent. of the total area.

*Temperature Observations.*—Temperatures taken at 5 p.m. on July 28, 1902, in the deep part of the loch gave the following results:—

Surface ... ..	57°·5 Fahr.
5 feet ... ..	57°·5 „
7 „ ... ..	57°·5 „
15 „ ... ..	57°·1 „
25 „ ... ..	56°·0 „

*Loch a' Bhaid-Luachraich* (see Plate L.).—Loch a' Bhaid-Luachraich (or Goose Loch) lies about a mile to the east of Loch Ewe, into which it drains at Aultbea by the Allt Bheithe. It is surrounded by low, rounded hills, steep only towards the south-east, covered with peat or morainic material. It is extremely irregular in outline, and in fact may almost be looked upon as two lochs with a connecting arm. The south-western part is shallow, the maximum depth observed in it being 43 feet, while the north-eastern part is much deeper, having a maximum depth of 143 feet; the maximum depth observed in the connecting arm was 15 feet. The lower part where the stream leaves the loch is thickly overgrown with reeds and rushes, and weeds are abundant in the two bays at the head of the loch. It was surveyed on July 29 and 30, 1902, and the elevation was determined, by levelling from bench-mark, as being 309·6 feet above the sea; when levelled by the officers of the Ordnance Survey on August 3, 1870, the elevation was found to be 310·5 feet above sea-level.

Loch a' Bhaid-Luachraich is over  $1\frac{1}{2}$  miles in length, and over a mile in maximum breadth, with a mean breadth of one-third of a mile. It covers an area of half a square mile, and it drains directly an area of  $3\frac{1}{4}$  square miles, but since it receives the outflow from Loch Mhic' Ille Riabhaich its total drainage area is nearly 4 square miles—an area eight times greater than that of the loch. The volume of water is estimated at 486 million cubic feet, and the mean depth at 34 feet. The bottom in the south-western part of the loch is rather irregular, while the north-eastern part forms a simple deep basin, the maximum depth of 143 feet having been observed near the centre at the widest part of this portion. Section A-B is taken across this wide portion at the position of the deepest sounding. The areas between the consecutive contour-lines, and the percentages to the total area, are as follows:—

0 to 25 feet	184 acres	56·2 per cent.
25 „ 50 „	84 „	25·5 „
50 „ 75 „	17 „	5·3 „
75 „ 100 „	17 „	5·0 „
Over 100 „	26 „	8·0 „
	<hr/> 328 „ <hr/>	<hr/> 100·0 „ <hr/>

These figures indicate that the average slope is gentle in the shallower water, and much steeper in depths exceeding 50 feet, but it will be observed from the map that the contour-lines approach very close to the shores in certain places, indicating a steep slope in these positions.

*Temperature Observations.*—The surface temperature at 11.45 a.m. on July 29, 1902, was  $56^{\circ}1$ , and at 4 p.m. on July 30, when the following series was taken, it was more than half a degree lower:—

Surface ...	...	...	...	...	...	...	...	$55^{\circ}4$ Fahr.
10 feet ...	...	...	...	...	...	...	...	$55^{\circ}4$ „
20 „ ...	...	...	...	...	...	...	...	$55^{\circ}4$ „
30 „ ...	...	...	...	...	...	...	...	$55^{\circ}4$ „
50 „ ...	...	...	...	...	...	...	...	$53^{\circ}6$ „
75 „ ...	...	...	...	...	...	...	...	$49^{\circ}8$ „
85 „ ...	...	...	...	...	...	...	...	$48^{\circ}4$ „
120 „ ...	...	...	...	...	...	...	...	$47^{\circ}2$ „

This series shows a constant temperature from the surface down to 30 feet, then a slight fall of  $1^{\circ}8$  between 30 and 50 feet, followed by a rapid fall of  $5^{\circ}2$  between 50 and 85 feet, thence to the bottom a slight fall of  $1^{\circ}2$ , the total range of temperature from surface to bottom being  $8^{\circ}2$ .

*Loch Mhic' Ille Riabhaich* (see Plate L.).—Loch Mhic' Ille Riabhaich is a small, irregular, shallow loch lying to the south-east of Loch a' Bhaid-Luachraich (into which it flows by the Allt na Criche), surrounded by low, rounded hills; on one of the islands is a fortress, but nothing seems to be known of its history. It was surveyed on July 31, 1902, but its elevation above the sea could not be determined; from the contour-lines on the Ordnance Survey maps it is apparently rather less than 600 feet above the sea. It is half a mile in length from north to south, and rather less in maximum breadth from south-east to north-west. It covers an area of about 36 acres, and drains an area of nearly three-quarters of a square mile. Two soundings of 12 feet were taken near the north end at the outflow, and a sounding of 10 feet off the eastern shore of the larger island; with these exceptions, the lake-floor is covered by less than 10 feet of water. The volume is estimated at 8 million cubic feet, and the mean depth at  $5\frac{1}{2}$  feet.

The temperature of the surface water at 12.30 p.m. on July 31, 1902, was  $57^{\circ}0$  Fahr.

Loch nan Dailthean (or na Daline), lying to the south-west of Loch Mhic' Ille Riabhaich, and flowing into Loch Thuirnaig (an inlet of Loch Ewe), was visited by the Lake Survey, but not sounded. It is said to be so shallow that cows may walk over the whole of it, except a small hole near Thuirnaig House, in which the depth is 4 feet.

*Loch an t-Slagain* (see Plate L.).—Loch an t-Slagain lies to the east of Slaggan bay, at the entrance to Loch Ewe, into which it flows by the Allt an t-Slagain. It is surrounded by low hills, and receives the outflow from several small lochs lying to the east and south. It was surveyed on August 11, 1902; the elevation above the sea was determined by levelling to be 103·5 feet; when visited by the officers of the Ordnance Survey on May 5, 1875, its elevation was 102·6 feet above sea-level. The height of the highest drift-mark observed was 2·3 feet above the surface of the water on August 11, 1902, so that the range of level is probably between 3 and 4 feet. The loch trends in a north-west and south-east direction, and is two-thirds of a mile in length by one-third of a mile in maximum breadth. Its waters cover an area of about 77 acres, and it drains an area 17 times greater, or over 2 square miles. The maximum depth of 55 feet was observed comparatively very near the south-eastern shore. The volume of water is estimated at 55 million cubic feet, and the mean depth at 16½ feet.

Loch an t-Slagain is of simple conformation, the 10-feet area being continuous from end to end, but the deeper water is cut into two portions by the shallower water around the central islands. To the north-west of the islands two soundings of 25 feet were recorded, while the deepest part of the loch lies to the south-east of the islands. The areas between the consecutive contour-lines, and the percentages to the total area, are as follows:—

0 to 10 feet	27 acres	35·3 per cent.
10 „ 25 „	39 „	50·6 „
25 „ 50 „	8 „	10·6 „
Over 50 „	3 „	3·5 „
	<hr/> <u>77</u> „	<hr/> <u>100·0</u> „

Thus 86 per cent. of the lake-floor is covered by less than 25 feet of water, and the major portion is covered by water between 10 and 25 feet in depth.

*Loch Sguod* (see Plate L.).—Loch Sguod lies less than half a mile from the western shore of Loch Ewe (opposite the Isle of Ewe), into which it flows by the Uidh Chrò. It drains the higher ground to the west and south-west by several streams flowing through the low peat bogs which surround the loch on all sides. It was surveyed on August 15, 1902, but its elevation above the sea could not be determined; the water may rise 2 feet above its level on the date mentioned. Loch Sguod is nearly three-quarters of a mile in length, with a maximum breadth of nearly half a mile, the mean breadth being a quarter of a mile. Its waters cover an area of about 107 acres, and it drains an area 26 times greater, or 4½ square miles. The maximum depth of

14 feet was recorded towards the eastern shore. The volume of water is estimated at 32 million cubic feet, and the mean depth at 7 feet, or half the maximum depth. The loch is quite simple in conformation, but the deeper water is confined to the central and north-eastern parts of the loch, approaching very close to the eastern shore, off which the slope is steep. The area of the lake-floor covered by less than 10 feet of water is about 78 acres, or 73 per cent. of the total area. The temperature of the surface water at 9 a.m. on August 15, 1902, was 57°·2 Fahr.

*Loch an Drainc* (see Plate L.).—Loch an Drainc (or an Druing) lies to the north-west of Loch Sguod, and flows through Loch nan Eun (which was not sounded) and the Abhuinn Leumnach into The Minch, about 2½ miles to the west of the entrance to Loch Ewe. The ground around the loch is mostly covered with peat, and to the east are low but steep knolls 200 to 300 feet in height, dotted over with small and beautiful lochs, while to the west and south there is a fairly steep ascent to Maol Breac, An Cuaidh, and Bac an Lethchoin (over 900 feet), the sides of which are well wooded. It was surveyed on August 16, 1902, but the elevation above the sea could not be determined; the water may rise 2 to 3 feet above its level on this date. Loch an Drainc trends north-north-west and south-south-east, and is nearly three-quarters of a mile in length, with a maximum breadth of over one-third of a mile, the mean breadth being nearly a quarter of a mile. Its waters cover an area of about 96 acres, and it drains an area 22 times greater, or nearly 3½ square miles. The maximum depth of 55 feet is approximately centrally placed, but nearer the western than the eastern shore. The volume of water is estimated at 108 million cubic feet, and the mean depth at 26 feet, or nearly half the maximum depth. The loch forms a simple basin, and, considering its area, is comparatively deep, the 25-foot area being over half a mile, and the 50-foot area one-fifth of a mile, in length. The areas between the consecutive contour-lines, and the percentages to the total area, are as follows:—

0 to 25 feet	47 acres	48·9 per cent.
25 „ 50 „	45 „	47·2 „
Over 50 „	4 „	3·9 „
	<hr style="width: 100%; border: none; border-top: 1px solid black; margin: 0;"/> 96 „	<hr style="width: 100%; border: none; border-top: 1px solid black; margin: 0;"/> 100·0 „

Temperatures taken at 3 p.m. on August 16, 1902, gave 59°·0 at the surface, and 58°·0 at a depth of 40 feet.

*Deposits.*—The deposits from certain parts of Loch an Drainc, as well as of Loch Sguod, were of a strikingly pink colour, and a sample from a depth of 20 feet in Loch an Drainc was found to be coherent

## SUMMARY TABLE.

Giving Details concerning the Lochs in the Ewe Basin.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.		
				Max.	Mean.		Max. feet.	Mean. feet.	Mean percent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.	
Maree	29.5	1196	13.46	2.16	0.89	6.6	367	125.3	34.1	194	567	38,539	11.03	171.66	15.4	
Loch on Eilean Subhainn	57.4	10	0.18	0.06	0.04	22.2	64	29.7	46.4	15	32	6	0.01	0.80	80.0	
Lochan Fada	[1005]	227	3.74	0.62	0.38	10.2	248	102.2	42.2	80	193	4,091	1.44	9.37	6.5	
Garbhaig	[1010]	82	1.18	0.30	0.19	16.1	93	35.4	38.1	67	176	228	0.23	2.41	10.5	
Clair	303.1	100	1.38	0.34	0.18	13.0	93	42.1	45.3	78	173	287	0.24	20.39	83.2	
Coulin	304.6	120	1.33	0.34	0.14	10.5	49	18.3	37.3	143	384	90	0.18	14.07	78.1	
Tollie	387.0	101	0.90	0.44	0.29	32.2	86	33.1	38.4	55	143	244	0.26	2.00	7.7	
Kernsary	68.9	148	1.35	0.40	0.23	17.0	93	38.2	41.0	77	187	333	0.31	8.56	27.6	
Ghuraigarstidh	116.7	68	0.68	0.21	0.13	19.1	37	9.1	24.5	97	396	23	0.09	0.87	9.7	
a' Bhaid-Luachraich	309.6	217	1.57	1.10	0.33	20.8	143	34.0	23.8	58	244	486	0.51	3.91	7.7	
Mhic' Ille Riabhaich	[less than 600]	34	0.49	0.46	0.11	22.4	12	5.3	44.6	216	483	8	0.06	0.67	11.2	
an t-Slagain	103.5	64	0.65	0.30	0.18	27.7	55	16.4	29.9	62	209	55	0.12	2.04	17.0	
Sguod	...	48	0.72	0.44	0.24	33.3	14	6.9	49.4	271	550	32	0.17	4.47	26.3	
an Drainc	...	58	0.72	0.36	0.21	29.2	55	25.9	47.0	69	147	108	0.15	3.43	22.9	
		2473										44,530	14.80	185.51*		12.5

\* The drainage area of Loch Maree includes those of Lochan Fada, Lochs Garbhaig, Clair, Coulin, Tollie, Kernsary, and Ghuraigarstidh; and that of Loch a' Bhaid-Luachraich includes that of Loch Mhic Ille Riabhaich.

when dry, and when wet plastic and creamy, not unlike cocoa and milk of a pink brown colour. The material is made up of probably 90 per cent. of clayey matter with minute mineral particles less than 0.05 mm. in diameter, the remaining 10 per cent. consisting of mineral particles with a mean diameter of 0.15 mm. Quartz is the principal mineral species, but small grains of pink microcline-felspar are very abundant, and it is apparently to this mineral that the pink colour of the deposit is due; the microcline shows cross-hatching, and is much kaolinized. The washed mineral grains have a decided pink tinge, which is, however, much more pronounced in the fine washings. Besides quartz and felspar, white and brown mica, hornblende, garnet, and magnetite were observed. There is little or no vegetable matter.

The particulars regarding the lochs in this basin are collected together in the table on p. 232 for convenience of reference and comparison. From this table it will be seen that in the fourteen lochs under consideration, which cover an area of nearly 15 square miles, nearly 2500 soundings were taken, or an average of 167 soundings per square mile of surface. The aggregate volume of water contained in the lochs is estimated at 44,500 millions of cubic feet, and the area draining into them is  $185\frac{1}{2}$  square miles, or  $12\frac{1}{2}$  times the area of the lochs.

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#### NOTES ON THE GEOLOGY OF THE LOCH MAREE DISTRICT.

By B. N. PEACH, LL.D., F.R.S., and J. HORNE, LL.D., F.R.S. With Geological Map (Plate LI.). Published by permission of the Director of the Geological Survey.

The Loch Maree district presents features of special geological importance relating to the subdivisions of the Archæan rocks, to the topography of the old pre-Torridonian land surface, and to the series of terrestrial movements which affected the north-west Highlands in post-Cambrian time. Throughout the mountainous region, stretching north to Dundonnell forest and south to Achnashellach and Glen Shieldaig, excellent sections are to be found showing the geological structure of that region.

The Archæan rocks ( $\mathfrak{A}$  on map), lying to the west of the great post-Cambrian displacements, occur mainly in the north-west of the area, where they form a broad tract of mountainous ground between Loch na Sheallag and Loch Maree, and westwards by Torrisdale to Gairloch. There is also an important development of them on both sides of Loch Torridon above Loch Shieldaig, and they likewise appear as inliers, surrounded by Torridon Sandstone, as, for instance, on the southern slope of Beinn Dearg north of Liathach. Within the territory affected

by the post-Cambrian movements there are masses of displaced gneiss, of which the most important lies immediately to the north of Kinlochewe; others appear further north on Mullach Coire Mhic Fhearchair, and far to the south on Glas Bheinn, on Torr na h-Iolaire, and at Coulags in Glen Carron. Over much of the region they form lofty ground and give rise to prominent peaks, as, for example, Beinn Lair (2817 feet), Beinn a' Chaisgein Mor (2802 feet), and Beinn Airidh Charr (2593 feet), all north of Loch Maree.

Throughout this area there is a remarkable development of those types of Archæan rocks that have affinities with plutonic igneous products, consisting mainly of massive and foliated, pyroxenic, hornblendic, and micaceous gneisses. Along the northern margin of this district, between Loch na Sheallag and Gruinard Bay, the original characters of the rocks that enter into the fundamental complex are well displayed. The various stages in the separation of the ferromagnesian from the quartzo-felspathic constituents, and the gradual development of mineral banding in the massive gneisses are there clearly shown. In that area, also, the intrusive character of the basic dykes traversing the gneiss in a west-north-west direction is proved beyond all doubt. Passing southwards to the tract lying south of Poolewe, both the gneisses and the intrusive dykes have been thrown into an anticlinal fold, which is represented on the Geological Survey Map (Sheet 91). Here we find that, under the influence of mechanical stresses, there has been differential movement of the rock constituents, and linear foliation has been developed in the basic dykes—the foliation being parallel with the pitch of the folds. Further south in the Torridon district biotite gneisses prevail, which are traversed by bands of hornblende-schist representing the original basic dykes.

Of special interest is the development of crystalline schists, that have affinities with rocks of sedimentary origin, north of Loch Maree and near Gairloch. The prominent members of this series are quartz-schists, mica-schists, graphitic-schists, limestones, and dolomites, with tremolite, garnet, and epidote, which are there associated with a massive intrusive sheet of hornblende-schist. Lithologically some of these crystalline schists closely resemble the altered sediments in the Eastern Highlands. The quartz-schists, mica-schists, and limestones are well exposed in various folds between Letterewe and Glen Tulacha, west of Lochan Fada, pierced by the great sill of hornblende-schist forming Beinn Lair and Beinn Airidh Charr (B<sup>c</sup> on map). The original relations of these altered sediments to the gneisses that have affinities with plutonic igneous rocks have been obscured by subsequent earth stresses. But along their outer margin they are bounded by gneiss apparently underlying them, and they are visibly overlain by gneiss with basic dykes, the whole series being affected by a common system of folds.

One of the most remarkable geological features of the Loch Maree district is the evidence relating to the topography of the primeval land surface on which the Torridonian sediments were laid down. Between the head of Loch Maree and Strath na Sheallag, where the overlying red sandstone has been partly removed by denudation, it is possible to trace the direction of the old valleys and the orientation of the ancient peaks. On the eastern slope of Ben Slioch, near Glen Fhasaigh, the observer may climb one of these hills, which rises to a height of about 2000 feet in the midst of the Torridon Sandstone, and trace the alternation of breccia and sandstone filling the ancient valley. Similar evidence is obtained further north in the mountainous region near the head of Glen na Muic. Where these deeply-eroded valleys are preserved, breccias of local origin frequently appear at the base of the Torridon Sandstone. In the Loch Maree district this formation has been subdivided into three groups: a lower, consisting of epidotic grits, dark and grey shales, with calcareous bands and red sandstones; a middle, composed of a great thickness of false-bedded grits and sandstones with scattered pebbles; an upper, comprising chocolate-coloured sandstones, micaceous flags, with dark shales and calcareous bands. The members of the lower group are well displayed in the district near Talladale and Slattadale, on the south-west shore of Loch Maree; those of the middle group are typically developed in the mountains round Loch Torridon, from which district this system takes its name, while the upper group appears in the islands north of Gruinard. Throughout this region this formation (*t* on map) reaches a vast thickness, for on the shores of Loch Torridon it rises on Liathach from the sea-level to a height of over 3000 feet. In the mountains between Slioch and An Teallach these sandstones have a gentle dip towards the south-east; in the Torridon district they are nearly horizontal, while further south they form a low arch.

As indicated in our previous notes on the geology of the Assynt district, the Torridon Sandstone is separated from the overlying quartzites by an unconformability, which in some parts of the Loch Maree area is not so prominent as in Assynt. On An Teallach in the Dundonnell forest and southwards towards Mullach Coire Mhic Fhearchair, the Cambrian quartzites are inclined at a higher angle to the south-east than the Torridon Sandstone. In the area lying to the west of the post-Cambrian displacements we find at various localities the normal Cambrian sequence in ascending order—1, the basal quartzites (*a*<sup>1</sup> on map); 2, the pipe-rock (*a*<sup>2</sup>); 3, the Fucoïd beds (*a*<sup>3</sup>). This sequence is displayed in the Dundonnell forest, on the western slope of Ben a' Vuinie near Kinlochewe, on the west declivity of Meall a' Ghuibhais south of Loch Maree, and on Beinn Eighe. Within these limits the Fucoïd beds have yielded at several localities well-preserved trilobites and other organic remains of Lower Cambrian age. The

Cambrian limestone rarely appears in the undisturbed area; in the displaced masses west of Glas Bheinn towards the head of Loch Kishorn it is largely represented.

The evidence bearing on the post-Cambrian movements obtained in the Loch Maree district is of special interest. On referring to the map, it will be seen that the belt affected by these movements runs southwards from Dundonnell by Kinlochewe, Beinn Eighe, and the Coulin forest to Glen Carron and Loch Kishorn. Throughout this area the geological structure is extremely complicated, but certain sections may be referred to as illustrating the continual variation in the relations of the rocks. The simplest type is met with in the Dundonnell forest, where on the west slope of Creag Rainich there are two powerful thrusts running parallel with each other for some distance in a north-north-east and south-south-west direction. West of these lines of displacement the Cambrian sequence is undisturbed from the basal quartzites to the Fucoid beds. On the horizon of the latter the first powerful thrust is met with, which brings forward a slice of Torridon Sandstone with a core of Archæan gneiss. Not far to the east the second thrust supervenes, which ushers in the crystalline schists overlying the Moine thrust-plane. A repetition of this structure in a more complicated form is found in the tract between Glen Fhasaigh and the heights of Kinlochewe, where the mass of displaced gneiss with its intrusive dykes is admirably displayed between the Moine thrust to the east and the outcrop of the Kishorn and Kinlochewe thrust-plane west of Ben a' Vuinie.

In the region stretching south from the head of Loch Maree by Beinn Eighe and the Coulin and Achnashellach forests to Loch Kishorn the structure is more complicated. For to the west of the two great lines of displacement just referred to, which have been traced south to Loch Kishorn and Glen Carron, the Torridon Sandstone and Cambrian strata have been repeated by a series of inverted folds and minor thrusts. Hence we find strips of Cambrian quartzite alternating with Torridon Sandstone, the strata having a general dip towards the south-east as if they formed part of a normal ascending sequence. The clear sections, however, on Beinn Eighe, on Sgurr Dubh, Beinn Liath Mhor, Sgurr Ruadh, and other peaks, show the overfolding and reversed faults which are the prominent features of the structure of that region. Still further south, towards the head of Loch Kishorn, and west of the slice of Archæan gneiss overlying the Kishorn thrust-plane, there is a constant repetition of the Fucoid beds and Cambrian limestone by inverted folds and reversed faults.

In the Loch Maree district, as in Assynt, there is evidence of the development of new structures resulting from the post-Cambrian movements. The deformation of the Torridon Sandstone, west of the Moine thrust, is well displayed in the stream south of the Kinlochewe

Hotel, where the grits have been made schistose, and where the felspars have been partially broken down and reconstructed. Near the outcrop of the Kishorn thrust, west of Glen Carron, the Lewisian gneiss is sheared and rolled out, passing into flaser gneiss and schist with a platy or fluxion structure.

East of the Moine thrust, which runs south from Dundonnell by Loch an Nid, the heights of Kinlochewe, and Loch Coulin to Glen Carron, the area represented on the map is occupied by crystalline schists of a remarkably uniform type. They consist mainly of flaggy granulitic quartzose schists and mica-schists, with prominent belts of garnetiferous muscovite-biotite schists. The latter are well developed on Fionn Bheinn, north of Achnasheen, and on Sgurr Mor Fannich, where they form conspicuous crags. Near the Moine thrust, and, indeed, for some miles to the east of the plane of that thrust, the Eastern or Moine schists have a persistent dip to the south-east. In the Fannich mountains they are over-folded on a stupendous scale, and similar evidence is obtained in the group of mountains north of Achnasheen.

Reference must now be made to the faults that affected the area after the post-Cambrian thrusts. Of these by far the most important is the great line of displacement that crosses the region in a north-west and south-east direction, coinciding with the long axis of Loch Maree, which may be termed the Loch Maree fault. It has been traced in a north-west direction along the river Ewe, by the south margin of Loch Ewe, towards Loch an Drainc, where the Torridon Sandstone on the north-east side is faulted down against the Lewisian gneiss at Poolewe. At Kinlochewe this dislocation has been traced up Glen Dochartie and onwards in the direction of Ledgown. Indeed, the probable continuation of this fault has been recently found far to the south-east—in the basin of the Conon. Where the line of fault is not obscured by drift, it gives rise to a prominent feature on the surface of the ground. This powerful fault shifts the outcrops of the Moine and Kishorn thrust-planes, and likewise of the overfolded strata associated with these thrusts. It further shifts the outcrop of the normal fault in Glen Fhasaigh, which runs in a north-east direction between the head of Loch Maree and Lochan Fada (see map). The continuation of the Fhasaigh fault is to be found in Glen Grudie, on the south side of Loch Maree, so that its outcrop is shifted at least for a distance of two miles by the Loch Maree dislocation.

In the north-west part of the area, in Isle Ewe, and in the promontory between Loch Ewe and Gruinard Bay, there is a strip of Triassic Sandstone (*f* on map) thrown down by two powerful faults.

Throughout the Loch Maree district, and especially in the mountainous region embracing the Torridon Sandstone and the Cambrian quartzite, there is evidence of intense glaciation. During the climax

of the glacial period, even the highest mountains in the Loch Maree district were overridden by the ice. Some of the evidence pointing to this conclusion may here be referred to. Along the top of Ben Slioch (3217 feet), which, as already indicated, is composed of Torridon Sandstone, blocks of thrust Archæan gneiss, Cambrian quartzite, and Moine schists are met with, all of which have been derived from the east. Similar evidence is obtained on Meall Ghuibhais (2882 feet), on the south side of Loch Maree. Again, in the Coulin forest, on the lofty ridge running south from Sgurr Dubh (2566 feet) to Beinn Liath Mhor (3034 feet), striæ have been recorded pointing in a westerly direction at elevations ranging from 1750 to 2000 feet. Blocks of crystalline schist derived from the area east of the Moine thrust, and occasional fragments of thrust Archæan gneiss, appear on this ridge. Further south on Sgurr Ruadh, ice-markings pointing a few degrees to the north of west occur at an elevation of 2500 feet. The top of Ruadh Stac (2919 feet), on the east side of Glen Kishorn, is finely glaciated, the striæ pointing W.  $25^{\circ}$  N. The summit of Meall a' Chinn Dearg (3095 feet), composed chiefly of Torridon Sandstones and grits, is strewn with transported blocks of Cambrian quartzite. Similar evidence might be adduced regarding that part of the Applecross area which is shown in the south-west corner of the map. For there, on Beinn Bhan (2936 feet), striæ have been recorded underneath the 2750 feet contour-line trending W.  $13^{\circ}$  to  $20^{\circ}$  N. Blocks of the Eastern or Moine schists appear at that level, and are fairly plentiful below 2500 feet. From these facts the inference seems obvious that during the maximum glaciation the western part of Ross-shire must have been completely overridden by ice moving in a westerly direction towards the sea.

The westerly flow of the ice is confirmed by the transport of the boulders in the drift deposits, which consist mainly of moraines in the area lying to the west of the Moine schists, and these contain numerous blocks of quartzose-schist and mica-schist derived from the east.

After the disappearance of the great ice-sheet there ensued a period of confluent valley glaciers. The direction of the ice-flow during this later glaciation is represented on the map by feathered arrows. On referring to the map, it will be seen that the prominent mountain groups north and south of Loch Maree formed independent centres of glaciation. In many of the valleys there is a splendid development of both lateral and terminal moraines. The closing phases of the glaciation of the region are indicated by the moraines encircling some of the high corries, and by similar deposits resting on the 50-foot beach at the head of Loch Torridon, where they have been recorded by our colleague, Mr. Hinxman.

A glance at the map will show that Loch Maree is by far the largest rock basin in that district; but as it lies along the line of a powerful fault, which has given rise to a prominent feature in the topography

of the region, we prefer not to discuss its features in connection with the theory of the glacial origin of lake basins.

*Lochan Fada* is a simple rock basin resting partly on Torridon Sandstone and partly on Lewisian gneiss. Along the greater part of its course it coincides with an old pre-Torridonian valley, trending in a west-north-west direction. At its eastern end it is bounded by the continuation of the Glen Fhasaigh fault, which brings down the Cambrian quartzite, Fucoid beds, Serpulite grit, limestone, and overlying Archæan gneiss above the Glen Logan or Kishorn thrust-plane. The sudden deepening of the loch at its lower end is evidently related to this fault, because harder and more durable strata on the east side of this fault have been brought against the softer Torridon Sandstone to the west. It is important to note that the downthrow side of this fault is towards the east; in other words, the eastern floor of Lochan Fada is not faulted down to the west. It is interesting to note that the deepest part of the basin, and the deepest sounding (248 feet), lie between Slioch and Ben Tarsuinn, where the erosion of the ice during the maximum glaciation would probably be greatest.

*Loch Garbhaig*, which is situated to the north of Ben Slioch, is a small lake over a mile in length, and evidently a rock basin from the appearance of Lewisian gneiss at its exit, where it is drained by the Amhainn na Fuirneis. The soundings prove the existence of two basins separated by a ridge, the eastern one reaching a depth of 93 feet, and the western 50 feet close to its outlet. This lake lies mainly along the junction of the Archæan rocks and Torridon Sandstone, the older rocks forming the greater part of the north shore, and the red sandstone the larger part of the south margin. A tongue of Torridon breccia occupies a hollow in the Archæan rocks on the north shore, where it rests on a mass of hornblende-schist. This breccia appears in an island in the loch, which forms part of the ridge separating the two basins. The loch may therefore be regarded as a rock basin eroded by ice, mainly out of Torridon Sandstone along its line of junction with the Archæan floor.

*Loch Kernsary* is very irregular in shape, and has four basins below the 50-foot level, the deepest sounding—93 feet—being found near its north-west extremity. The Archæan gneiss forms part of its north-east shore, while the Torridonian rocks floor the remaining portions, save near the west limit of the north shore, where a boss of Lewisian gneiss projects through the Torridon Sandstone. As the Torridon sandstones and conglomerates dip at angles varying from  $20^{\circ}$  to  $35^{\circ}$  to the north-west, we may infer that those sediments are resting on a very uneven floor of gneiss. The bed of the lake, therefore, may here correspond with the pre-Torridonian surface, the softer Torridon Sandstone being more easily removed than the more durable gneiss. Striæ pointing in a north-west direction are found round the lake, the trend of which is

slightly oblique to the long axis of the loch, but almost parallel to that of the 50-foot basins. The latter in turn have their longer axes somewhat oblique to the strike of the Torridonian strata.

*Loch Ghiuragarstidh* is a shallow loch lying along the strike of the Torridon Sandstone, with an exposure of Lewisian gneiss near its outlet, its greatest depth being 37 feet. A long ridge of sand and gravel, probably a moraine, occurs near its mouth, so that this lake may lie partly in drift and partly in rock.

*Loch Tollie* is a true rock basin of very irregular shape, surrounded by Lewisian gneiss, the deepest sounding being 86 feet. This basin belongs to the shallow plateau type so common in the Archæan area in the west of Sutherland. Its irregularity is due to the folding and intense shearing of the component members of the Lewisian gneiss in that region. Glacial striæ are met with at several localities round the loch, varying in direction from W.  $10^{\circ}$  N. to W.  $41^{\circ}$  N. The dominant strike of the foliation of the gneiss is west-north-west and east-south-east. The long axes of the bays in the loch are more in accordance with the direction of the ice-flow than with the strike of the foliation.

*Loch Clair* lies partly in moraine drift and partly in thrust Torridonian strata. Drift occurs at the outlet and along its western margin, and all the islands are composed of moraines.

*Loch Coulin* is separated from Loch Clair by an alluvial fan brought down by the Allt na Luib. The river Coulin has silted up the greater part of the upper end of the lake, and its limits have been still further restricted by detritus borne downwards by the streams on the north.

## LOCHS OF THE SHIEL BASIN.

ONLY two lochs belonging to this basin were sounded, viz., Lochs Shiel and Dilate; one or two other small lochs within the basin (the principal one being Lochan Dubh, at the head of Glen Hurich) were not sounded.

*Loch Shiel* (see Plates LII. and LIII.).—Loch Shiel is one of the larger Scottish fresh-water lochs, having a total length of  $17\frac{1}{2}$  miles. In this respect it is inferior only to Lochs Awe, Ness, and Lomond, which are  $25\frac{1}{2}$ ,  $24\frac{1}{4}$ , and  $22\frac{1}{2}$  miles in length respectively, and is closely followed by Loch Shin, which is  $17\frac{1}{4}$  miles in length. Its elevation above the sea is only  $11\frac{1}{2}$  feet, so that a slight subsidence of the strip of land through which the river Shiel flows would convert it into an arm of the sea. Seals occasionally make their way into this loch from the sea at the present time. The principal upper portion of the loch trends in a north-east and south-west direction, but about 6 miles above the outflow there is a bend in the outline of the loch, and the lower portion trends almost due west. The river Shiel follows a north-westerly course for about 2 miles before emptying itself into Loch Moidart. The scenery around the loch is very fine, becoming grand and wild towards the head. At the foot of the loch the surrounding ground is low, but on proceeding up the loch mountainous country borders the loch on both sides, culminating in heights exceeding 3000 feet at the head of Glen Finnan. To the south rises Ben Resipol (2774 feet), between Loch Shiel and Loch Sunart; to the east Sgor an Tarinachain (2474 feet), Meall Mor (2487 feet), Meall nan Creag Leac (2474 feet), Glas Garbh (2369 feet), Meall Doire na Mnatha (2094 feet); to the north Beinn nan Tom (2603 feet), Streap (2988 feet), Sgor Choileam (3164 feet), Sgor nan Coireachan (3133 feet), Fraoch-bheinn (2489 feet); to the west Beinn Odhar (2895 feet), Druim Fiaclach (2851 feet), a' Chroit-bheinn (2178 feet), and Beinn Gaire (2179 feet). The principal feeders are the river Finnan, Amhainn Shlatach, and Callop river, which enter the loch at its head, Glenaladale river entering about 6 miles down on the north-western shore, and the river Polloch (bearing the outflow from Loch Dilate) entering about 11 miles down on the south-eastern shore, where the bend in the trend of the loch occurs. There are

numerous small islands and a few larger ones, the largest being Eilean Gleann Fhionainn at the head of the loch, while on Eilean Fhianain, at the narrows towards the foot of the loch, are the remains of St. Finnan's Church and a romantic burying-place of the Clanranald. At the head of the loch stands Prince Charlie's monument, erected by the late Colonel Macdonald, of Glenaladale, on the spot where that ill-fated prince raised his standard. Salmon, grilse, sea-trout, and brown trout abound in the loch, and yield fair sport, some of the salmon and trout being very heavy.

Considering its great length, Loch Shiel is very narrow, for at no place does the loch attain a width of a mile, the maximum breadth being about nine-tenths of a mile, and this occurs at the great bend in the outline of the loch, opposite the entrance of the river Polloch. The mean breadth of the loch is less than half a mile, being only  $2\frac{1}{2}$  per cent. of the length—a smaller percentage than has been observed in any of the larger lochs surveyed by the Lake Survey, the lochs most nearly approaching it in this respect being Loch Shin with 3 per cent., and Loch Ness with 4.3 per cent. The waters of Loch Shiel cover an area of about 4840 acres, or over  $7\frac{1}{2}$  square miles, and it drains directly an area of over  $72\frac{1}{2}$  square miles, but, since it receives the outflow from Loch Dilate, its total drainage area is about  $85\frac{1}{2}$  square miles—an area over eleven times greater than that of the loch. Over 700 soundings were taken, the maximum depth recorded being 420 feet, about 4 miles from the head of the loch, between the heights of Beinn a' Chaoruinn and Beinn Odhar Bheag to the north-west, and of Meall nan Creag Leac to the south-east. The volume of water contained in the loch is estimated at 27,986 million cubic feet, and the mean depth at  $132\frac{3}{4}$  feet, or nearly 32 per cent. of the maximum depth. Loch Shiel was surveyed on July 2 to 9, 1902. The elevation of the lake-surface above the sea was determined, by levelling from bench-mark, as being 11.4 feet; when levelled by the officers of the Ordnance Survey on November 6, 1897, the elevation was found to be 12 feet above sea-level. The water may rise 4 to 5 feet higher than the level given above.

The floor of Loch Shiel is on the whole rather irregular. The 50-foot contour-line encloses a continuous area extending from close to the upper end to within 2 miles from the lower end at Acharacle, but all the deeper contours are broken up so as to enclose two or more isolated areas. The 50-foot contour follows approximately the general outline of the loch, but it is in places of a sinuous character. At the head of the loch it extends both to the north-west and south-east of Eilean Ghleann Fhionainn. About 2 miles down there are sinuosities in the contour on both sides of the loch, due to a tongue of deep water projecting between the south-eastern shore and the island Sgeir Ghiubhsachain, and to a shoaling of the water off the north-western shore from 33 to 15 feet. Further down, off the north-western shore, above

the entrance of the Glenaladale river, there is a twist in the 50-foot contour, where the water shoals from 55 to 20 feet. Still further down, opposite the entrance of the Allt na Dalach, sinuosities in the 50-foot contour occur on both sides of the loch, the water shoaling off the south-eastern shore from 47 to 35 feet, and off the north-western shore from 41 to 19 and 22 feet. The last-mentioned shoaling occurs to the north-east of Eileanan Comhlach, at the entrance of the Allt a' Ghiubhais, and it is curious to observe a similar shoaling on the opposite (south-west) side of the island from 41 to 18 and 21 feet, while between the island and the mouth of the stream a depth of 32 feet was observed.



FIG. 41.—LOCH SHIEL, FROM PRINCE CHARLIE'S MONUMENT.

(*Photograph by Mr. T. N. Johnston, M.B., C.M., F.R.S.E.*)

Towards the lower end of the wide part of the loch, and almost due south of Eilean Druim nan Laogh (or Heron island, as it is now called in the district), there is, near the middle of the loch, a shoal covered by only 2 or 3 feet of water. During the visit of the Lake Survey the regular mail steamer was laid up for repairs, having shortly before struck on this shoal and damaged the propeller. The captain of the steamer supplied information as to the position of the shoal, and the local gillie employed by the surveyors stated that in calm weather the bottom can be seen, but in the stormy weather prevailing at the time of the survey he was unable to find it, so that it must be of very small extent, for deep soundings were recorded near the spot indicated. The

same gillie stated that a shoal bank extended from Ruadh Bac na Moine in an approximately south-west direction towards the opposite shore; this was confirmed by fishermen, and is probably indicated by the outward bend of the 50-foot contour-line at that place.

The 100-foot contour-line is less sinuous in character than the 50-foot contour, the main basin being about 12 miles in length, extending from near the head of the loch to the narrows at Eilean Fhianain, with two small subsidiary basins—one off Rudha Leathan, about  $3\frac{1}{2}$  miles from the foot of the loch, based on a sounding of 112 feet; the other between the promontory on the south-eastern shore called Rudha Torr a' Chonnaidh and the outlying islands, about 7 miles from the head of the loch, based on a sounding of 148 feet. A remarkable rise in the bottom was observed within the main 100-foot basin, about a mile above the entrance of the river Polloch, where soundings of 84 and 43 feet were taken, surrounded on all sides by about 150 feet of water. The contour of the lake-floor along this line of soundings is shown in cross-section C-D on the map (Plate LII.).

The main 200-foot basin is nearly 8 miles in length, approaching to within half a mile from the head of the loch, and extending as far down as Eileanan Comhlach. There are two small subsidiary basins, separated from the main basin by an interval of over half a mile, between the entrance of the Allt na Claise on the south-eastern shore and the entrance of the An Garbh-allt on the north-western shore. This line of soundings shows a curious configuration of the bottom, which rises in the central part of the loch and sinks again on both sides nearer the shore: thus, on proceeding from south-east to north-west the water deepens to 201 feet, then shoals to 122 feet, then deepens again to 172, 209, and 224 feet, shoaling again towards the north-western shore. It is interesting to note the close proximity of these two small deep basins to the rise covered by 43 feet of water already mentioned. The 200-foot contour shows a peculiar loop off the north-western shore, about 4 miles from the head of the loch, where the water shoals from 199 to 163 feet.

The principal 300-foot basin is distant about a mile from the head of the loch, and extends down the loch for over 4 miles, enclosing the deepest parts of the loch. Separated from this basin by an interval of a quarter of a mile (in which the greatest depth is 282 feet) is a second small basin based upon a sounding of 307 feet, and after a similar interval (in which the greatest depth is 284 feet) there is a third 300-foot basin 2 miles in length, having a maximum depth of 385 feet. Within this third basin there is a slight rise of the bottom covered by 288 feet of water; the line of soundings on which this rise is situated is shown in cross-section E-F on map (Plate LIII.).

There are two small basins with depths exceeding 400 feet, the smaller about 3 miles from the head of the loch, based on soundings

of 416 and 419 feet, separated by an interval of three-quarters of a mile (in which the greatest depth is 375 feet) from the larger, which is less than a mile in length and encloses the maximum depth of the loch (420 feet), recorded near the north-eastern end of this larger basin, and over 4 miles from the head of the loch. The line of soundings, which includes the deepest one, is shown on cross-section G-H on map (Plate LIII.).



FIG. 42.—LOCH SHIEL, FROM HIGH GROUND AT THE HEAD OF THE LOCH.

(*Photograph by Mr. David Brigham.*)

From the foregoing description, it will be noticed that in Loch Shiel the deeper water occurs towards the head of the loch. Proceeding from Acharacle, at the foot of the loch, one must row 2 miles up before encountering a depth of 50 feet; a further  $1\frac{1}{2}$  miles before meeting with a depth of 100 feet, and this merely a small patch, a further  $1\frac{1}{2}$  miles having to be traversed before reaching the main 100-foot basin, or a total distance of 5 miles from the foot of the loch. The main 200-foot basin is distant about 9 miles, the lower 300-foot basin nearly 10 miles, and the principal 400-foot basin over 12 miles, from the foot of the loch.

The areas between the consecutive contour-lines drawn at equal intervals, and the percentages to the total area of the loch, are as follows:—

0 to 100 feet	2632 acres	54·4 per cent.
100 ,, 200 ,,	968 ,,	20·0 ,,
200 ,, 300 ,,	711 ,,	14·7 ,,
300 ,, 400 ,,	484 ,,	10·0 ,,
Over 400 ,,	45 ,,	0·9 ,,
	<u>4840</u> ,,	<u>100·0</u> ,,

This table shows that more than half of the entire floor of Loch Shiel is covered by less than 100 feet of water, and about three-fourths by less than 200 feet, while only 1 per cent. is covered by water exceeding 400 feet in depth. The slope of the bottom is on the whole gentle, but in certain places deep water was found comparatively close inshore, and the consequent crowding of the contour-lines indicates a steeper slope than usual in these positions.

*Temperature Observations.*—Numerous observations were made on the temperature of the surface water of Loch Shiel during the week spent on the survey, the range observed being 8°·2, from 54°·2 to 62°·4. Three serial temperatures were taken beneath the surface, with the following results:—

TABLE OF SERIAL TEMPERATURES TAKEN IN LOCH SHIEL.

Depth in feet.	July 5, 1902, 6 p.m. Off Scamodale.	July 8, 1902, Off Eilean Druim nan Laogh.	July 9, 1902, 5 p.m. 3 miles from head of loch.
0	° Fahr. 57·1	° Fahr. 55·9	° Fahr. 56·5
5	..	54·9	..
10	57·0	54·5	..
20	56·3	54·4	56·5
30	55·5	..	..
50	50·2	54·0	56·0
75	..	50·9	..
100	47·0	47·0	47·4
130	..	46·2	..
200	45·7	..	45·2
280	45·3	..	..
300	..	..	45·2
400	..	..	45·3

In this table the observations are arranged chronologically, but the series given in the first column was taken about midway between the other two series, the second column giving a series taken towards the foot, and the third column a series taken towards the head, of the loch. The central series in the first column was taken three days earlier than the others, and is therefore not strictly comparable; it shows a higher temperature in the surface waters, and a lower tempera-

ture at a depth of 50 feet than in either of the others. The temperature observed near the foot of the loch was lower at all depths than that observed towards the head, the difference amounting to  $2^{\circ}$  at 20 and at 50 feet, and to  $0^{\circ}\cdot4$  at 100 feet. The most pronounced fall in temperature was recorded between 50 and 100 feet towards the two ends of the loch, but between 30 and 50 feet in the central series (first column). The range of temperature shown by these serial observations is about  $12^{\circ}$ , while the extreme range of all the observations from surface to bottom during the week spent on the survey is over  $17^{\circ}$ .

*Loch Dilate* (see Plate LIV.)—Loch Dilate (or Doilate) lies about  $1\frac{1}{2}$  miles to the east of the lower portion of Loch Shiel, into which it flows by the river Polloch entering Loch Shiel about 6 miles above its outflow. The ground between the two lochs is low, the fall from Loch Dilate to Loch Shiel being only  $10\frac{1}{2}$  feet, but high and mountainous country surrounds Loch Dilate in all other directions. The principal feeder is the river Hurich, which takes its rise in Lochan Dubh at the head of Glen Hurich, and after a course of 6 miles empties itself into the east end of Loch Dilate. The loch trends east and west, and is nearly  $1\frac{1}{2}$  miles in length. It is widest towards the east end, where the maximum breadth is over one-third of a mile, the mean breadth being about one-seventh of a mile. Its waters cover an area of about 142 acres, or nearly a quarter of a square mile, and it drains an area fifty-eight times greater, or nearly 13 square miles. Forty-five soundings were taken in Loch Dilate, the maximum depth observed being 55 feet. The volume of water contained in the loch is estimated at 145 million cubic feet, and the mean depth at  $23\frac{1}{2}$  feet, or 43 per cent. of the maximum depth. The loch was surveyed on July 8, 1902, and the elevation of the lake-surface above the sea, by levelling from bench-mark, was found to be 22·0 feet. When levelled by the officers of the Ordnance Survey on October 16, 1867, the elevation was found to be 23·4 feet above sea-level.

Loch Dilate forms a simple basin, the deeper water being centrally placed, and the contour-lines following approximately the outline of the loch. A sounding of 12 feet was recorded off the bay in the south-east corner of the loch, apparently surrounded by shallower water, though possibly continuous with the 10-foot area, but this is the only irregularity in the lake-floor indicated by the soundings. Along the central portion of the southern shore the contour-lines closely hug the shore, indicating a comparatively steep slope in this locality. A section along the central line of the loch from west to east is shown in section A-B on the map. The areas between the contour-lines drawn in at equal intervals, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	78 acres	55.4 per cent.
25 ,, 50 ,,	49 ,,	34.3 ,,
Over 50 ,,	15 ,,	10.3 ,,
	<u>142</u> ,,	<u>100.0</u> ,,

*Temperature Observations.*—The following serial temperatures were taken at 3 p.m. on July 8, 1902, in the deepest part of Loch Dilate:—

Surface ... ..	62°·3 Fahr.
10 feet ... ..	62°·3 ,,
20 ,, ... ..	62°·3 ,,
25 ,, ... ..	61°·5 ,,
30 ,, ... ..	55°·3 ,,
50 ,, ... ..	53°·3 ,,

This series shows a constant temperature from the surface down to a depth of 20 feet, a slight fall of 0°·8 between 20 and 25 feet, then a very rapid fall of 6°·2 between 25 and 30 feet (a fall exceeding 1° per foot of depth), and a further fall of 2° between 30 and 50 feet, the extreme range of temperature being 9° Fahr.

## LOCHS OF THE AILORT BASIN.

LOCH EILT is the only loch to be dealt with here; the few very small hill lochs within the basin were not surveyed.

*Loch Eilt* (see Plate LV.).—Loch Eilt lies about  $1\frac{1}{2}$  miles to the east of the head of Loch Ailort (into which its outflow is carried by the river Ailort), and about 4 miles to the west of Glenfinnan. The hills around it rise steeply up to a height of over 1500 feet, the highest points exceeding 2000 feet. It was formerly considered a good loch for salmon and sea-trout; but Mr. Harvie-Brown believes that the blasting operations during the construction of the Mallaig extension of the West Highland railway resulted in the destruction of a large amount of spawn and fry, and that now the fish are greatly disturbed by the passage of the trains across the bays on the south shore.

Loch Eilt trends east and west, and is  $3\frac{1}{3}$  miles in length, with a maximum breadth of half a mile, the mean breadth being one-fifth of a mile. Its waters cover an area of about 424 acres, or two-thirds of a square mile, and it drains an area of 12 square miles. Over 250 soundings were taken, the maximum depth recorded being 119 feet. The volume of water contained in the loch is estimated at 686 million cubic feet, and the mean depth at 37 feet. The loch was surveyed on July 9 and 10, 1902; the elevation of the lake-surface was found, by levelling from bench-marks, to be 96.4 feet above the sea. The keeper stated that the water might rise about 3 feet above, and fall about 9 inches below, this level. During the night of July 9 and 10, 1902, the water rose nearly 10 inches.

Loch Eilt is naturally divided into three portions by two narrow constrictions in its outline, the western portion being by far the largest and deepest, covering an area of about 360 acres, while the area of the central and eastern portions is in each case about 32 acres. The western portion is connected with the central portion by a channel 6 feet in depth, with a rocky islet in the centre, the sides of the channel being also of rock *in situ*, thus dividing the loch into two rock-basins; the central portion is separated from the eastern portion by detritus brought down by the Allt a' Choire Bhuidhe, the channel

between them having a depth of 7 feet. The small eastern and central basins are quite simple in conformation, the maximum depth observed in the eastern one being 52 feet, and in the central one 70 feet. The floor of the large western basin is much more irregular, there being four areas with depths exceeding 50 feet: (1) a small area near the east end, based on a sounding of 52 feet; (2) the main 50-foot area, which encloses the deepest part of the loch, over a mile in length, and



FIG. 43.—LOCH EILT, LOOKING EAST.

(*Photograph by Mr. David Brigham.*)

with a rocky islet rising to the surface near its western margin; (3) a small area between the large island (Eilean Mòr) and the northern shore, based on a sounding of 55 feet; and (4) a small area near the west end, based on two soundings of 55 feet. At the extreme west end of the loch, between the two islands, a depth of 40 feet was recorded. The 75-foot area is about half a mile, and the 100-foot area about a quarter of a mile, in length, occupying the wide central part of the western basin, but rather nearer the east than the west end. The deepest part of the loch falls below sea-level (the 100-foot contour-line

corresponding approximately with the level of the sea), and is flat-bottomed in character, as shown in cross-section C-D on the map.

The areas between the consecutive contour-lines drawn in at equal intervals, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	187 acres	44.1 per cent.
25 „ 50 „	111 „	26.0 „
50 „ 75 „	88 „	20.9 „
75 „ 100 „	20 „	4.8 „
Over 100 „	18 „	4.2 „
	<u>424 „</u>	<u>100.0 „</u>

*Temperature Observations.*—The temperature of the surface water in Loch Eilt during the two days spent on it varied from 58° to 60° Fahr. On July 10, 1902, three series of temperatures were taken beneath the surface, one in each of the three basins into which the loch is divided, with the following results:—

Depth in feet.	Loch Eilt (eastern basin).	Loch Eilt (central basin).	Loch Eilt (western basin).
	July 10, 1902, 2.30 p.m.	July 10, 1902, 3.30 p.m.	July 10, 1902, 5 p.m.
Surface.	° Fahr. 58.0	° Fahr. 58.1	° Fahr. 60.0
10	58.0	58.1	60.0
20	58.0	58.1	60.0
27.5	55.7	57.7	60.0
35	52.8	53.6	59.7
50	50.7	52.8	54.8
75	...	...	53.0
100	...	...	51.0

These series show a constant temperature down to 20 feet in each case, but the water in the deep western basin was 2° warmer than in the other two basins. Beyond the depth of 20 feet, again, the temperature was about 2° higher in the western basin than in the central basin, and 2° higher in the central basin than in the eastern basin, so that at a depth of 100 feet in the western basin the temperature was rather higher than at a depth of 50 feet in the eastern basin. The water in the western basin was warmer at all depths than that in the central basin, and in the central basin than in the eastern basin. To explain this peculiar distribution of temperature in the waters of Loch Eilt on the afternoon of July 10, 1902, the weather conditions during the few preceding days must be taken into account. The wind had been blowing strong from the north-east from the 3rd till the afternoon of the 9th. Rain commenced to fall about 6 a.m. on the 9th, and continued till about 8 a.m. on the 10th, so that during the twelve hours from 9 p.m. on the 9th to 9 a.m. on the 10th the surface of the loch rose

9 $\frac{3}{4}$  inches. About 11.30 a.m. on the 10th the wind rose from the west, and by 4 p.m. was blowing a gale, so much so that the greatest difficulty was experienced in keeping the boat in position for the 5 p.m. series of temperatures. It would thus appear that the easterly winds of the previous week had blown the warm surface water into the western portion of the loch, and the west wind of the 10th had not yet had time to reverse this effect; the fact that the area draining into the western basin is nearly double that draining into the other two basins would doubtless accentuate this result, since more water would enter the western basin than the other basins, and this inflowing water at this season of the year would be warmer than the water of the loch. The range of temperature from surface to bottom in the eastern basin was 7°·3 Fahr., the greatest fall being 5°·2 between 20 and 35 feet; in the central basin the range was 5°·3, the greatest fall being 4°·5, also between 20 and 35 feet; in the western or main basin the range was 9° (representing the extreme range observed throughout the entire loch), and the greatest fall was 4°·9 between 35 and 50 feet.

## LOCHS OF THE NAN UAMH BASIN.

THE lochs to be dealt with here are Loch Dubh, between the head of Loch Ailort and the head of Loch nan Uamh, and Lochs Màmna and na Creige Dùibhe lying to the north-east. Loch Doir' a' Gherrain in Ardnish could not be sounded, because there was no boat on it at the time of the visit of the Lake Survey.

*Loch Dubh* (see Plate LVI).—Loch Dubh is a small loch situated at the head of the peninsula of Ardnish, which separates Loch Ailort from Loch nan Uamh, the two branches of the sound of Arisaig. The Mallaig extension of the West Highland railway runs along its southern shore, and the outfall flows through the old bed of the little Lochan Deabhtha, which has been completely drained by the railway, leaving only a channel through it for the escape of the waters from Loch Dubh. After leaving Lochan Deabhtha the outfall joins the Schoolhouse burn, which has been deflected, thence into the Arnabol burn, falling into the head of Loch Beag, an inlet of Loch nan Uamh. It is surrounded, except on the western side, by low though steep hills, which impart a dark and sullen appearance to the loch, hence its name—the Black loch. Considering its superficial area, it is the deepest loch visited by the Lake Survey.\* Its great depth, and the remarkable temperature conditions discovered in it, well repaid the trouble of carting a boat from Loch nan Uamh and carrying it down to the loch. Its catchment area is very small, and it would seem that the unpleasant taste of its water, resembling that of a stagnant pool, is due to the small amount of fresh water entering it. This unpleasantness is probably something more than mere taste, for attempts to stock the loch with trout have been unsuccessful, the fish rapidly dying; eels, however, abound in it.

Loch Dubh trends in a north-west and south-east direction, the broadest part being rather nearer the south-east end. Its length is

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\* The deepest lake in East Prussia is, according to Halbfass (*Globus*, Bd. 86, p. 187, September 15, 1904), the Wuchsnigsee, which is about  $1\frac{1}{2}$  miles in length, and has a maximum depth of about 210 feet. Loch Dubh is less than half a mile in length, and its maximum depth is 153 feet.

under half a mile, its maximum breadth one-sixth of a mile, and its mean breadth one-tenth of a mile. Its waters cover an area of about 32 acres, and it drains an area eight times greater, or about 262 acres. Sixty-five soundings were taken, and the maximum depth observed was 153 feet, which bears the ratio to the length of the loch of 1 to 15. This low ratio is only equalled by the little loch on Eilean Subhainn in Loch Maree, and the loch which most nearly approaches it is Loch Fender in the Tay basin, in which the ratio is as 1 to 22, followed by Loch Dhugaill, near Kishorn, in which the ratio is as 1 to 27. Among the larger Scottish lochs, the nearest approach is found in Loch Treig, with a ratio of depth to length of 1 to 62. The volume of water contained in the loch is estimated at 86,956,000 cubic feet, and the mean depth at nearly 63 feet, or 41 per cent. of the maximum depth. The loch was surveyed on July 12, 1902; the elevation of the lake-surface above the sea was found, by levelling from bench-marks, to be 103·0 feet; when visited by the Ordnance Survey officers on August 6, 1869, the elevation was 103·3 feet above sea-level. No drift-marks were seen, but the keeper stated that the annual range in level was about 9 inches.

Loch Dubh is very simple in conformation, the contour-lines following approximately the shore-line. Near the north-west end there is a slight rise of the bottom, as shown in section A-B on the map, but otherwise the lake-floor slopes down regularly to the deepest part, which lies towards the north-eastern shore. The maximum depth of 153 feet was observed at a distance of about 120 feet from this shore, giving a slope of 59°; the height of the hill immediately adjoining is 240 feet, and the slope 35°, hence the slope from the top of the hill to the bottom of the loch is one of 45°. The areas between the consecutive contour-lines drawn in at equal intervals, and the percentages to the total area of the loch, are as follows:—

0 to 50 feet	14·8 acres	40·7 per cent.
50 „ 100 „	8·9 „	30·9 „
100 „ 150 „	7·6 „	26·5 „
Over 150 „	0·5 „	1·9 „
	<u>31·8 „</u>	<u>100·0 „</u>

*Temperature Observations.*—A most interesting series of temperatures was taken in Loch Dubh at the time of the survey, as given in the first column of the following table. The loch was revisited in March, 1903, when the water was found to be uniform in temperature from surface to bottom, as given in the second column of the table—

Depth in feet.	Loch Dubh. July 12, 1902, 3 p.m.	Loch Dubh. March 28, 1903.
	Fahr.	Fahr.
0	59·0	41·0
10	59·0	...
16	58·9	...
20	56·0	...
25	53·7	...
35	51·5	...
50	47·1	41·0
75	44·1	41·0
100	43·6	40·9
150	43·5	40·9

The series taken in March calls for no discussion, but the series taken in July is remarkable for the low temperature of the deep water at this season of the year, and for the great range of temperature from surface to bottom. Compared with the temperatures recorded in Loch Shiel a week earlier in the same month, we find the temperature in Loch Dubh  $1^{\circ}7$  lower at the bottom in 150 feet than in Loch Shiel in 420 feet, and in Loch Morar (the deepest of all Scottish lochs), ten days earlier in the same month, a temperature equal to that at the bottom of Loch Dubh was recorded only after descending to a depth of 250 feet. The extreme range of temperature shown by the series in Loch Dubh amounts to  $15^{\circ}5$ , while the series taken in Loch Shiel shows a range of only  $12^{\circ}$ , and the series in Loch Morar shows a range of only  $13^{\circ}$ , from surface to bottom. The extraordinary temperature conditions observed in Loch Dubh may probably be accounted for (1) by the great depth of the loch compared with other lochs of similar area; (2) by the small extent of its drainage area, so that very little rain-water enters the loch; and (3) by the small area of the loch and the steepness of the surrounding hills reducing the mixing effect of the wind to a minimum.

Lochs Mâma and na Creige Duibhe doubtless formed at no distant date one sheet of water, which was gradually separated into two portions by the deposition of material brought down by the Allt Dearg. This is evidenced by the fact that locally the name Mâma is applied to both divisions, but in this place that name is restricted to the western basin, the name na Creige Duibhe being applied to the larger and deeper eastern basin. The connecting stream is about 60 yards in length, with a depth of 7 to 8 feet, the fall from Loch na Creige Duibhe to Loch Mâma being less than a foot. The tract of alluvium separating the two lochs was about  $2\frac{1}{2}$  feet above the water of Loch Mâma, and the keeper stated that he had often seen it flooded when the lochs were high. The hills along the northern and southern shores of the lochs rise steeply up to heights exceeding 1000 feet, approaching 2000 feet along the northern shores, down the sides of which a few torrents rush

after heavy rains. The two lochs trend east and west, and the outflow from Loch na Creige Duibhe passes into Loch Mâma, and thence by the Gleann Mâma into Loch nan Uamh.

*Loch Mâma* (see Plate LVI.).—Loch Mâma is over one-third of a mile in length, one-eighth of a mile in maximum breadth, and one-twelfth of a mile in mean breadth. Its waters cover an area of about 17 acres, and it drains directly an area of two-thirds of a square mile, but since it receives the outflow from Loch na Creige Duibhe its total drainage area is over 2 square miles, an area seventy times greater than that of the loch. Nearly 40 soundings were taken, the maximum depth observed being 44 feet. The volume of water contained in the loch is estimated at 11 million cubic feet, and the mean depth at  $14\frac{1}{4}$  feet. The loch was surveyed on July 11, 1902, and the elevation of the lake-surface above the sea was determined from spot-levels as being 359 feet. It forms a simple basin, the deepest part being found towards the east end. The areas between the contour-lines, and the percentages to the total area, are as follows:—

0 to 10 feet	8.0 acres	46.9 per cent.
10 „ 25 „	6.4 „	37.5 „
Over 25 „	2.6 „	15.6 „
	<u>17.0 „</u>	<u>100.0 „</u>

*Loch na Creige Duibhe* (see Plate LVI.).—Loch na Creige Duibhe is four-fifths of a mile in length, one-eighth of a mile in maximum breadth, and one-fourteenth of a mile in mean breadth. Its waters cover an area of about  $36\frac{1}{2}$  acres, and it drains an area twenty-four times greater, or about  $1\frac{1}{2}$  square miles. Over 70 soundings were taken, the maximum depth recorded being 93 feet. The volume of water is estimated at 52 million cubic feet, and the mean depth at  $32\frac{1}{2}$  feet. The loch was surveyed on the same day as Loch Mâma (July 11, 1902); the elevation of the lake-surface above the sea, from spot-level and by comparison with Loch Mâma, was found to be 359.7 feet. An inspection of the map shows Loch na Creige Duibhe to be (like Loch Mâma) a long narrow basin of very simple conformation. It is much deeper than Loch Mâma, and the deeper water approaches nearer to the west than to the east end, that is to say, nearer to the alluvial cone separating the two lochs. A similar state of matters has been noted in the case of Lochs Voil and Doine in the Forth basin, formerly a continuous loch, now divided into two portions by the deposition of material brought down by the river, where deep water approaches close to the dividing promontory of land on both sides.\*

The areas between the consecutive contour-lines drawn in at equal

\* See p. 9.

intervals, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	21·2 acres	58·1 per cent.
25 „ 50 „	6·9 „	19·0 „
50 „ 75 „	5·1 „	14·1 „
Over 75 „	3·2 „	8·8 „
	<hr/> 36·4 „ <hr/>	<hr/> 100·0 „ <hr/>

*Temperature Observations.*—The surface temperature observed in Loch na Creige Duibhe on the date of the survey was 57°·4, in the stream between the two lochs 57°·1, and in Loch Màmà 56°·5. The following serial temperatures were taken in the deepest part of Loch na Creige Duibhe at 4.45 p.m. on July 11, 1902:—

Surface ... ..	57°·4 Fahr.
10 feet ... ..	57°·4 „
20 „ ... ..	57°·4 „
30 „ ... ..	53°·0 „
50 „ ... ..	50°·8 „
75 „ ... ..	49°·2 „
90 „ ... ..	48°·8 „

This series shows a constant temperature down to 20 feet, then a fall of 4°·4 between 20 and 30 feet, and a further fall of 2°·2 between 30 and 50 feet, the extreme range of temperature from surface to bottom being 8°·6.

The details regarding the lochs in the Shiel, Ailort, and nan Uamh basins are collected together in the table on p. 258 for convenience of reference and comparison. From this table it will be seen that in the six lochs under consideration nearly 1200 soundings were taken, and that the aggregate area of the water-surface is over 8½ square miles, so that the average number of soundings per square mile of surface is 139. The aggregate volume of water contained in the lochs is estimated at about 29,000 millions of cubic feet. The area drained by these lochs is nearly 100 square miles, or 11½ times the area of the lochs.

*Geology of the Loch Shiel Catchment Basin.*—Though the basin of Loch Shiel has not been surveyed by the Geological Survey, we understand that certain members of the staff have examined the rock cuttings on the line of railway between Loch Eil and Kinlochailort. The rocks exposed in these cuttings consist of muscovite-biotite gneiss and flaggy mica-schists, which are included in the Moine series of crystalline schists by the Geological Survey. The general strike of these strata is north-east and south-west, so that in all likelihood they are continued to the south-west along both sides of Loch Shiel. This conclusion is supported by the fact that on the lofty watershed between Loch Shiel

## SUMMARY TABLE.

Giving Details concerning the Lochs in the Shiel, Ailort, and nan Uamh Basins.

Lochs.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. feet.	Mean feet.	Mean percent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
Shiel	11.4	715	17.40	0.88	0.43	2.5	420	132.73	31.6	219	692	27,986	7.56	85.42	11.30
Dilate	22.0	45	1.43	0.37	0.15	10.5	55	23.50	42.7	137	321	145	0.22	12.81	58.23
Eilt ...	96.4	254	3.37	0.51	0.20	5.8	119	37.12	31.2	149	479	686	0.66	12.05	18.26
Dubh	103.0	65	0.43	0.17	0.10	23.2	153	62.70	41.0	15	36	87	0.05	0.41	8.20
na Creige Duibhe	359.7	74	0.80	0.13	0.07	8.7	93	32.49	34.9	45	130	52	0.06	1.46	24.33
Màma	359.0	38	0.37	0.13	0.08	21.6	44	14.29	32.5	44	137	11	0.03	2.09	69.66
		1191										28,967	8.58	99.97*	11.65

\* The drainage area of Loch Dilate is included in that of Loch Shiel, and that of Loch na Creige Duibhe in that of Loch Màma.

and Loch Linnhe these muscovite-biotite gneisses have been mapped by the Geological Survey. These schists and gneisses, which are supposed to represent altered sediments, are traversed by numerous veins of pegmatite and dykes of diorite, dolerite, and basalt.

On the watershed between Glen Hurich and Glen Scaddle, on the crest of Sgor Dhomhail (2915 feet), there is a mass of foliated granite, and, further to the south-west, the later igneous intrusions of the Strontian district may enter the Loch Shiel catchment basin.

#### NOTES ON THE BIOLOGY OF THE LOCHS IN THE SHIEL DISTRICT.

By JAMES MURRAY.

Of the six lochs surveyed, tow-nettings were taken in four, and a shore-netting in a fifth. The biology presented little of special interest. *Diaptomus laciniatus* was found in two of the lochs (Shiel and Eilt); these are the most southerly lochs in which this northern species was observed by the Lake Survey, though it has been recorded by Dr. Scott from one loch (Loch Doon) much farther south.

*Loch Shiel*.—Owing to the great abundance of *Holopedium*, which choked up the nets, it was difficult to collect other animals in any numbers. The most plentiful animals were: *Diaptomus gracilis*, *Diaptomus laciniatus*, *Cyclops strenuus*, *Bosmina obtusirostris*, *Bythotrephes*, *Polyphemus*, six species of pelagic Rotifers (including *Floscularia pelagica*), and *Dinobryon*. The plants noted were: *Xanthidium antilopeum*, *Staurastrum gracile*, and *Staurastrum brazilense*. *Lobelia* and *Littorella* were in flower at the upper end of the loch.

*Loch Dilate*.—As compared with Loch Shiel, the most notable features of this loch were: the greater abundance of life, the absence of *Holopedium* and *Diaptomus laciniatus*, and the presence of *Diaphanosoma brachyurum* in considerable numbers. Among the organisms observed were: *Diaptomus gracilis*, *Cyclops strenuus*, *Synchæta pectinata*, *Plasoma truncata*, *Dinobryon*, *Peridinium*, two species of *Ceratium* (*C. hirundinella* and *C. cornutum*), *Anabæna flos aquæ* with its adherent *Vorticellæ*.

*Loch Eilt*.—Life was abundant, the characteristic animals being *Holopedium*, *Diaptomus laciniatus*, *Cyclops strenuus*, *Anuræa cochlearis*, *Notholca longispina*, and *Polyarthra*. *Leptodora* and *Bythotrephes* were scarce. *Bosmina obtusirostris* and a variety approaching *B. longispina* were seen. The brilliant red and blue Rotifer, *Notops pygmaeus*, was plentiful. Some immature specimens of *Diaptomus* probably belonged to *D. gracilis*. On the mud in the deepest part of the loch were numbers of a pretty little green larva of an insect, enclosed in transparent flask-shaped cases.

*Loch Dubh*.—This little loch, remarkable for its great relative depth and temperature conditions, resembling those in a great lake, was examined on two occasions. On the first visit in July, 1902, the surface temperature was 59° Fahr., while on the second visit in March, 1903, the temperature throughout was about 41° Fahr. Notwithstanding this difference in temperature there was little difference in the animals observed on the two occasions. Those found in July were: *Diaptomus gracilis* (blue and red, grey, red, blue), *Cyclops strenuus*, *Bosmina obtusirostris* (small, purple), *Daphnia lacustris* (all pale red), *Eurycercus*, *Polyphemus*, *Triarthra*, *Polyarthra*, *Anuræa cochlearis*, *Conochilus*, *Ceratium hirundinella*, *Dinobryon*. In March all the same animals were found, except *Polyphemus*, and there were in addition a few larvæ of *Corethra* (phantom larvæ), *Notholca foliacea*, a second species of *Ceratium* (*C. cornutum*—less common in lakes), *Mallomonas*. A very small form of *Asterionella* occurred. Near the shore large spheres of *Ophridium* were found on the weeds. In the mud from the bottom were many Rhizopods of the species *Cyphoderia ampulla*, *Diffugia pyriformis*, *D. globulosa*, and *D. arcuata*. *Lobelia* and *Myriophyllum* were growing along the shores.

*Loch na Creige Duibhe*.—As this loch was only examined by means of a net thrown out from the shore, it is probable that some of the pelagic animals may have been missed. The animals seen were: *Diaptomus gracilis* (reddish), *Cyclops strenuus* (yellow), *Alonopsis elongata*, *Chydorus sphaericus*, *Anuræa cochlearis*, *Bosmina obtusirostris*, *Arcella vulgaris*. A few of the commonest filamentous Algæ and Desmids were seen. *Asterionella* was scarce.

## LOCHS OF THE CONON BASIN.

FOURTEEN lochs draining into the Cromarty firth were surveyed by the staff of the Lake Survey, viz., Lochs Crann, a'Chroisg, Gown, Achanalt, a' Chuilinn, Fannich, Luichart, Beannachan, Achilty, Garve, Kinellan, Ussie, Glass, and Morie. The majority of these lochs drain by the river Conon into the head of the Cromarty firth, while Lochs Glass and Morie drain by independent streams, which fall into the Cromarty firth on its north-western shore. It has been found convenient, also, to include in this place a description of Loch Eye, situated between Cromarty firth and Dornoch firth. The drainage area under consideration is indicated in the index map of the district (Fig. 44), by reference to which the relations between the various lochs will be readily understood, and extends from the mouth of the Cromarty firth on the east to the heights of Carn Breac and An Groban on the west, Carn Chuinneag on the north, and Sgorr a' Choir-Ghlais on the south. The total area, as measured by the planimeter on the 1-inch Ordnance Survey maps, is over 770 square miles, and of this total 336 square miles (or one-half) drain into the lochs now to be dealt with; as will be seen from the summary table.

The headwaters of the basin take their rise on the flanks of Carn Breac, flowing by various streams into Loch na Moine Moire and Loch an t-Sior (which were not sounded), thence into Loch Crann and Loch a' Chroisg, the outflow from which is carried by the river Bran into Loch Achanalt and Loch a' Chuilinn, and thence into Loch Luichart. Shortly after leaving Loch a' Chroisg the river Bran receives the outflow from Loch Gown, which is fed by the Allt Gharagain, taking its rise on the flanks of Moruisg (3026 feet), and shortly before entering Loch Luichart the river Bran is joined by the river Fannich bearing the outflow from Loch Fannich, which is fed by various streams draining the flanks of a grand series of mountains exceeding 3000 feet in height. After the junction of the Bran and the Fannich the river receives the name of Conon, and shortly after leaving Loch Luichart it is joined by the river Meig, bearing the outflow from Loch Beannachan, taking its rise among lofty mountains culminating in Sgurr a' Chaoruinn (3452 feet). Still further on the river Conon is joined by the Black Water, bearing the outflow from Lochs Garve and Achilty, and taking its rise

far to the north on the flanks of Beinn Dearg (3547 feet). Still further on the river Conon is joined by the river Orrin, and finally falls into the head of the Cromarty firth at Dingwall. The river Glass, which in its course flows through Loch Glass, rises on the flanks of Beinn nan Eun, and empties itself in the Cromarty firth at Balconie Point. The river Alness, which flows through Loch Morie, rises on the flanks of Beinn a' Chaisteil, and falls into the Cromarty firth at Alness Point.

The geology of the district is dealt with by Drs. Peach and Horne, whose notes are appended, as well as a few biological notes by Mr. James

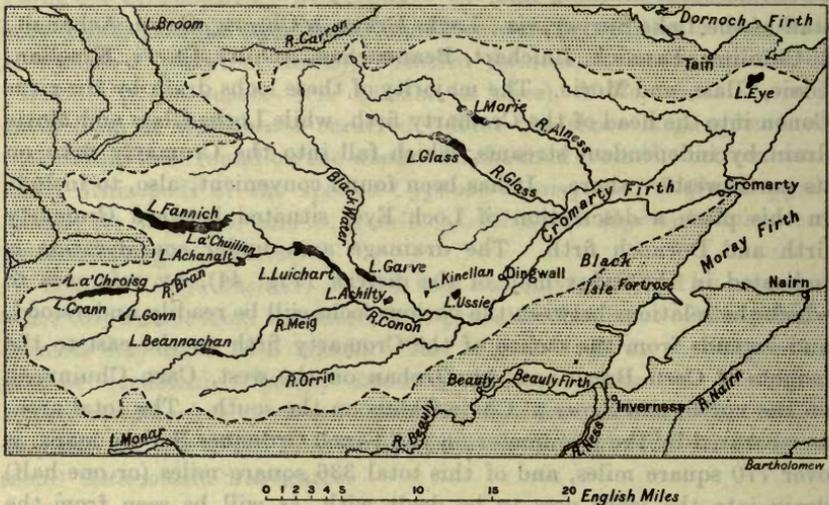


FIG. 44.—INDEX MAP OF THE CONON BASIN.

Murray. Mr. R. M. Clark, B.Sc., who took part in the survey of the lochs in the Conon basin in 1902, has supplied us with several series of temperatures taken by him the previous summer (1901) in Lochs Achilty, Garve, Achanalt, a' Chuilinn, and a' Chroisg, which are here incorporated.\*

\* These temperature observations, taken by Mr. Clark in the summer of 1901, are interesting, as compared with the observations taken in the same lochs in the summer of 1902, when viewed in connection with the atmospheric conditions in the two seasons. It will be observed that all the readings taken in the superficial waters of these lochs in 1901 are higher than those taken in 1902, and this is evidently related to the warmer season in the first-named year. Thus the mean temperature over Scotland for July, 1901, was  $61^{\circ}\cdot8$  Fahr., or  $3^{\circ}$  above the long-period average for that month, while for July, 1902, it was  $54^{\circ}\cdot4$ , or  $4\frac{1}{2}^{\circ}$  below the average; for August, 1901, the mean was  $57^{\circ}\cdot5$ , or  $1^{\circ}$  above the average, while for August, 1902, the mean was  $53^{\circ}\cdot9$ , or  $2\frac{1}{2}^{\circ}$  below the average. The nearest station to the Conon basin lochs from which observations are available is Inverness, and the mean temperature there for July, 1901, was  $61^{\circ}\cdot0$ , or  $4^{\circ}$  above the long-period average, while for July, 1902, the mean temperature was  $45^{\circ}\cdot4$ , or  $3\frac{1}{2}^{\circ}$  below the

*Loch Crann* (see Plate LVII.).—Loch Crann is a small shallow loch situated a short distance to the west of Loch a' Chroisg, and lying at a slightly higher level. Its striking characteristic is the large area of hilly country draining into it—an area nearly 600 times greater than that of the loch. It is roughly quadrangular in outline, with a maximum diameter of less than a quarter of a mile, and it covers an area of about  $13\frac{1}{2}$  acres, 80 per cent. of which is under less than 10 feet of water. The deeper soundings were taken in the southern half of the loch, the maximum depth observed being 17 feet. The volume of water is estimated at 4 million cubic feet, and the mean depth at nearly 7 feet. Loch Crann was surveyed on August 19, 1902, when the level was determined as being 513·7 feet above the sea. The temperature of the surface water at 5 p.m. on that date was  $59^{\circ}\cdot6$  Fahr., and at a depth of 14 feet  $56^{\circ}\cdot2$ .

*Loch a' Chroisg* (see Plate LVII.).—Loch a' Chroisg (or Loch Rosque) is one of the larger and more important lochs within the basin, lying amid beautiful scenery, the hills on both sides rising to heights exceeding 1500 feet, and culminating in Meall a' Chaoruinn (2313 feet) on the northern shore (see Fig. 45). It is a good trout loch, and char also occur, but the fishing is strictly preserved. The loch trends almost due east and west, though very slightly sinuous in outline; the shore-line is on the whole very regular, except that two conspicuous alluvial cones have been laid down on the northern shore at the mouths of the Allt Duchairidh and neighbouring stream. The loch is  $3\frac{1}{2}$  miles in length, with a maximum breadth of nearly half a mile, the mean breadth being over a quarter of a mile. Its waters cover an area of about 640 acres (1 square mile), and it drains directly an area of over  $7\frac{1}{2}$  square miles, but, as it receives the outflow from Loch Crann, its total drainage area is over 19 square miles. The maximum depth of 168 feet was observed approximately near the centre of the loch, opposite the mouth of the Allt Duchairidh entering the loch on its northern shore, and about 2 miles from the east end. The volume of water contained in the loch is estimated at 2057 million cubic feet, and the mean depth at nearly 74

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average; for August, 1901, the mean was  $58^{\circ}\cdot7$ , or  $2^{\circ}$  above the average, while for August, 1902, the mean was  $54^{\circ}\cdot2$ , or  $2\frac{1}{2}^{\circ}$  below the average. Sunshine records are available for Strathpeffer within the Conon basin during these seasons, and they bear the same relations: thus during July, 1901, 162·1 hours of sunshine were recorded at Strathpeffer (or  $34\cdot5$  above the normal for that month, and 30 per cent. of the possible amount), while during July, 1902, the duration of sunshine was 95·6 hours (or  $32\cdot0$  below the normal, and 18 per cent. of the possible amount); during August the difference was not so marked in the two years, the duration in August, 1901, being 140·0 hours (or  $18\cdot5$  above the normal, and 30 per cent. of the possible amount), while in August, 1902, the duration was 131·8 hours (or  $10\cdot3$  above the normal, and 28 per cent. of the possible amount). The sunshine records for Inverness agree closely with those given above for Strathpeffer for the two seasons under consideration.

feet. The loch was surveyed on July 30 to August 1, 1902, and the elevation of the lake-surface, on commencing the survey, was found, by levelling from bench-mark, to be 508·4 feet above the level of the sea; when levelled by the Ordnance Survey officers on July 3, 1868, the elevation was 507·9 feet above sea-level.

Loch a' Chroisg forms a simple basin with no pronounced irregularities of the lake-floor, as is well shown by the longitudinal and cross sections on the map; the contour-lines enclose continuous areas following approximately the outline of the loch. The 100-foot basin



FIG. 45.—LOCH A' CHROISG, LOOKING WEST.

(Photograph by Mr. T. N. Johnston, M.B., C.M., F.R.S.E.)

exceeds 2 miles, and the 50-foot basin is nearly  $2\frac{3}{4}$  miles, in length, approaching in each case rather nearer to the east than to the west end of the loch, while the small 150-foot basin lies nearer to the west than to the east end. The approximate areas between the consecutive contour-lines drawn in at equal intervals, and the percentages to the total area of the loch, are as follows:—

0 to 50 feet	241 acres	37·7 per cent.
50 ,, 100 ,,	186 ,,	29·0 ,,
100 ,, 150 ,,	195 ,,	30·5 ,,
Over 150 ,,	18 ,,	2·8 ,,
	<u>640</u> ,,	<u>100·0</u> ,,

The slightly larger area between 100 and 150 feet than between 50 and 100 feet indicates the flat-bottomed character of the deeper part

of the loch, and the soundings show in certain places rather steep slopes both off the northern and southern shores.

*Temperature Observations.*—In the following table are given the results of a series of temperatures taken in Loch a' Chroisg on August 22, 1901, by Mr. Clark, and of two series taken by the Lake Survey staff on August 1, 1902:—

Depth in feet.	August 22, 1901 (R. M. Clark).	August 1, 1902. $\frac{1}{2}$ mile from E. end of loch in 106 feet.	August 1, 1902. Deepest part of loch in 156 feet.
	° Fahr.	° Fahr.	° Fahr.
0	58·2	55·0	54·0
20	58·2	...	...
25	...	53·7	53·9
40	58·0	...	...
50	...	53·1	53·2
60	57·6	...	...
75	...	53·3	51·0
80	51·9	53·2	...
90	...	50·5	...
100	48·5	49·9	49·1
120	47·5	...	...
150	...	...	48·9

The series taken in 1901 shows a range from surface to bottom amounting to  $10^{\circ}7$ , whereas the two series taken in 1902 show a range of only  $5^{\circ}$  in each case, and an extreme range of  $6^{\circ}$ . The upper layers of water down to a depth of 60 feet were much warmer in 1901 than in 1902, but between 60 and 100 feet the 1901 observations indicated a fall of  $9^{\circ}$  (viz., a fall of  $5^{\circ}7$  between 60 and 80 feet, and a fall of  $3^{\circ}4$  between 80 and 100 feet), so that the temperature of the bottom layers of water beyond 100 feet was lower in 1901 than was observed at these depths in 1902.

*Seiche.*—On August 19, 1902, between 4.30 and 5.30 p.m., a seiche was observed by Mr. James Murray within the shelter of the pier at the east end of Loch a' Chroisg, a light west breeze blowing at the time. The amplitude was a quarter of an inch, and the period about  $11\frac{1}{2}$  minutes.

*Loch Gown* (see Plate LVII.).—Loch Gown (or Lédgowan) lies about a mile to the south-east of Loch a' Chroisg, and is also a good trout loch, but the fishing is preserved. It trends in a north-east and south-west direction, is very irregular in outline, and about  $1\frac{1}{4}$  miles in length. Though it may at one time have formed a single lake, it is now divided into two distinct lakes having, at the time of the survey, a difference in level exceeding 2 feet. This separation has probably been brought about mainly by the deposition of material laid down by the Allt Mhàrtuin, and the passage between them is obstructed by weeds, so that it is impossible to row a boat from one loch to the other, except after heavy floods. The two lochs are nearly equal in superficial area, but the southern basin is much deeper than the northern one.

*South Loch Gown.*—The southern loch is roughly quadrangular in outline, over half a mile in length, and nearly a third of a mile in maximum width, covering an area of about 55 acres, while it drains an area exceeding 13 square miles. The maximum depth of 52 feet was observed relatively close to the north-eastern shore. The volume of water is estimated at 38 million cubic feet, and the mean depth at nearly 16 feet. The loch forms a simple basin, the 10-foot contour following approximately the outline of the loch and extending a short distance into the passage leading to the northern loch, and the 25-foot basin is centrally placed. Of the entire lake-floor, only 13 per cent. is covered by more than 25 feet of water. It was surveyed on August 2, 1902, when the elevation was determined as being 524·4 feet above the level of the sea.

*North Loch Gown.*—The northern loch is more oblong in outline than the southern loch, so that while nearly equal in length its maximum width is less, viz., about a fifth of a mile. Its waters cover an area of about 48 acres, and it drains directly an area of about 1 square mile; but, since it receives the outflow from the southern loch, its total drainage area is over 14 square miles—nearly 200 times greater than the area of the loch. The greatest depth observed was 17 feet, approximately near the centre of the loch. The volume of water is estimated at 14 million cubic feet, and the mean depth at nearly 7 feet. A constriction in the outline towards the southern end of the loch is accompanied by a slight shoaling of the bottom, the result being that a small 10-foot basin near the southern end, with a maximum depth of 13 feet, is separated from the large main basin. Of the entire lake-floor 22 per cent. is covered by more than 10 feet of water. It was surveyed on the same day as the southern loch (August 2, 1902), and the elevation was determined as being 522·1 feet above sea-level.

*Temperature Observations.*—Serial temperatures were taken in the deepest part of each loch, with the following results:—

Depth in feet.	North Loch Gown, August 2, 1902, 1 p.m.	South Loch Gown, August 2, 1902, 4 p.m.
Surface	° Fahr. 55·7	° Fahr. 55·0
10	55·7	55·0
15	55·7	...
20	...	55·0
30	...	53·8
40	...	52·1

In the shallow north loch the temperature was found to be constant from surface to bottom, and in the south loch the temperature was constant from the surface down to a depth of 20 feet (though more

than half a degree lower than in the north loch); between 20 and 30 feet the fall was  $1^{\circ}2$ , and between 30 and 40 feet  $1^{\circ}7$ —a fall of nearly  $3^{\circ}$  in the 20 feet of depth.

*Loch Achanalt* (see Plate LVIII.).—Loch Achanalt is an irregular shallow loch apparently in process of being silted up, the material brought down by the river Bran forming two long spits extending out towards the centre of the loch. The northern spit extends nearly across the loch, joining the islands, and leaving only a narrow passage close to the eastern shore, through which there was a strong current, and thus practically cutting the loch into two portions. The western shores are bordered by weeds. It flows into Loch a' Chuilinn by a short and rapid stream, the difference in level exceeding 4 feet; the Highland railway is carried over the passage between the two lochs. Loch Achanalt is approximately quadrangular in outline, its maximum diameter exceeding three-quarters of a mile, and it covers an area of about 160 acres, or one-quarter of a square mile. The deepest water was found comparatively close to the western shore, south of the entrance of the river Bran, where two soundings of 9 feet and two soundings of 8 feet were recorded. The volume of water is estimated at 31 million cubic feet, and the mean depth at  $4\frac{1}{2}$  feet—half the maximum depth. The area draining directly into Loch Achanalt is very large, exceeding 39 square miles; but, since it receives the outflow from Lochs a' Chroisg and Gown, its total drainage area exceeds  $72\frac{1}{2}$  square miles, or 290 times the area of the loch. Loch Achanalt was surveyed on August 9, 1902, when the elevation of the lake-surface was found to be 365.1 feet above the sea; when levelled by the Ordnance Survey officers on May 9, 1870, the elevation was 364.7 feet above sea-level. The temperature of the surface water on the date of the survey was  $57^{\circ}1$  Fahr.; the temperature of the river Bran being  $55^{\circ}2$ . On August 19, 1901, Mr. Clark observed a temperature of  $60^{\circ}1$  at the surface, and a temperature of  $60^{\circ}4$  at a depth of 5 feet.

*Loch a' Chuilinn* (see Plate LVIII.).—Loch a' Chuilinn (or Culen) trends east and west, is irregular in outline, of varying width, and with an undulating floor. It is  $1\frac{1}{3}$  miles in length, with a maximum breadth of one-third of a mile. Its waters cover an area of about 113 acres, and it drains directly an area of nearly  $1\frac{3}{4}$  square miles; but as it receives the outflow from Loch Achanalt, its total drainage area is over 74 square miles—over 400 times the area of the loch. The maximum depth of 43 feet was observed approximately near the middle of the loch. The volume of water is estimated at 50 million cubic feet and the mean depth at  $10\frac{1}{4}$  feet. The bottom of Loch a' Chuilinn is most irregular; close to the west end is a 10-foot basin, with a maximum depth of 29 feet, the slopes of which are in places steep, depths of 20

and 21 feet having been found close inshore. Separated from this western basin by an interval of about 600 yards, in which the depth does not exceed 8 feet, lies the central 10-foot basin, enclosing the maximum depth of the loch (43 feet), and here again the slope is steep, one sounding of 29 feet being recorded close to the southern shore. Separated from this central basin by a short interval, 7 feet in depth, is a small eastern basin, with a maximum depth of 29 feet, and after another shallow interval the water deepens at the exit of the outflowing river, where soundings of 13 feet were taken. Of the entire lake-floor, 75 acres (or 67 per cent.) are covered by less than 10 feet of water, and 7 acres (or 6 per cent.) by more than 25 feet of water. The loch was surveyed on August 11, 1902, when the elevation of the lake-surface was found to be 360·8 feet above the sea.

*Temperature Observations.*—The following table gives the results of observations taken in Loch a' Chuilinn by Mr. Clark on August 19, 1901, and by the Lake Survey on August 11, 1902:—

Depth in feet.	August 19, 1901 (R. M. Clark).	August 11, 1902.
0	° Fahr. 60·3	° Fahr. 55·7
5	60·0	...
10	59·6	...
15	...	55·4
20	59·6	...
30	...	54·7
40	58·6	...

These observations show that the whole body of water was much warmer in 1901 than at the same season in 1902, the difference amounting on the average to about 4°; the range of temperature was in each case small.

*Loch Fannich* (see Plate LIX.).—Loch Fannich is the largest within the Cromarty firth drainage-basin, and is surpassed in depth only by Loch Glass. It is situated in Fannich deer forest amid splendid scenery (see Fig. 46), the mountains along the northern shore rising to heights exceeding 3000 feet, including An Coileachan (3015 feet), Meallan Rairigidh (3109), Sgùrr Mòr (3637), Sgùrr nan Clach Geala (3500), Sgùrr Breac (3000), and a' Chailleach (3276). The trout fishing is good, the fish being of fair size, but the loch is strictly preserved. The general trend of the loch is east and west, but the two ends have a tendency to bend slightly to the northwards. Loch Fannich is nearly 7 miles in length, the maximum breadth exceeding three-quarters of a mile, and the mean breadth is over half a mile. Its waters cover an area of 2300 acres (or over 3½ square miles), and it drains an area ten times

greater (over  $35\frac{1}{2}$  square miles). The maximum depth of 282 feet was observed about  $1\frac{1}{4}$  miles from the east end, and about  $5\frac{1}{2}$  miles from the west end. The volume of water is estimated at 10,920 millions of cubic feet, and the mean depth at nearly 109 feet. Loch Fannich forms a simple basin, all the contour-lines enclosing continuous areas, though the deepest part (exceeding 200 feet in depth) lies in the eastern half of the loch. The 50-foot area extends from end to end, coinciding approximately with the outline of the loch. The 100-foot area approaches to within half a mile from both ends, and is nearly 6 miles in length; there is a slight shoaling of the water opposite Rudha Mòr



FIG. 46.—LOCH FANNICH, LOOKING EAST.

(*Photograph by Mr. T. N. Johnston, M.B., C.M., F.R.S.E.*)

to 103 feet, with deeper water to the east and west. The 150-foot area is distant over  $2\frac{1}{2}$  miles from the west end, and is over  $3\frac{1}{2}$  miles in length. The 200-foot area is  $2\frac{1}{2}$  miles, and the 250-foot area  $1\frac{3}{4}$  miles, in length, and they approach to within three-quarters of a mile from the east end. The slight shoaling opposite Rudha Mòr has already been referred to, and a similar shoaling is observable within the 200-foot contour opposite Fannich Lodge, where the depth decreases from 226 feet to 212 feet, and increases again on proceeding eastwards into the 250-foot area; these two shoalings are indicated in the longitudinal section A-B on the map. A sinuosity is also seen in the 200-foot contour off the southern shore, opposite Fannich Lodge, due to the shoaling of the water from 202 to 191 feet, but on the whole the lake-floor may be said to be extremely regular in conformation. The cross section

C-D is taken across the loch in the position of the deepest sounding. The areas between the consecutive contour-lines drawn in at equal intervals, and the percentages to the total area of the loch, are as follows:—

0 to 50 feet	658 acres	28·6 per cent.
50 ,, 100 ,,	582 ,,	25·2 ,,
100 ,, 150 ,,	418 ,,	18·1 ,,
150 ,, 200 ,,	272 ,,	11·8 ,,
200 ,, 250 ,,	220 ,,	9·6 ,,
Over 250 ,,	155 ,,	6·7 ,,
	<u>2305</u> ,,	<u>100·0</u> ,,

The regularity of the average slope of the bottom is indicated by the gradually decreasing areas between the contour-lines, and the comparatively large area within the deepest contour indicates the flat-bottomed character of the deeper part of the loch.

Loch Fannich was surveyed on August 13 and 14, 1902, and the elevation of the lake-surface was found, on commencing the survey, to be 821·9 feet above sea-level, which is identical with the level observed by the Ordnance Survey on May 27, 1870.

*Temperature Observations.*—The temperature of the surface water during the two days spent on the survey varied from 52°·7 Fahr. to 58°·1. Two serial temperatures were taken on August 14, 1902, with the following results:—

Depth in feet.	August 14, 1902, 4·15 p.m. Deepest part of loch.	August 14, 1902, 5·30 p.m. South-east of Rudha Mòr.
	° Fahr.	° Fahr.
Surface	53·0	54·0
5	52·0	...
10	51·9	...
20	51·6	53·0
40	...	52·5
50	51·0	...
70	...	50·0
100	48·6	46·7
130	...	45·7
150	45·6	...
200	44·9	...
250	44·5	...
281	44·4	...

Each of these series shows a range from surface to bottom of about 8½°. The temperature was higher in the upper 40 feet of water towards the west end of the loch than in the deep water towards the east end, but at the depth of 100 feet the temperature was 2° lower in the former position. Off Rudha Mòr there was a fall of 2°·5 between 40 and 70 feet, and a further fall of 3°·3 between 70 and 100 feet (equal to 5°·8 in

the 60 feet of water), while in the deepest part there was a fall of  $2^{\circ}4$  between 50 and 100 feet, and a further fall of  $3^{\circ}$  between 100 and 150 feet (equal to  $5^{\circ}4$  in the 100 feet of water). All the observations indicate a range of temperature throughout the entire body of water amounting to  $13^{\circ}7$ .

*Loch Luichart* (see Plate LX.).—Loch Luichart is another large and important loch within the Cromarty firth drainage basin, second as



FIG. 47.—LOCH LUICHART, LOOKING ACROSS THE HEAD OF THE LAKE.

(Photograph by Mr. David Brigham.)

regards length only to Loch Fannich, though slightly inferior as regards superficial area to Loch Glass. It is a good fishing loch situated amid grand scenery, where Strath Bran bends to the south-east to join Strath Conon (see Fig. 47). Its general trend is north-west and south-east, bending round the base of Sgùrr Maire-suidhe, and it is broadest at the north-west end, narrowing towards the south-east. It is 5 miles in length, with a maximum breadth of nearly a mile, the mean width being one-third of a mile. Its waters cover an area of about 1130 acres, or  $1\frac{3}{4}$  square miles, and it drains directly an area of about  $39\frac{1}{2}$  square miles,

but since it receives the outflow from all the lochs described in the preceding pages, its total drainage area is very large—about  $149\frac{1}{2}$  square miles, an area 85 times greater than the area of the loch. The maximum depth of 164 feet was observed about  $1\frac{1}{2}$  miles, or about one-third of the length of the loch, from the north-west end. The volume of water is estimated at 3288 millions of cubic feet, and the mean depth at nearly 67 feet. The loch was surveyed on August 16, 1902, when the elevation of the lake-surface was found to be 249.8 feet above the sea.

The floor of Loch Luichart is irregular, there being three 50-foot basins separated by shallower water. The largest and deepest lies in the wider north-western half of the loch, and is about  $2\frac{1}{4}$  miles in length, approaching to within less than 200 yards from that end. The central 50-foot basin is separated from the north-western basin by an interval of half a mile, in which lies the single small island in the loch, and where the depth in the centre at another place is only 5 feet, and is over  $1\frac{1}{4}$  miles in length. Immediately to the south-east of this central basin there is a narrow constriction in the outline of the loch, in which a depth of 16 feet was recorded, succeeded by a slight expansion containing the third 50-foot basin, with a maximum depth of 55 feet and of small extent. The principal 100-foot basin in the north-western part of the loch is nearly 2 miles in length, and encloses the deepest part of the loch. Two small subsidiary 100-foot basins lie within the central 50-foot basin: one based upon an isolated sounding of 100 feet, the other near the south-eastern end having a maximum depth of 115 feet. The 150-foot basin is nearly a mile in length, and is distant three-quarters of a mile from the north-west end of the loch; the maximum depth of 164 feet was recorded near the south-eastern end of the basin. It is curious to note the difference in the outline of this 150-foot basin as compared with the outlines of the 50 and 100-foot basins enclosing it, for, while the shallower contours follow approximately the shoreline, and therefore enclose areas widest towards the north-west and narrowing gradually in the opposite direction, the 150-foot basin is widest towards the south-east and narrows gradually to the north-west as the outline of the loch widens out. At the same time the deep basin approaches nearer to the northern shore at its north-west end, while it approaches nearer to the southern shore at the opposite deeper end, so that at the position of the deepest sounding the slope off the southern shore is much steeper than off the northern shore, as is well brought out in the cross-section C-D on the map. The longitudinal section A-B down the centre of the loch shows the three basins included in the loch, each successively deeper on proceeding towards the north-west end. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 50 feet	482 acres	42·7 per cent.
50 ,, 100 ,,	385 ,,	34·1 ,,
100 ,, 150 ,,	208 ,,	18·4 ,,
Over 150 ,,	54 ,,	4·8 ,,
	<u>1129</u> ,,	<u>100·0</u> ,,

*Temperature Observations.*—The following table gives the results of observations taken in Loch Luichart by Mr. Clark on August 25, 1901, and by the Lake Survey on August 16, 1902:—

Depth in feet.	August 25, 1901 (R. M. Clark).	August 16, 1902, 5 p.m. Deepest part of loch in 152 feet.	August 16, 1902, 6 p.m. Near N.W. end in 93 feet.
	° Fahr.	° Fahr.	° Fahr.
0	60·6	55·9	56·0
10	60·0	...	...
20	59·6	55·8	...
40	59·1	...	...
50	...	54·8	56·0
60	57·2	...	...
70	...	...	56·0
75	...	51·6	...
80	50·9	...	...
90	...	...	48·5
100	50·5	48·4	...
150	...	48·0	...

The range of temperature shown by the 1901 observations amounts to 10°, while that shown by the 1902 observations amounts to 8°. The temperature of the upper 60 feet of water was higher in 1901 than was observed in 1902, as was also the case at a depth of 100 feet, but a lower reading was recorded at 80 feet in 1901 than at 70 and 75 feet in 1902. The two serials taken in 1902 show the effect of the strong wind which was blowing up the loch at the time of the survey, the maximum temperature observed extending down to a depth of 70 feet near the head of the loch, whereas  $1\frac{1}{2}$  miles further down the loch the temperature was always lower, amounting to a difference of 1°·2 at 50 feet and 4°·4 at 70 feet, beyond which depth a much larger fall of temperature was observed towards the head of the loch than was recorded farther down (equal to a fall of 7°·5 in the interval of 20 feet between 70 and 90 feet in the former case, and a fall of 3°·2 in the interval of 25 feet between 75 and 100 feet in the latter case).

*Loch Beannachan* (see Plate LVIII.).—Loch Beannachan (or Ben-nachran) is situated at the head of Strath Conon, amid wild moorland scenery. It trends in a west-north-west and east-south-east direction,

narrowing towards the eastern end. It is over  $1\frac{3}{4}$  miles in length, with a maximum breadth of one-third of a mile, the mean breadth being a quarter of a mile. Its waters cover an area of 267 acres, or nearly half a square mile, and it drains an area 72 times greater—an area exceeding 30 square miles. The maximum depth of 176 feet was observed approximately near the centre of the loch. The volume of water is estimated at 819 million cubic feet, and the mean depth at  $70\frac{1}{2}$  feet. The loch was surveyed on August 22, 1902, when the elevation of the lake-surface was found to be 465·6 feet above sea-level; when visited by the officers of the Ordnance Survey on June 6, 1870, the elevation was 465·1 feet above the sea.

Loch Beannachan forms a simple basin, the contour-lines following approximately the outline of the loch, but approaching in each case nearer to the western than to the eastern end. There is a large wooded island at the entrance of the inflowing river at the west end, and a small island near the exit of the outflowing river at the opposite end. The slope offshore is in some places very steep, especially at certain points along the southern shore, and at the position of the deepest sounding the slope is steeper off the southern than off the northern shore, as is shown in the cross section C-D on the map. The longitudinal section A-B shows the gradual slope towards the two ends, with quite a flat-bottomed character in the deeper water, which is also indicated by the larger area between 100 and 150 feet than between 50 and 100 feet, as given in the following table:—

0 to 50 feet	113 acres	42·3 per cent.
50 „ 100 „	67 „	25·0 „
100 „ 150 „	72 „	27·2 „
Over 150 „	15 „	5·5 „
	<hr/>	<hr/>
	267 „	100·0 „
	<hr/> <hr/>	<hr/> <hr/>

*Temperature Observations.*—A series of temperatures taken in the deepest part of the loch at 4.15 p.m. on August 22, 1902, gave the following results:—

Surface ... ..	55°·0 Fahr.
10 feet ... ..	55°·0 „
20 „ ... ..	54°·8 „
30 „ ... ..	53°·0 „
40 „ ... ..	52°·9 „
50 „ ... ..	52°·0 „
60 „ ... ..	50°·5 „
75 „ ... ..	46°·9 „
100 „ ... ..	46°·1 „
170 „ ... ..	46°·0 „

This series shows a range of temperature from surface to bottom amounting to 9° Fahr. The upper 20 feet of water was practically of uniform temperature, followed by a fall of 1°·8 between 20 and 30 feet, but the greatest fall observed was one of 3°·6 between 60 and 75 feet.

*Loch Achilty* (see Plate LXI.).—Loch Achilty is a small but deep loch in Torrachilty wood, near Strathpeffer, containing char. In outline it is somewhat elliptical, with the long axis trending north-east and south-west. It is about 1500 yards in length, by 700 yards in maximum breadth, the mean breadth being 450 yards. Its waters cover an area of about 147 acres (or nearly a quarter of a square mile), and it drains an area exceeding 2 square miles. The maximum depth of 119 feet was observed about 250 yards from the western shore. The volume of water is estimated at 332 million cubic feet, and the mean depth at 51 $\frac{3}{4}$  feet. The floor of Loch Achilty is irregular. The 10-foot contour follows approximately the outline of the loch, in many places approaching very close to the shore, but the deeper contours are all sinuous in character, and there are two small basins exceeding 100 feet in depth, the larger and deeper towards the western shore, and the smaller, based on a sounding of 112 feet, near the centre of the loch. Deep soundings were recorded in some positions near shore, while in other positions comparatively shallow soundings were taken some distance offshore. A longitudinal section along the axis of maximum depth is shown in section C-D on the map. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	41 acres	28·0 per cent.
25 „ 50 „	28 „	19·2 „
50 „ 75 „	39 „	26·2 „
75 „ 100 „	30 „	20·2 „
Over 100 „	9 „	6·4 „

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147 „	100·0 „
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This table shows a smaller area, and therefore an average steeper slope, between 25 and 50 feet, than in the deeper water. The loch was surveyed on August 20 and 21, 1902, when the elevation of the lake-surface was found to be 98·5 feet above the sea, so that the 100-foot contours show approximately the two small portions of the lake-floor which lie below the level of the sea.

*Temperature Observations.*—In the following table are given the results of three series of temperatures taken in Loch Achilty by Mr. Clark in 1901, along with a series taken in 1902 at the time of the survey:—

Depth in feet.	August 11, 1901 (R. M. Clark).	August 23, 1901 (R. M. Clark).	September 2, 1901 (R. M. Clark).	August 21, 1902 (Lake Survey).
	° Fahr.	° Fahr.	° Fahr.	° Fahr.
0	63·5	61·9	...	58·4
5	...	61·9	...	...
10	62·0	...	...	58·1
20	...	61·5	...	57·6
25	59·4	57·3	...	56·0
30	...	52·0	...	54·9
35	...	46·0	...	50·9
40	46·0	44·0	45·9	48·0
50	...	43·2	43·2	46·0
55	...	42·8	42·8	...
60	...	42·8	42·8	...
70	42·3	...	...	...
100	...	...	...	44·9

These serials indicate a most remarkable range of temperature—a range amounting to 21°·2 from the surface to a depth of 70 feet on August 11, 1901, and 19°·1 from the surface to a depth of 60 feet on August 23, 1901; the range observed in 1902 was much less, viz., 13°·5 from the surface to a depth of 100 feet. Down to a depth of 25 feet the readings were higher in 1901 than in 1902, but beyond that depth the temperature was lower in 1901 than in 1902. The greatest fall of temperature was observed between the depths of 25 and 40 feet in both seasons, but the decrease of temperature within this interval of 15 feet amounted in 1901 to 13°·3 and 13°·4, while in 1902 it amounted only to 8°. The only observations that may be compared, as regards range of temperature, with these in Loch Achilty, were taken in Loch Monzievaïrd\* in the Tay basin on June 8, 1903, when the range amounted to 20°·6 from the surface to a depth of 36 feet, and when a fall of temperature equal to 1°·5 per foot of depth was observed between 5 and 15 feet. The temperature conditions observed in Loch Achilty (as well as in Loch Monzievaïrd) may probably be ascribed to—(1) the comparatively great depth, (2) the comparatively small drainage area, and (3) the sheltered position, the thickly wooded shores tending to temper the force of the winds blowing across the surface of the water. Mention may here be made also of the large range of temperature observed in the little Loch Dubh† in the nan Uamh basin on July 12, 1902, when the range amounted to 15½° from the surface to a depth of 100 feet; it is possible that under favourable weather conditions, and later in the season, the range of temperature in the waters of Loch Dubh may equal that observed in Loch Achilty.

\* See p. 120.

† See p. 255.

*Loch Garve* (see Plate LXI.).—Loch Garve lies about 5 miles to the west of Strathpeffer, and to the south-west of the mighty Ben Wyvis (3295 feet). It receives the drainage from a large tract of mountainous country lying to the north and north-west. The body of the loch trends in a north-west and south-east direction, and is somewhat elliptical in outline, while the south-eastern end takes a slight bend to the north-east. The loch is over  $1\frac{1}{2}$  miles in extreme length, with a maximum breadth of half a mile, the mean breadth being over one-third of a mile. Its waters cover an area of about 380 acres, or over half a square mile, and it drains an area of 114 square miles—an area nearly 200 times greater than that of the loch. The maximum depth of 105 feet was observed near the centre of the loch, but towards the south-western shore. The volume of water is estimated at 721 million cubic feet, and the mean depth at  $43\frac{1}{2}$  feet. The loch forms on the whole a simple basin, with a slight shoaling at the position of the bend in the outline of the loch. The 10-foot and 25-foot contours extend from end to end of the loch, following approximately the form of the shore-line; but the deeper contours are confined to the wide body of the loch, the 50-foot basin being nearly a mile, and the 100-foot basin nearly a quarter of a mile, in length. Off the central portions of both the north-eastern and south-western shores the slope is moderately steep. The longitudinal section A-B on the map is taken along the axis of maximum depth, and shows the slight deepening of the water near the south-eastern end. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

•	0 to 25 feet	131 acres	34.5 per cent.
	25 „ 50 „	104 „	27.4 „
	50 „ 75 „	72 „	18.8 „
	75 „ 100 „	64 „	16.9 „
	Over 100 „	9 „	2.4 „
		<hr/>	
		380 „	100.0 „
		<hr/>	

From this table it will be seen that nearly two-thirds of the entire lake-floor is covered by less than 50 feet of water. Loch Garve was surveyed on August 15, 1902, when the elevation of the lake-surface was found to be 218.8 feet above the sea; when visited by the Ordnance Survey officers on August 15, 1871, the elevation was 219.6 feet above sea-level.

*Temperature Observations.*—The following table gives the results of observations made in Loch Garve in 1901 by Mr. Clark, and in 1902 by the Lake Survey:—

Depth in feet.	August 18, 1901 (R. M. Clark).	August 15, 1902.
	° Fahr.	° Fahr.
0	59·3	54·2
5	59·3	...
10	59·3	54·2
15	59·2	...
20	59·2	...
30	...	54·2
40	59·0	...
50	...	54·0
55	55·4	...
60	54·2	...
70	51·0	53·5
85	49·0	...

The 1901 observations show a range exceeding  $10^{\circ}$ , whereas the 1902 observations show that the temperature was practically uniform from surface to bottom, which may perhaps be ascribed to the influence of the strong winds prevailing at the time of the survey, causing a thorough circulation in the whole body of water.

*Loch Kinellan* (see Plate LXI.).—Loch Kinellan is a small shallow loch near Strathpeffer, which was surveyed on August 23, 1902. The elevation of the lake-surface was not determined by levelling, but from the Ordnance Survey contours it is evidently nearly 500 feet above the sea. It trends north-east and south-west, widest in the south-western portion, and with a large wooded island near the centre. Weeds abound along the western and south-western shores, and also between the island and the eastern shore. It is one-third of a mile in length, and its waters cover an area of about 15 acres. Soundings of 10 and 11 feet were taken to the north-east of the island, but the deepest part lies to the south-west, the maximum depth of 16 feet having been observed about midway between the island and the southern shore; 73 per cent. of the lake-floor is covered by less than 10 feet of water. The volume of water is estimated at 5 million cubic feet, and the mean depth at over 7 feet. The temperature of the surface water at 12.30 p.m. on the date of the survey was  $58^{\circ}\cdot7$  Fahr., and at a depth of 14 feet  $58^{\circ}\cdot3$ .

*Loch Ussie* (see Plate LXI.).—Loch Ussie (or Usie) is about a mile from Strathpeffer and 3 miles from Dingwall. It is irregular and subcircular in outline, with a maximum diameter from north-east to south-west of nearly a mile. There is one large island with a heronry upon it, and several smaller ones, and weeds are abundant in some of the bays and in the vicinity of the islands. It was surveyed on August 29, 1902, but the elevation above the sea was not determined

by levelling; when visited by the Ordnance Survey officers on September 7, 1870, the elevation was 418·9 feet above sea-level. Its waters cover an area of nearly 200 acres, or less than one-third of a square mile, and it drains an area of nearly 4 square miles. The loch is on the whole very shallow, with a deep hole in the north-eastern part of the loch, in which two soundings of 35 feet were taken; except for a neighbouring sounding of 22 feet, the remainder of the lake-floor is covered by less than 20 feet of water, and all the western and southern parts of the loch are less than 10 feet in depth. The volume of water is estimated at 68 million cubic feet, and the mean depth at 8 feet. Only 22 per cent. of the lake-bottom is covered by more than 10 feet of water, and only 2 per cent. by more than 25 feet of water. At 5.15 p.m. on the date of the survey the surface temperature was 59°·3 Fahr., and a reading at 27 feet gave 59°·0.

*Loch Glass* (see Plate LXII.).—Loch Glass is one of the larger and more important lochs within the drainage basin of the Cromarty firth, and it exceeds in depth all the other lochs of the basin. It lies in a mountainous district to the north of Strathpeffer, with Ben Wyvis and other peaks exceeding 3000 feet in height to the south-west, and lesser mountains to west, north, and north-east. It trends in a north-west and south-east direction, but with a slight bend in the outline, causing it to appear somewhat crescent-shaped. It is 4 miles in length, with a maximum width near the centre of two-thirds of a mile, narrowing gradually towards the south-east end, where the river Glass flows out, the mean breadth being nearly half a mile. Its waters cover an area of nearly 2 square miles, and it drains an area exceeding 25 square miles. The maximum depth of 365 feet was observed nearer the north-west than the south-east end, and towards the north-eastern shore. The volume of water is estimated at 8265 millions of cubic feet, and the mean depth at 159 feet. It was surveyed on August 26 and 27, 1902, but the elevation of the lake-surface above the sea was not determined by levelling; when visited by the Ordnance Survey officers on September 1, 1868, the elevation was found to be 712·9 feet above sea-level.

Loch Glass forms a simple basin, with very few minor undulations of the lake-floor. The deeper water lies towards the north-west end, and the contour-lines all enclose continuous areas. The 100-foot basin is  $2\frac{3}{4}$  miles in length, approaching close to the north-west end, but distant nearly a mile from the south-east end. The 200-foot basin is nearly 2 miles, and the 300-foot basin over a mile, in length, being distant respectively  $1\frac{1}{2}$  and 2 miles from the south-east end. The soundings indicate here and there slight irregularities on the lake-floor, and sometimes in very deep water. One of these gives rise to a curious sinuosity in the 300-foot contour-line off the south-western shore, and the sounding immediately to the south-west of the maximum depth of

365 feet indicates a shoaling of the water to 346 feet, followed by a deepening of the water to 354 feet, which is well brought out in the cross section C-D on the map. The longitudinal section A-B shows the rapid deepening of the water on proceeding from the north-west end, and the gradual shoaling of the water on approaching the opposite end of the loch. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 100 feet	454 acres	38·1 per cent.
100 „ 200 „	309 „	25·8 „
200 „ 300 „	269 „	22·6 „
Over 300 „	161 „	13·5 „
	<u>1193 „</u>	<u>100·0 „</u>

The comparatively large area of the lake-floor covered by more than 300 feet of water indicates the flat-bottomed character of the deeper part of the loch, and this is also shown by the comparatively great width of the 200-foot and 300-foot basins, and is well seen in the cross section C-D.

*Temperature Observations.*—An interesting series of temperatures was taken in the deepest part of Loch Glass at 6 p.m. on August 27, 1902, as given in the following table:—

Surface ... ..	54°·7 Fahr.
50 feet ... ..	51°·7 „
100 „ ... ..	46°·2 „
150 „ ... ..	43°·5 „
250 „ ... ..	42°·5 „
350 „ ... ..	42°·3 „

This series shows a range of temperature from surface to bottom amounting to 12°·4, the greatest fall being one of 5°·5 between 50 and 100 feet. The temperatures taken in Loch Achilty six days earlier gave a higher temperature from the surface down to 30 feet than was observed at the surface of Loch Glass, but a lower temperature at 50 and 100 feet, the differences being respectively 5°·7 and 1°·3.

*Loch Morie* (see Plate LXIII.).—Loch Morie (or Muilie) lies less than 2 miles to the north of Loch Glass, with the crests of Meall Beag (2121 feet) and Meall Mor (2419 feet) rising between them. It is an important and deep loch, containing trout, but the fishing is preserved. Lochs a' Chaoruinn and Loch Magharaidh, which flow into it, could not be sounded for lack of boats. It trends in a north-west and south-east direction, with a slight sinuosity in its outline. It is 2½ miles in length, with a maximum breadth of over half a mile. Its waters cover an area of nearly a square mile, and it receives the drainage from a large tract of the mountainous country to the north-west, the area

of which exceeds 35 square miles. The maximum depth of 270 feet was observed in the central part of the loch, but nearer the south-western than the north-eastern shore, as will be seen in the cross section C-D on the map, which is taken at the position of the deepest sounding. The volume of water is estimated at 3201 millions of cubic feet, and the mean depth at 125 feet. Loch Morie was surveyed on August 28, 1902, when the water-surface was found to be 621·6 feet above the sea; when visited by the Ordnance Survey officers on September 28, 1868, the elevation was 622 feet. The loch forms a simple basin, the contour-lines all enclosing continuous areas. The shallower contours follow approximately the outline of the loch, but the deeper ones bend in their central portions towards the south-western shore. The 100-foot basin is over  $1\frac{1}{2}$  miles, and the 200-foot basin is over a mile, in length. The slope of the bottom is in some places very steep—for instance, off the south-western shore towards the north-west end, where a sounding of 75 feet was taken about 60 feet from shore, and one of 124 feet about 120 feet from shore, showing in each case a gradient exceeding 1 in 1. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 50 feet	148 acres	25·2 per cent.
50 „ 100 „	92 „	15·8 „
100 „ 150 „	104 „	17·7 „
150 „ 200 „	113 „	19·2 „
200 „ 250 „	106 „	18·0 „
Over 250 „	24 „	4·1 „
	<u>587</u> „	<u>100·0</u> „

It will be observed that the area between 50 and 100 feet, and to a less extent that between 100 and 150 feet, are smaller than the shallower and deeper zones, indicating an average slope steeper between 50 and 150 feet than elsewhere. The temperature of the surface water was 54°·0 Fahr. on the date of the survey, but serial temperatures could not be attempted on account of the gale that was blowing.

*Loch Eye* (see Plate LXIV.).—Loch Eye is a rather large but very shallow loch, about 3 miles from Tain and a mile from Inver bay, an inlet of the Dornoch firth. It was surveyed on September 26, 1902, when the surface of the water was found to stand 47·8 feet above the sea; on December 24, 1867, the Ordnance Survey officers found the elevation to be 50·7 feet above sea-level, or 3 feet higher than in 1902. The loch is  $1\frac{3}{4}$  miles in length, with a maximum width of nearly two-thirds of a mile, and covers an area of over 210 acres, or one-third of a square mile. The maximum depth is 7 feet, and the mean depth 4 feet, the volume of water being estimated at 37 million cubic feet.

## SUMMARY TABLE.

Giving Details concerning the Locks in the Conon Basin.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. feet.	Mean feet.	Mean percent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
Crann	513.7	26	0.22	0.17	0.10	43.5	17	6.8	39.9	68	171	4	0.02	11.52	576.0
a' Chroisg	508.4	183	3.47	0.42	0.29	8.4	168	73.8	43.9	109	248	2,057	1.00	19.15	19.2
South Loch Gown,	524.4	69	0.55	0.30	0.16	29.1	52	15.9	30.5	56	183	38	0.09	13.10	150.6
North "	522.1	72	0.57	0.19	0.13	22.8	17	6.9	40.4	177	438	14	0.07	14.16	191.3
Achanalt	365.1	122	0.84	0.67	0.30	35.7	9	4.5	50.0	493	986	31	0.25	72.63	280.5
a' Chuilinn	360.8	125	1.35	0.31	0.13	9.6	43	10.2	23.8	166	697	50	0.18	74.32	412.0
Fannich	821.9	383	6.92	0.79	0.52	7.5	282	108.8	38.6	130	336	10,920	3.60	35.69	9.9
Luichart	249.8	255	5.05	0.90	0.35	6.9	164	66.8	40.8	163	399	3,288	1.76	149.45	84.9
Beannachan	465.6	91	1.85	0.35	0.23	12.4	176	70.4	40.0	55	139	819	0.42	30.12	71.7
Achilty	98.5	131	0.87	0.40	0.26	29.9	119	51.8	43.5	39	89	332	0.23	2.11	9.2
Garve	218.8	137	1.54	0.53	0.39	25.3	105	43.6	41.5	77	186	721	0.59	113.97	193.2
Kinellan	...	37	0.33	0.12	0.07	21.2	16	7.1	44.6	109	244	5	0.02	0.90	45.0
Ussie	418.9 [7/9/70]	109	0.84	0.66	0.37	44.0	35	8.0	22.8	127	556	68	0.31	3.85	12.4
Glass	712.9 [1/9/68]	224	4.03	0.65	0.46	11.4	365	139.1	43.6	58	134	8,265	1.86	25.35	13.6
Morie	621.6	126	2.30	0.60	0.40	17.3	270	125.2	46.4	45	97	3,201	0.92	35.28	38.3
Eye ...	47.8	98	1.72	0.62	0.19	11.0	7	4.1	58.6	1294	2215	37	0.33	5.30	16.1
		2188										29,850	11.65	366.33*	31.5

\* The drainage areas of Lochs Crann, a' Chroisg, Gown, Achanalt, a' Chuilinn, and Fannich are included in that of Loch Luichart.

The loch is a flat-bottomed shallow basin, 45 per cent. of the lake-floor being covered by more than 5 feet of water. The temperature of the surface water on the date of the survey was  $54^{\circ}8$  Fahr., while a reading at the bottom in 7 feet gave  $55^{\circ}0$ .

The particulars regarding the lochs in the Conon basin are collected together in the table on p. 282 for convenience of reference and comparison. From this table it will be seen that in the sixteen lochs under consideration, which cover an area of over  $11\frac{1}{2}$  square miles, nearly 2200 soundings were taken, or an average of 188 soundings per square mile of surface. The aggregate volume of water contained in the lochs is estimated at nearly 30,000 millions of cubic feet, and the area draining into them is over 366 square miles, or  $31\frac{1}{2}$  times the area of the lochs.

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#### NOTES ON THE GEOLOGY OF THE CONON BASIN.

By B. N. PEACH, LL.D., F.R.S., and J. HORNE, LL.D., F.R.S.

The rock groups entering into the geological structure of the Conon basin and the area including Strath Glass and Strath Rusdale, north of Ben Wyvis, belong to the crystalline schists and the Old Red Sandstone. A line drawn from a point in Strath Rusdale above Ardross Castle, south-west by Eileneach in Strath Glass, Achterneed station, the Falls of Rogie, and across the Conon to Glen Orrin above Muirtown House, roughly marks the boundary between the metamorphic rocks to the west and the Old Red Sandstone bordering the Cromarty firth. It will thus be seen that the crystalline schists form not only the greater part of the basin, but also the highest and wildest territory.

From the researches of the Geological Survey, extending over the greater portion of the area under description, it would appear that the metamorphic rocks may be arranged in two divisions: (1) a group of acid, basic, and ultrabasic rocks, resembling certain types of Lewisian gneiss of pre-Torridonian age along the western seaboard of Sutherland and Ross; (2) the Moine series, representing altered sediments and including the main subdivisions, (*a*) granulitic quartz-schists or quartz biotite granulites, (*b*) flaky muscovite biotite schists or gneiss frequently garnetiferous, and passing into flaggy mica-schists (pelitic schists).

Though the group of rocks of Lewisian type comprises certain acid granulitic gneisses that closely resemble the quartzose members of the Moine series, yet their dominant feature is the alternation of acid and basic materials in the form of biotite and hornblende gneisses. With

these are associated bands of garnet, amphibolite, and hornblende schist that have been mapped for some distance both in the Fannich mountains and near Scardroy, in the basin of the Meig. In some areas schists of the ultra-basic type appear that represent original masses of peridotite. This group forms isolated areas or inliers in the midst of the Moine series, being regarded as older than the latter, and probably representing the floor or platform on which the members of the Moine series rest. It is significant that different bands of the so-called Lewisian gneisses in the Conon basin are in contact with the crystalline Moine schists of sedimentary origin, and that different subdivisions of the latter overlap the former.

These gneisses of Lewisian type appear at intervals, sometimes forming comparatively narrow zones, and, again, rather broad belts. On the north and west slopes of the Fannich mountains they have been traced for several miles, being there overlain and underlain by the flaky muscovite biotite schists of the Moine series. Southwards between Strath Bran and the basin of the Meig, near Scardroy, there is a large development of them, where their relations to the Moine schists are well displayed. They likewise appear in Glen Orrin, and southwards towards Glen Strathfarrar, and eastwards near Loch Luichart.

With the exception of certain masses of foliated and unfoliated, intrusive, igneous rocks, the members of the Moine series occupy the rest of the area covered by the crystalline schists. Their lithological characters are comparatively uniform. The two main subdivisions, already indicated, graduate into each other in certain localities, thus forming an intermediate type between the highly quartzose granulitic schists on the one hand and the flaky muscovite biotite schists on the other. The members of the Moine series, which have the largest development and the widest distribution, consist of granulitic quartz-schists or quartz biotite granulites, but the pelitic schists sometimes form the most elevated ground, as, for instance, on Sgùrr Mor Fannich (3637 feet), the highest of the Fannich mountains.\* The boundary line between the two main subdivisions of the Moine series is highly involved, showing intricate rapid folding, frequently isoclinal, and pointing to intense reduplication of the strata. The most prominent belts of the garnetiferous muscovite schists have a wide distribution in the basin of the Conon. For example, they appear in the Fannich mountains, and extend south-west by Ben Fionn and Loch Rosque to Moruisg, east of Glen Carron. They likewise appear in Glen Orrin and Glen Meig, and prominent bands have been traced more or less continuously from Strath Bran north-north-west by Aultguish and the hills west of Strath Vaich to Glen Beg and Glen Alladale, in the basin of Strath Carron.

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\* The quartz-schists contain pebbly bands in places, thus clearly showing their derivative origin.

Still further east, this characteristic zone has been followed from Ben Wyvis across Strath Glass and Strath Rusdale to the hills near Fearn.

The constant reappearance, throughout the metamorphic area of the Conon basin, of the two main subdivisions of the Moine series suggests the repetition of these zones by folding. Indeed, such is the view adopted by the Geological Survey, and hence the actual thickness of this series may be much more limited than the persistent dip of the strata in one direction would lead us to suppose. The researches of the Survey indicate a probable order of succession in these schists which obtains in the tract between Ben Wyvis and Ben Dearg, and between Garve and the Carron that flows into the Dornoch firth.

In the flaky muscovite biotite schists, and in the quartzose granulites, bands of garnet amphibolite and hornblende schists occur, which have a wide distribution and are characteristic of certain horizons.

Reference must now be made to the foliated granite, intrusive in the Moine series, which is one of the most interesting features in the geology of the Conon basin. Its boundaries are of prime importance, because the distribution of the boulders supplies valuable evidence regarding the direction of the ice-flow during the glacial period. There are two important masses of these older intrusive rocks. The larger one extends from Carn nan Aigheinn, near the head of Strath Rannoch, north-east by Carn Chuinneag to Cnoc an Liath-bhaid beyond Strath Rusdale, and measures about 12 miles in length and about 5 miles in breadth. The smaller one stretches from the hills above Loch Luichart north-east by Inchbae to Carn More east of Strath Rannoch, being about 5 miles long and less than 3 miles broad. Again, on the north shore of Loch Luichart there are four outcrops of foliated granite, evidently belonging to the same set of intrusions. The Inchbae type of augen-gneiss or granite is well known, with large porphyritic crystals of orthoclase felspar oriented in a definite direction, enclosed in a granulitic ground-mass of quartz, felspar, and micas, together with crystals of garnet and sphene. This coarse porphyritic variety is largely developed in the Carn Chuinneag mass, where it is associated with foliated riebeckite granite or augen gneiss. Frequently the rock is fine grained, and merges into a finely crystalline schist.

Evidence has been obtained that these older granite masses with their basic modifications were intruded into the series of Moine sediments before they were converted into crystalline schists. A well-marked aureole of contact metamorphism accompanied this intrusion, which in places has been obscured by subsequent deformation. But at intervals round the margin the sediments are hornfelsed, and still show their original bedding-planes, while garnets and crystals of andalusite have been developed. It is further apparent that the granite masses and the Moine sediments have been subjected to a common series of dynamic stresses, for the planes of schistosity in the granite are

parallel to those in the Moine schists; indeed, in certain localities they pass, irrespective of the boundary-line, from the igneous to the altered sedimentary rocks.

On either side of the Sutors of Cromarty, and stretching southwards along the sea-cliff to Fortrose, there is a narrow belt of crystalline schists rising from underneath the Old Red Sandstone. They belong to the group of quartz biotite granulites, and are associated with bands of amphibolite.

Newer granite masses are also represented in the area, as, for instance, on the hills north of Ardross Castle above Strath Rusdale, and in Glen Orrin west of Fairburn House. They resemble the normal types of the newer granite masses of the Highlands, and were erupted after the Moine schists had assumed their present crystalline character.

The strata of Old Red Sandstone age in the basin of the Cromarty firth are arranged in the form of a great syncline, whose axis runs in a north-north-east and south-south-west direction. The base of the series and the order of succession are admirably displayed on the sea-cliffs at Cromarty, and on the south-east shore of that firth as described long ago by Hugh Miller. The basal conglomerate is there overlain by the well-known fish-band, with calcareous nodules, graduating upwards into the coarse sandstones that form the centre of the basin. On the west side of the firth a similar sequence is observable. The basal conglomerate along the flanks of the hills is usually brought into conjunction with the crystalline schists by a fault, evidently of no great amount, for the unconformity is visible at certain localities. This horizon is surmounted by red sandstones and flagstones, calcareous and bituminous shales, and occasional intercalations of clays with limestone nodules, with fish remains. These are followed by an upper band of conglomerate, which is overlain by the coarse sandstones in the centre of the basin.

Various outliers of Old Red Sandstone, largely composed of conglomerate, and resting unconformably on the highly denuded platform of crystalline schists, occur some miles to the west of the main area of this formation in the Conon basin. Some of these are met with on the plateau between Loch Luichart and Aultguish. By far the largest and most important is that still further north in Strath Vaich, where an extremely coarse conglomerate, composed largely of blocks of the contiguous foliated granite, is found on the crest of Meall a' Ghrianain (2531 feet).

At the base of the sea-cliff formed by the crystalline schists and Old Red Sandstone of the Black Isle and the North Sutor, there are small patches of Oolitic rocks which have only a limited development. They occur on the beach below high-water mark at Eathie and at Port-an-Righ and Cadh-an-Righ near Sandwick. By means of the great fault that traverses the line of the Caledonian Canal, and is continued north-east along the shore of the Black Isle, these Secondary strata have been let down against the older rocks.

Regarding the lines of displacement in the Conon basin, one of the most important is that just referred to, which skirts the base of the Black Isle, and is prolonged north-east to Tarbat Ness, whereby this straight feature has been determined. The great fault that traverses Loch Maree and Glen Docharty passes south-east by Ledgown, thence across the watershed by Carn Chaorainn to Loch Beannachan in the basin of the Meig. Another powerful dislocation, nearly at right angles to the course of the Loch Maree fault, has determined the north-north-east direction of the Meig valley between Inbhir-Chaorainn and Milton of Strathconon, and stretches south-west up Glen Chaorainn in the direction of Loch Monar, and north-north-east to the head of Loch Luichart.

During the period of extreme glaciation it would appear that the ice-sheet lay some distance to the east of the existing watershed in part of the Conon basin, for boulders of foliated granite or augen gneiss, from one or other of the masses near Inchbae, have been carried westward into the valley of Loch Broom, to Inverlael, and nearly as far as Ullapool. Their distribution in an eastward direction is no less remarkable, for they have been traced as erratics across the Black Isle and the Moray firth to the plain of Moray and the low grounds of Banffshire. The boulder clay of the north part of the Black Isle contains numerous blocks of this well-known rock, which were probably dispersed during the greatest extension of the ice. Such evidence is in harmony with that obtained in the Assynt district, where blocks of the eastern schists have been carried from the plateau of the Moine schists, east of the existing watershed, to higher elevations to the west, formed of Cambrian strata. In view of these facts, it seems probable that during one stage of the glacial period the Conon basin must have been buried under an ice-sheet that overtopped the highest hills, the movement of which was largely independent of the physical features of the region.

During the period of confluent glaciers that ensued, the great mountain groups formed more or less independent centres of dispersion. Indeed, many of the striæ, the disposition of the moraines, and the distribution of the carried blocks furnish evidence relating to this phase of glaciation. In the Fannich mountains—a range running east and west for about 7 miles, and whose main peaks rise above 3000 feet—ice-markings were found on the southern slopes at elevations between 2250 and 2500 feet trending south-south-east. Striæ pointing in a similar direction occur at various points on the ridge between Loch Fannich and Strath Bran, thus showing that at one period the Fannich ice must have crossed that loch into the Bran valley. Again, during this later glaciation, ice crossed the watersheds from Glen Fhiodaig and from Strath Conon into the valley of the Bran, and after uniting with the glaciers from Fannich and the Blackwater, passed eastwards

by the Conon valley towards the Black Isle. The striæ, trending about east-south-east, found on the tops of Meall na Speirag and Beinn Liath Beag at elevations of about 2000 feet, on the watershed between the Blackwater and the streams flowing into Loch Luichart, clearly show the development of the ice during this period.

Important evidence regarding the transport of materials during the time of the confluent glaciers is furnished by the distribution of boulders of foliated granite and Old Red Sandstone on the slopes of Ben Wyvis. These have been carried from the west or west-north-west, and have been traced up to a height of 2400 feet on Carn Gorm and Little Wyvis, while their upper limit on Ben Wyvis itself is 2300 feet. It is further apparent that the ice moved through the pass between Little Wyvis and An Cabar, and streamed down the valley of Loch Glass north of Ben Wyvis. Still further north in Kildermorie forest and Strath Rusdale, the direction of the ice-flow was south of east, as proved by the striæ, and the transport of boulders of foliated granite or augen gneiss. From the period of confluent glaciers to the time of their disappearance in the upland glens, the various stages of retrocession are represented by the moraines.

*Loch Fannich.*—The soundings clearly show that this lake gradually deepens towards the eastern portion, the deepest sounding, 282 feet, being situated about a mile above the outlet. The hill-slopes on both sides of the loch for considerable distances are covered with morainic drift, save near the outlet, where there is a prominent barrier of rock. At the latter point the southern spur of An Coileachan approaches the northern margin of the lake, and is prolonged on the south side in An Cabhar and Carn na Beiste. Along the eastern side of this ridge, the quartzose granulites and muscovite biotite schists are isoclinally folded on vertical axes striking north and south—that is, at right angles to the course of the lower part of the loch. At the outlet, and for a mile below that point, the Grudie river flows on alluvial deposits, these materials having been largely contributed by side streams, and especially by Allt a' Choin Idir, draining from the north. Beyond the alluvium, at the 800-foot level, the Moine schists are exposed in the bed of the river and on the hill-slopes, and there is here no indication of a pre-glacial river channel filled with drift. The surface of Loch Fannich is 822 feet above Ordnance datum, so that the depth of the rock basin below the rocky barrier, visible about a mile beyond the outlet, is 260 feet.

*Loch Luichart.*—This lake is a true rock basin lying among the crystalline schists, with a barrier formed of these materials at its outlet. Where the stream issues from the loch, it runs through a narrow gorge of rock and over successive waterfalls. In this sheet of water there are three basins, of which the most westerly is the most important, its greatest depth being 164 feet. The surface of the lake is 250 feet above

Ordnance datum line. The axis of the upper part of the loch coincides with the strike of the crystalline schists, while that of the lower is obliquely across it. It is interesting to note that the deepest basin has been excavated out of the flaky muscovite biotite schists, while the shallow part about the middle of the loch north of Creag Mhor corresponds with a belt of highly siliceous Moine schists folded over a core of gneiss of Lewisian type. The head of the lake nearly coincides with the Strath Conon fault already referred to, which crosses the lake in a north-north-east direction, and has there produced considerable brecciation of the strata. Only a small part has been silted up at the western end by the alluvial material brought down by the Bran and the Grudie.

*Loch a' Chroisg* and *Loch Crann*.—The former lake is evidently a rock basin, for, though at its outlet it flows over alluvial deposits that mark the site of an old lake, the rocky barrier appears about 2 miles east of Achnasheen, where the 400-foot contour-line crosses the Bran river. The surface of the loch is 508 feet above Ordnance datum, and the deepest sounding is 168 feet, so that the depth of the loch below the rocky barrier beyond Achnasheen is 60 feet. Loch Crann has been separated from Loch a' Chroisg by a cone of alluvium brought down by the streams on both sides of the valley at that point.

*Loch Achanalt* and *Loch a' Chuilinn* represent the remains of a lake which once extended for 4 miles up the valley to Dismuckeran, the level of which has been lowered by the Bran. The materials cut through during this process of denudation consisted of moraine matter, but the river has now reached the solid rock. The terraces round Loch Achanalt and Loch a' Chuilinn rise to a height of 20 feet above the surface of these sheets of water. The deepest sounding in the former is 9 feet, and in the latter 43 feet. While Loch Achanalt is being rapidly silted up by alluvial detritus, Loch a' Chuilinn preserves its character of a rock basin. At its outlet the water flows over an ice-moulded surface of granulitic quartzose schist. The strike of the strata is nearly parallel with the long axis of the loch.

*Loch Beannachan*.—As already indicated, this lake lies along the line of the powerful fault that has been traced in a south-east direction from Loch Maree and Glen Docherty.

*Loch Garve* is evidently the remnant of a much larger sheet of water that formerly extended from Little Garve down to the Falls of Rogie—a distance of about 4 miles. The former level of the lake has been lowered by the erosion of the drift deposits and the cutting of the rock gorge at the Falls of Rogie. The surface of the present loch is 220 feet above Ordnance datum line, and the deepest sounding is 105 feet. The 200-foot contour-line crosses the stream at these waterfalls. Hence, on the assumption that the Moine schists and epidiorite sills exposed at

the latter locality formed the original rocky barrier of the lake, the depth of water below this level in Loch Garve is still 84 feet.

*Loch Achilty*.—Though this lake is small, its extreme depth (119 feet) is remarkable. There is no proof that it occupies a rock basin, but it is not improbable that such may partly be the case. Towards the east it has been filled in by the delta gravels of the Blackwater, and on the other side by those of the Conon at the time of the formation of the 100-foot beach.

*Loch Ussie* is a shallow basin, 35 feet in depth, resting in drift; and *Loch Kinellan* appears to be banked by superficial deposits at the west end, while at its eastern margin the bituminous shales of the Old Red Sandstone are exposed. Its greatest depth is only 16 feet.

*Loch Morie* is obliquely traversed by a line of fault, with a down-throw towards the south-west, that branches westwards in the upper part of the basin. Each branch shifts the outcrop of the zone of altered strata in contact with the mass of foliated granite already referred to. The stream issuing from the lake flows over a rocky barrier, but it is possible that there may have been a former outlet now concealed by drift.

*Loch Glass*.—Round the north-east margin there are traces of terraces between Culzie Lodge and the foot of the lake. No rocky barrier appears till the Falls of Eillenach are reached, where the stream flows over a mass of conglomerate of Old Red Sandstone age at an elevation of about 680 feet. As the surface of the loch is 713 feet above Ordnance datum line, and the deepest sounding is 365 feet, it follows that the depth of water in Loch Glass below the level of the barrier at the Falls of Eillenach is 332 feet.

*Loch Eye* lies on the stratified deposits of the 100-foot beach.

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#### NOTES ON THE BIOLOGY OF THE LOCHS IN THE CONON BASIN.

By JAMES MURRAY.

The lochs of the Conon basin, with the exception of Loch Eye, which will be separately noticed, have the plankton of a very uniform character. The fauna includes only those species which are common to the whole country, and calls for little detailed notice. The most important feature in it is the total absence of all those species of *Diaptomus* (*D. Wierzejskii*, *D. laticeps*, *D. laciniatus*) which are common in the districts to the north and south of the Conon valley. This valley, extending nearly across Scotland, forms a line of interruption in the distribution of those species, a line completed towards the west by Lochs Maree, Dhugaill, and Sgamhain, all of similar

character. Any slight peculiarity in the fauna will be noted under the name of each loch.

In contradistinction to the absence of western species in the fauna of these lochs, is the occurrence in the flora of several Desmids of the western type. These western Desmids, though less numerous than in districts both to the north and south, are in most of the lochs.

*Loch Gown, North and South.*—These very shallow basins had an admixture of littoral species in the plankton, and the numerous Desmids included both pelagic and bog species.

*Loch a' Chroisg.*—The only peculiarities of this loch were the abundance of algæ and of the smaller pelagic animals, such as Rotifera and Protozoa. *Floscularia pelagica*, Rousselet, was abundant.

*Loch Achanalt.*—Owing to its shallow weedy character, littoral species were more numerous than pelagic ones. A species of *Gammarus* was of a bright slaty blue colour. *Ophridium* was abundant on the weeds.

*Loch a' Chuilinn.*—Among the Rotifera observed were *Euchlanis lyra*, *E. dilatata*, and *Plæsoma truncatum*. The Desmid *Staurastrum arctiscon* was frequent.

*Loch Fannich.*—As in most of our largest lakes, there were skeletons of *Clathrulina elegans* floating in the water. Although this is not a true plankton organism (it lives attached by a stalk to plants), the skeletons have seldom or never been observed during the Lake Survey work except in large lakes, while it has rarely been seen living at the margins of those lakes. The lightness of the skeletons, enabling them to float on fresh water, may serve for the distribution of the species, and small cysts are commonly seen in them. Granting this, their absence from smaller lakes is still unexplained. The only suggestion I can offer is that the lower specific gravity, resulting from the higher temperature of smaller lakes, may prevent the floating of the skeletons, or that the higher temperature may lead to a more rapid decomposition of the material of which they are composed, and so prevent their accumulation in the water.

*Loch Garve.*—There was nothing peculiar in the plankton, except the apparent absence of Desmids.

*Loch Luichart.*—In contrast with the neighbouring Loch Garve, Desmids were here abundant, and other algæ were also numerous.

*Loch Achilty.*—Desmids were numerous, including, among species of the western type, *Staurastrum arctiscon* and *S. jaculiferum*.

*Loch Kinellan.*—*Ceratium hirundinella* was very abundant, of a form with long divergent middle horns. There were also observed *Volvox globator*, *Asterionella* with very short rays, a species of *Ceriodaphnia*, and a few larvæ of *Corethra*.

*Loch Ussie.*—*Ceratium hirundinella*, of the same form as in Loch Kinellan, was the most abundant organism. This was the only loch in the district in which *Latona setifera* was seen.

*Lochs Glass and Morie* have no peculiarity worthy of remark, except the much greater abundance of algæ in Loch Glass.

*Loch Eye*.—This loch, which is only considered along with the Conon lochs as a matter of convenience, really approximates biologically to the lochs of the Shin basin, and of Sutherland generally. It is remarkable for the abundance of *Diaptomus Wierzejskii*, this being the most southern locality on the mainland where the type of the species has been observed by the Lake Survey, though it extends much further south in the Outer Hebrides, where Dr. Scott got it in Barra. The Rotifer *Triarthra longiseta* was also abundant.

## LOCHS OF THE SHIN BASIN.

THE lochs visited by the Lake Survey draining by the river Shin and river Oyckell into the Dornoch firth are Lochs Shin, Merkland, a' Ghriama, Fiodhaig, Gorm Loch Mòr, Ailsh, Craggie, an Daimh, Migdale, and an Lagain, and it has been found convenient to include also Loch Buidhe, flowing by the river Fleet into Loch Fleet, lying to the north of the Dornoch firth. The drainage area to be dealt with is indicated on the index map (Fig. 48), and extends from Tarbat Ness on the east to Cnoc a' Choilich (little more than 3 miles from the shores of Loch Broom) on the west, and to Ben Hee and Carn Dearg on the north, the total area being about 860 square miles, of which about 770 square miles drain into the Dornoch firth and about 90 square miles into Loch Fleet. Of this total about 240 square miles drain into the lochs under consideration, as will be seen from the summary table on page 305. The principal loch is Loch Shin, one of the largest of Scottish lochs, the others being comparatively small, Loch Merkland being the only one exceeding 2 miles in length. Loch Shin receives the outflow from Lochs Merkland and a' Ghriama at its northern end, and the outflow from Loch Fiodhaig about 5 miles down on its eastern shore. Gorm Loch Mòr lies at the headwaters of the river Cassley, a tributary of the river Oyckell, and Loch an Daimh flows by the river Einig into the river Oyckell, which also receives the outflow from Lochs Ailsh and Craggie. The river Shin, bearing the outflow from Loch Shin, joins the river Oyckell to form the Kyle of Sutherland at the head of the Dornoch firth. Loch Migdale flows by a short stream into the Dornoch firth on its northern side, and Loch an Lagain flows by a longer stream (the river Evelix) also into the Dornoch firth on its northern side. Loch Buidhe flows by the river Torboll into the river Fleet at the head of Loch Fleet. The boundary-line between Ross-shire and Sutherlandshire follows the course of the river Oyckell from the head of the Dornoch firth to Breabag Tarsuinn, passing up the middle of Loch Ailsh, which thus lies partly in Ross and partly in Sutherland, while Lochs Craggie and an Daimh are located in Ross-shire and the remaining lochs under consideration in Sutherlandshire.

*Loch Shin* (See Plates LXV. and LXVI.).—Loch Shin is the largest loch in Scotland to the north of Loch Ness, and, as regards length, it

ranks fifth of all Scottish lochs, being exceeded in this respect only by Lochs Awe, Ness, Lomond, and Shiel. It is a fine sheet of water situated amid beautiful scenery, with Ben More Assynt and Coniveall rising to heights exceeding 3200 feet on the west, and Meall an Eoin (3154 feet) on the north-east. It is a good trout loch, containing also *Salmo ferox*, and the islands are much frequented by wildfowl. It trends in a north-west and south-east direction, and the length measured along the centre of the loch is about  $17\frac{1}{4}$  miles. The loch is on the whole very narrow, the maximum breadth exceeding 1 mile at the junction with the small arm leading to Loch a' Bhainbh, and also at the position of the delta formation at the mouth of the river Fiodhaig. Elsewhere the breadth is considerably less than a mile, and the upper portion, to the north-west of the entrance of the river Fiodhaig, is all less than half a mile in width. The mean breadth of the entire loch is half a mile, or only 3 per cent. of the length—a percentage smaller than has been observed in any other large loch except Loch Shiel.\* The waters of Loch Shin cover an area of about 5570 acres, or nearly  $8\frac{3}{4}$  square miles, and the area of land draining into it is over 150 square miles, but as it receives the outflow from Lochs Merkland, a' Ghriama, and Fiodhaig, its total drainage area is over 190 square miles—an area 22 times greater than that of the loch. Over 800 soundings were taken, the maximum depth recorded being 162 feet, about 7 miles from the foot of the loch, opposite the little Loch an Fhreceadain on the north-eastern shore. The volume of water contained in the loch is estimated at 12,380 millions of cubic feet, and the mean depth at 51 feet, or  $31\frac{1}{2}$  per cent. of the maximum depth. Loch Shin was surveyed on August 25 to September 1, 1902, when the elevation of the lake-surface above the sea was determined, by levelling from bench-mark, as being 270·85 feet; when levelled by the officers of the Ordnance Survey on August 4, 1870, the elevation was found to be 269·7 feet above sea-level. The farmer at Overscaig stated that the water might fall 1 foot below, and rise 6 feet above, the level at the time of the survey.

The floor of Loch Shin is very irregular. None of the contour-lines are continuous from end to end of the loch, and the lines themselves are usually of a sinuous character. The 25-feet contour encloses two areas, the 50-feet contour three areas, the 100-feet contour four areas, and the 150-feet contour two areas. The lower 25-feet basin is nearly 10 miles in length, extending from close to the lower end of the loch as far as the alluvial cone at the mouth of the river Fiodhaig. Here for an interval of nearly half a mile the soundings indicate depths less than 20 feet, except for an isolated sounding of 25 feet towards the north-eastern shore. The upper 25-feet basin is nearly 6 miles in length, approaching to within half a mile from the head of the loch.

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\* See p. 242.



upon soundings of 104, 106, and 108 feet. Within the central 100-foot basin above mentioned the bottom sinks in two places below the depth of 150 feet—(1) at the south-eastern end of the 100-foot basin, where soundings of 156 and 157 feet were recorded; and (2) about half a mile farther up the loch and towards the north-eastern shore, where the deepest sounding in the loch (162 feet) was taken—apparently a deep hole surrounded by much shallower water. A section across the loch at the position of the deepest sounding is shown in cross-section E-F on Plate LXVI., and similar sections are shown in cross-section C-D on Plate LXV. taken towards the head of the loch, and in cross-section G-H on Plate LXVI. taken towards the foot of the loch. In these three sections the deepest part of the loch is seen to lie nearer to the north-eastern than to the south-western shore, but this disposition does not hold good throughout the loch, for in some of the other lines of soundings the deepest casts were taken towards the south-western shore. The longitudinal section A-B, placed at the foot of the two maps, taken along the axis of maximum depth from end to end of the loch, shows how irregular the lake-floor is along this central line, and many of the lines of soundings indicate undulations more or less pronounced, some of which give rise to striking sinuosities in the contour-lines, while others do not affect the contours, or only slightly, and are therefore not so easily remarked. As a rule, shallow water is found offshore, but occasionally deep soundings were taken close inshore—for instance, off the small promontory on the north-eastern shore,  $1\frac{1}{4}$  miles from the head of the loch, a sounding of 36 feet was recorded; farther down the same shore, off the mouth of the an Garbh-allt, a sounding of 57 feet was taken; near the pier at Shiness quarry on the same shore depths of 32 and 40 feet were found; and along the opposite shore towards the foot of the loch depths of 32, 36, 37, and 38 feet were found here and there inshore.

The alluvial cone at the mouth of the river Fiodhaig has already been referred to, and here shallow water extends right across the loch, cutting it into two deeper portions. The land has been cut into a delta-shaped form at the head of the loch, where the river from Loch a' Ghriama flows into Loch Shin.

The areas between the consecutive contour-lines at equal intervals, and the percentages to the total area of the loch, are as follows:—

0 to 50 feet	3260 acres	58·5 per cent.
50 „ 100 „	1480 „	26·6 „
100 „ 150 „	814 „	14·6 „
Over 150 „	14 „	0·3 „
	<u>5568 „</u>	<u>100·0 „</u>

These figures show that Loch Shin is comparatively shallow, 58 per

cent. of the lake-floor being covered by less than 50 feet of water, and 85 per cent. by less than 100 feet of water, while the area deeper than 150 feet is exceedingly small.

*Temperature Observations.*—Numerous surface temperatures were taken during the week spent on the survey of Loch Shin, the readings ranging from 56°·0 Fahr. to 59°·0. Three serial temperatures were taken, with the following results:—

Depth in feet.	August 27, 1902, 5.15 p.m.	August 30, 1902, 6 p.m.	September 1, 1902, 5.30 p.m.
	° Fahr.	° Fahr.	° Fahr.
0	56·5	56·7	57·0
25	...	56·1	56·8
50	56·0	56·0	56·6
90	...	56·0	...
100	54·2	...	...
150	51·2	...	...

These observations show that the whole body of water down to a depth of 90 feet was practically uniform in temperature, but in the deepest part of the loch a fall of temperature amounting to 3° was observed between 100 and 150 feet. The extreme range of temperature from surface to bottom and from end to end of the loch amounted to only 7°·8.

*Loch Merkland* (see Plate LXVII.).—Loch Merkland lies about 3 miles to the north of the head of Loch Shin, amid beautiful surroundings, Ben Hee rising to a height of 2864 feet on the north-east, with Carn Dearg (2613 feet) and other heights to the north, and Ben Leoid (2579 feet) to the west. It trends in a north-north-west and south-south-east direction, and is 3 miles in length, with a maximum breadth of over one-third of a mile, the mean breadth being a quarter of a mile. Its waters cover an area of about 440 acres, or two-thirds of a square mile, and it drains an area of about 16 square miles. Nearly 120 soundings were taken, the maximum depth of 85 feet having been observed close to the narrows towards the head of the loch. The volume of water is estimated at 577 million cubic feet, and the mean depth at over 30 feet. The loch was surveyed on September 2, 1902, when the elevation of the lake-surface above the sea was found to be 360·2 feet.

Loch Merkland is comparatively simple in conformation; the deeper water occurs towards the head of the loch, and is cut into two portions by a shoaling of the bottom at the narrow portion where the large alluvial cone laid down at the mouth of the Allt nan Allbannach on the north-eastern shore approaches the smaller cone at the mouth of the Garbh Allt on the opposite shore. The depth of the channel at the narrows referred to is 31 feet, and the 10-foot and 25-foot basins extend

from end to end, roughly approximating with the outline of the loch. The principal 50-foot basin extends from the narrows for a distance of three-quarters of a mile down the loch, and there is an isolated sounding of 52 feet to the north-west of the narrows. The 75-foot basin is a long and narrow area, half a mile in length, the deepest sounding having been recorded at the upper end of this basin, and comparatively close to the south-western shore, off which the slope is steep. This is well shown in the cross-section E-F on the map, and at other places along both shores the soundings indicate steep slopes. The longitudinal section A-B shows the shoaling of the water at the narrows, deepening immediately to the south-east to the maximum depth of the loch; there is also a scarcely perceptible shoaling farther down the loch, where a sounding of 37 feet was recorded, with 47 feet to the north-west and 41 feet to the south-east. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	190 acres	43 per cent.
25 ,, 50 ,,	198 ,,	45 ,,
50 ,, 75 ,,	37 ,,	9 ,,
Over 75 ,,	14 ,,	3 ,,
	<u>439</u> ,,	<u>100</u> ,,

These figures show that the average slope is slightly steeper within the 25-foot line than between 25 and 50 feet, and they also show how circumscribed is the area deeper than 50 feet, 88 per cent. of the lake-floor being covered with less than 50 feet of water.

*Temperature Observations.*—A series of temperatures taken in the deepest part of the loch at 6 p.m. on the date of the survey gave the following results:—

Surface ... ..	56°·8 Fahr.
25 feet ... ..	56°·2 ,,
50 ,, ... ..	56°·0 ,,
80 ,, ... ..	55°·8 ,,

These observations indicate a range of only 1° from surface to bottom.

*Loch a' Ghriama* (see Plate LXVII.).—Loch a' Ghriama (or Griam) lies immediately to the north of the head of Loch Shin, into which its waters are carried by a short rapid stream. The distance between the two lochs is only a quarter of a mile, and at the time of the survey there was a difference in level of nearly 33 feet. It is a good trout loch, and *Salmo ferox* is also found in it. The principal feeder is the Amhainn an Ceardaich, over a mile in length, bearing the outflow from Loch Merkland. It trends almost north and south, and is 1½

miles in length, nearly uniform in width, the maximum breadth being over a third of a mile, and the mean breadth over a quarter of a mile. Its waters cover an area of about 260 acres, and it drains directly an area of over  $6\frac{1}{2}$  square miles; but since it receives the outflow from Loch Merkland, its total drainage area is over  $22\frac{1}{2}$  square miles—an area 57 times greater than that of the loch. The maximum depth of 64 feet was observed approximately in the centre of the loch, but rather nearer the northern than the southern end. The volume of water is estimated at 314 million cubic feet, and the mean depth at 28 feet. The loch was surveyed on September 1, 1902, when the elevation of the lake-surface above the sea was found to be 303·7 feet, which is almost identical with the elevation observed by the Ordnance Survey officers on July 4, 1856, viz. 303·5 feet.

The conformation of Loch a' Ghriama is simple, with one or two very slight undulations of the lake-floor, the principal of which gives rise to a striking sinuosity in the 50-feet contour; otherwise the contour-lines coincide approximately with the outline of the loch. The 25-feet basin is about  $1\frac{1}{4}$  miles, and the 50-feet basin over half a mile, in length. The longitudinal section C-D, and the cross section G-H taken at the position of the deepest sounding, show generally a gradual slope down to the greatest depth, and this is borne out by the following table, giving the areas between the contour-lines and the percentages to the total area of the loch:—

0 to 25 feet	121 acres	47 per cent.
25 „ 50 „	106 „	41 „
Over 50 „	30 „	12 „
	<u>257 „</u>	<u>100 „</u>

*Temperature Observations.*—The following series of temperatures, taken at 3 p.m. on September 1, 1902, in the deepest part of Loch a' Ghriama, indicates a range of only 2° from surface to bottom:—

Surface ... ..	57°·0 Fahr.
25 feet ... ..	56°·2 „
55 „ ... ..	55°·0 „

*Loch Fiodhaig* (see Plate LXVIII.).—Loch Fiodhaig (or Fiodiag, or Fiag) lies to the north-east of the head of Loch Shin, into which its superfluent waters are carried by the river Fiodhaig (or Fiag). This is a good trout loch, but the fishing is preserved, surrounded by moorland hills, with Ben Hee rising to the north. It receives the outflow from Loch a' Ghorm-Choire and another smaller loch lying to the north, which were not sounded. The loch trends in a north and south direction, and is over  $1\frac{1}{2}$  miles in length, with a maximum breadth near the northern end of two-thirds of a mile. Its waters cover an

area of about 370 acres, or over half a square mile, and an area twenty times greater—an area of over  $11\frac{1}{2}$  square miles—drains into it. The maximum depth of 71 feet was observed not far from the largest island in the loch, and nearer the northern than the southern end. The volume of water is estimated at 415 million cubic feet, and the mean depth at nearly 26 feet. Loch Fiodhaig was surveyed on October 23, 1902, but the elevation above the sea was not determined by levelling; judging from the contour-lines, the lake-surface is apparently nearly 700 feet above sea-level. The loch is irregular both in outline and conformation. The lake-floor shows undulations, and in some places deep water approaches very close to the shore, as may be seen in the two sections on the map. The areas between the contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	203 acres	55 per cent.
25 „ 50 „	133 „	36 „
Over 50 „	33 „	9 „
	<hr/>	
	369 „	100 „
	<hr/>	<hr/>

The temperature of the surface water on the date of the survey was  $48^{\circ}0$  Fahr.

*Gorm Loch Mòr* (see Plate LXIX.).—*Gorm Loch Mòr* lies about 4 miles to the west of the head of Loch Shin, in a mountainous district, with Beinn Leoid (2597 feet) to the north, Beinn Uidhe (2384 feet) to the west, and Ben More Assynt (3273 feet) and Coniveall (3234 feet) to the south. Its outflow is carried through a series of smaller lochs (*Fionn Loch Mòr*, *Fionn Loch Beag*, and *Loch na Sròine Luime*), which could not be sounded, into the river *Cassley*. Though a comparatively small loch, it has the distinction of being deeper than the other lochs in the basin, except *Loch Shin*. It is very irregular in outline, and includes many islands. The length of the loch, along a straight line from north-west to south-east, is slightly over a mile; but along a line following the deeper water it is considerably more. The greatest width in a north-and-south direction is over half a mile, the mean breadth of the entire loch being less than a quarter of a mile. Its waters cover an area of about 185 acres, or over a quarter of a square mile, and it drains an area of  $5\frac{1}{4}$  square miles. Nearly 70 soundings were taken, the maximum depth of 91 feet being observed comparatively close to the western shore. The volume of water is estimated at 196 million cubic feet, and the mean depth at over 24 feet. The loch was surveyed on October 22, 1902, when the elevation of the lake-surface was found to be 847.0 feet above the sea; when visited by the Ordnance Survey officers on October 1, 1870, the elevation was 846.4 feet above sea-level.

The floor of Gorm Loch Mòr is most irregular, islands and banks and deep soundings being found here and there in close proximity, while in other places deep water approaches close to the shore. The contour-lines are of the most sinuous description, with isolated deep and shallow patches. The deepest part of the loch runs along the western shore, off which the slope is uniformly rather steep, and occurs towards the north-western end, as will be seen in the longitudinal section A-B on the map. The areas between the contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	126 acres	68 per cent.
25 ,, 50 ,,	35 ,,	19 ,,
50 ,, 75 ,,	16 ,,	8 ,,
Over 75 ,,	8 ,,	5 ,,
	<hr/>	
	185 ,,	<hr/>
	<hr/>	100 ,,
		<hr/>

*Temperature Observations.*—A surface reading at 10 a.m. on October 22, 1902, when commencing the survey, gave 44° Fahr., but at 2 p.m. in the deepest part of the loch a series of temperatures gave identical readings, viz. 46°·2, at the surface and at 10, 25, 50, and 75 feet.

*Loch Ailsh* (see Plate LXIX.).—Loch Ailsh lies about 10 miles to the west of Loch Shin, with the heights of Ben More Assynt and Coniveall rising to the north. It is a moderate-sized but rather shallow loch, containing trout and an occasional salmon or grilse. It is irregular in outline, slightly under a mile in length from north to south, with a maximum width in the northern portion exceeding half a mile. Its waters cover an area of about 245 acres, and it drains an area 44 times greater—an area of nearly 17 square miles. The maximum depth of 24 feet was observed in the north-eastern part of the loch, less than a quarter of a mile from the alluvial cone laid down at the mouth of the river Oyke on the northern shore. The volume of water is estimated at 88 million cubic feet, and the mean depth at 8½ feet. The loch was surveyed on September 6, 1902, when the elevation of the lake-surface above the sea was found to be 498·5 feet, almost identical with that observed by the Ordnance Survey officers on August 29, 1871, viz. 498·4 feet. The highest drift-mark observed was 4 feet above the level of the water on the date of the survey. The southern and western portions of Loch Ailsh are covered by less than 10 feet of water, the deeper part lying along the eastern shore and towards the north-eastern angle of the loch. The area of the lake-floor covered by less than 10 feet of water is about 173 acres, or 71 per cent. of the entire area, while that covered by more than 20 feet of water is only about 12 acres, or 5 per cent. The temperature of the surface water at 2 p.m. on the date of the survey was 55°·3 Fahr., and a reading at a depth of 20 feet gave 54°.

*Loch Craggie* (see Plate LXIX.).—Loch Craggie is a small but rather deep loch, less than 3 miles to the south of Loch Ailsh, the road from Oykeil Bridge to Lochinver running along the northern shore. It trends in a north-west and south-east direction, is nearly two-thirds of a mile in length, and covers an area of about 45 acres. The maximum depth of 40 feet was observed approximately in the centre of the loch. The volume of water is estimated at 30 million cubic feet, and the mean depth at  $15\frac{1}{2}$  feet. It was surveyed on September 23, 1902, when the elevation of the lake-surface was found to be 505·95 feet above the sea; when visited by the Ordnance Survey officers on August 26, 1871, the elevation was 506·5 feet above sea-level.

Loch Craggie is quite simple in conformation. The water is deep close to the shore all round, except towards the outflow at the south-east end, the area of the lake-floor covered by less than 10 feet of water being only about 15 acres, or 34 per cent. of the entire area; more than half of the bottom is covered by water between 10 and 25 feet in depth, while about 6 acres, or 13 per cent., are covered by more than 25 feet of water. Temperature observations taken at 3.30 p.m. on the date of the survey showed that the water was practically uniform in temperature from surface to bottom, the reading at the surface being  $52^{\circ}\cdot 8$  Fahr., and at the depths of 15 and 30 feet,  $52^{\circ}\cdot 5$ .

*Loch an Daimh* (see Plate LXIX.).—Loch an Daimh (or Damph) is situated about 7 miles to the south-west of Oykeil Bridge, and about 8 miles to the east of Ullapool on Loch Broom. Though at present in the eastern watershed, the day may not be far distant when it will be diverted to the west, for the small stream flowing into the Rhidorroch river is cutting back rapidly, is much lower than the loch, and will probably tap the loch at its south-west end. The shores rise well above the loch, and the south-eastern shore is wooded; it is a good trout loch, but the fishing is preserved. Loch an Daimh is a narrow loch trending south-west and north-east, nearly  $1\frac{3}{4}$  miles in length, with a maximum breadth of only one-fifth of a mile. Its waters cover an area of about 173 acres, or a quarter of a square mile, and it drains an area of about  $2\frac{1}{2}$  square miles. The maximum depth of 52 feet was observed approximately near the centre of the loch, but towards the south-west end. The volume of water is estimated at 205 million cubic feet, and the mean depth at over 27 feet. The loch was surveyed on August 23 and 25, 1902, when the elevation of the lake-surface was found to be 671·5 feet above the sea—identical with the elevation observed by the Ordnance Survey officers on August 1, 1870; during the winter of 1901-2 the water rose 2 to 3 feet.

Loch an Daimh is extremely simple in conformation, with no pronounced irregularities of the lake-floor. The 10-foot and 25-foot basins extend from end to end, and the 50-foot basin, half a mile in length,

occupies a central position. The offshore slope is in some places very steep, and the average slope outside the 25-foot contour is steeper than in the deeper water between 25 and 50 feet, as shown in the following table giving the areas between the contour-lines, and the percentages to the total area of the loch:—

0 to 25 feet	77 acres	44·5 per cent.
25 „ 50 „	87 „	50·6 „
Over 50 „	9 „	4·9 „
	<hr/> 173 „ <hr/>	<hr/> 100·0 „ <hr/>

The surface temperature on August 23, 1902, at 12.30 p.m., was 57° Fahr.; and on August 25, at 11.45 a.m., 56°.

*Loch Migdale* (see Plate LXX.).—Loch Migdale is situated close to the northern shore of the Dornoch firth, and less than a mile from Bonar Bridge at the head of that firth. It contains trout and pike, and the surrounding scenery is very fine, a conspicuous hill called Migdale Rock rising off the north-eastern shore. The island at the west end of the loch is artificial, composed of large and small stones; a crossing passes from the western shore to the island, and was covered by a foot of water at the time of the survey. The loch trends in a north-west and south-east direction, and is nearly 2 miles in length, with a maximum width of nearly half a mile towards the north-west end, the loch narrowing gradually towards the opposite end. Its waters cover an area of about 260 acres, and it drains an area of about  $7\frac{1}{4}$  square miles. The maximum depth of 49 feet was observed rather nearer the north-west than the south-east end. The volume of water is estimated at 242 million cubic feet, and the mean depth at over 21 feet. Loch Migdale was surveyed on September 24, 1902, when the elevation of the lake-surface was found to be 113·6 feet above the sea; when visited by the Ordnance Survey officers on November 1, 1869, the elevation was 115·1 feet above sea-level.

The loch forms a simple basin, with a few minor undulations of the lake-floor. The contour-lines approach nearer to the eastern end, where the Spinningdale burn flows out, the water being shallower towards the opposite end, with weeds growing off the northern shore, at the entrances of Migdale burn and Munroe's burn. The area of the lake-floor covered by less than 10 feet of water is about 70 acres, or 27 per cent. of the total area, while that covered by more than 25 feet of water is about 94 acres, or 36 per cent. Temperatures taken at 6 p.m. on the date of the survey, in the deepest part of the loch, showed very little variation in the temperature of the water, the reading at the surface being 54°·9 Fahr., at 25 feet 54°·1, and at 40 feet 54°.

*Loch an Lagain* (see Plate LXX.).—Loch an Lagain (or Laggan) lies about  $3\frac{1}{2}$  miles to the north-east of Bonar Bridge. It receives the outflow from Loch Laro (which was not sounded), and its superfluent waters are carried by the river Evelix, after a long winding course, into the Dornoch firth. It is a small, comparatively shallow loch, trending almost east and west, one mile in length, with a maximum width towards the western end of nearly a quarter of a mile, narrowing gradually towards the eastern end. Its waters cover an area of about 68 acres, and it drains a relatively large tract of country, the area of which exceeds 8 square miles—an area 74 times greater than that of the loch. The maximum depth of 18 feet was observed near the centre of the loch, but towards the northern shore. The volume of water is estimated at 23 million cubic feet, and the mean depth at  $7\frac{1}{2}$  feet. The loch was surveyed on September 25, 1902, but the elevation of the lake-surface above the sea could not be determined; the Ordnance Survey officers levelled the loch on November 23, 1869, and found the elevation to be 446·2 feet above sea-level. The lake-floor is quite simple in conformation, with no irregularities, the deeper water approaching nearer to the eastern than to the western end; the area covered by less than 10 feet of water is about 49 acres, or 71 per cent. of the total area of the loch. The temperature of the surface water was  $53^{\circ}\cdot 0$  Fahr., and a reading at a depth of 9 feet gave  $52^{\circ}\cdot 9$ .

*Loch Buidhe* (see Plate LXX.).—Loch Buidhe (or Buie) lies amid moorland hills about 5 miles to the north-east of Bonar Bridge, the road from that place to Golspie running along its southern shore. It receives the outflow from Lochs Cracail Mor and Cracail Beag (which were not sounded), and flows, as already stated, into the head of Loch Fleet. It is a good trout loch, but an attempt to introduce salmon failed. The loch trends east and west, and is  $1\frac{1}{4}$  miles in length, with a maximum breadth of nearly a quarter of a mile. Its waters cover an area of about 133 acres, and it drains an area of about  $8\frac{3}{4}$  square miles—an area over 40 times greater than that of the loch. The maximum depth of 36 feet was observed approximately in the centre of the loch. The volume of water is estimated at 68 million cubic feet, and the mean depth at  $11\frac{3}{4}$  feet. The loch was surveyed on September 25, 1902, when the elevation of the lake-surface above the sea was found to be 528·45 feet; when visited by the officers of the Ordnance Survey on May 21, 1870, the elevation was 527·3 feet above sea-level. By means of the sluice at the east end of the loch the level of the water may be raised 4 or 5 feet, but it is seldom, or never, used; according to the keeper, the water may fall 2 feet below the level on the date of the survey.

Loch Buidhe is quite simple in conformation, the bottom sinking gradually on all sides from the shore to the deepest part, which occupies a central position. The area of the lake-floor covered by less than 10

SUMMARY TABLE.

Giving Details concerning the Lochs in the Shin Basin

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.	Max. feet.	Mean feet.	Mean percent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
Shin	270·85	815	17·22	1·12	0·51	162	51·0	31·5	561	1781	12,380	8·70	190·29	21·9
Merkland	360·2	115	3·02	0·37	0·23	85	30·1	35·5	188	529	577	0·69	15·94	23·1
a' Ghriama	303·7	80	1·50	0·37	0·27	64	28·0	43·8	124	283	314	0·40	22·60	56·5
Fiodhaig	...	47	1·61	0·68	0·36	71	25·8	36·3	120	330	415	0·58	11·66	20·1
Gorm Loch Mòr	847·0	68	1·39	0·52	0·21	91	24·3	26·7	81	302	196	0·29	5·21	18·0
Ailsh	498·5	89	0·95	0·58	0·40	24	8·3	34·6	209	604	88	0·38	16·83	44·3
Craggie	505·95	41	0·62	0·18	0·11	40	15·3	38·3	82	214	30	0·07	0·87	12·4
an Daimh	671·5	65	1·71	0·20	0·16	52	27·2	52·3	174	332	205	0·27	2·44	9·0
Migdale	113·6	104	1·92	0·41	0·21	49	21·2	43·2	207	479	242	0·41	7·21	17·6
an Lagain	440·2 [23,11/69]	60	1·00	0·23	0·11	18	7·6	42·1	263	697	23	0·11	8·14	74·0
Buidhe	528·45	80	1·27	0·22	0·16	36	11·7	32·6	186	572	68	0·21	8·70	41·4
		156±									14,538	12·11	239·69*	19·8

\* The drainage areas of Lochs Merkland, a' Ghriama, and Fiodhaig are included in that of Loch Shin.

feet of water is about 66 acres, or 50 per cent. of the total area of the loch, while that covered by more than 25 feet of water is about 4 acres, or 3 per cent. Temperature observations taken in the deepest part of the loch at 1.30 p.m. on the date of the survey showed little variation, the reading at the surface being  $52^{\circ}.6$  Fahr., at 20 feet  $52^{\circ}.1$ , and at 30 feet  $52^{\circ}.0$ .

The particulars regarding the lochs of the Shin basin are collected together in the table on p. 305 for convenience of reference and comparison. From this table it will be seen that in the eleven lochs under consideration, which cover an area of over 12 square miles, nearly 1600 soundings were taken, or an average of 129 soundings per square mile of surface. The aggregate volume of water contained in the lochs is estimated at 14,500 millions of cubic feet, and the area draining into them is nearly 240 square miles, or twenty times the area of the lochs.

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#### NOTES ON THE GEOLOGY OF THE SHIN BASIN.

By B. N. PEACH, LL.D., F.R.S., and J. HORNE, LL.D., F.R.S.

Of the area included in the basin of the Shin, only narrow belts along the west, north, and east margins have been mapped by the Geological Survey. The greater part of the tract is occupied by crystalline schists of the types so largely developed in the counties of Sutherland and Ross, to the east of the line of complication which stretches southwards from Loch Eriboll by the headwaters of the Cassley and the Oykell rivers to Ullapool. The course of the Moine thrust—the most easterly of the great Post-Cambrian displacements described in the “Notes on the Geology of the Assynt District”<sup>\*</sup>—runs south from Gorm Loch Mòr by Loch Ailsh to near Loch Craggie, thence it curves westwards to Knockan beyond the limits of the Shin basin. East of this dislocation, the metamorphic rocks include quartz schists, quartz-biotite granulites, garnetiferous muscovite-biotite schists and flaggy micaceous gneisses. These are pierced by igneous materials (granite and diorite) that cover considerable areas, as near Lairg.

Along the eastern part of the basin there is a belt of Old Red Sandstone strata running in a north-east and south-west direction, its western limit being approximately defined by a line drawn from the Mound station to a point west of Edderton station. Both the middle

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<sup>\*</sup> See p. 178.

or Orcadian and the upper divisions of this formation are represented, the latter occurring between Tain and Tarbat Ness and northwards along the shore by Dornoch.

*Gorm Loch Mòr*.—This lake, situated in the high plateau east of Ben More, lies in a rock basin formed mainly of Cambrian quartzite. Part of the floor, where the Garbh Allt enters the loch, may be composed of thrust Lewisian gneiss underlying these quartzites. The deepest sounding is 91 feet, and at the outlet the water flows over ledges of the higher or "pipe-rock" zone of the quartzite. Around the lake, the traces of glaciation are extremely abundant. Both the striæ and the disposition of the carried boulders prove that, during the greatest extension of the later glaciers, the ice radiating from the east side of the Ben More range crossed the ridge in a north-east direction beyond Gorm Loch Mòr and overflowed into Loch Shin. At a later stage, the glacier that issued from Coire a' Mhadaidh curved round Cailleach an t-Sniomha on the west side of Gorm Loch Mòr, and moved north-west by Glen Beg to the head of Loch Glencoul. The quartzite plateau in the east part of the lake is dotted over with moraines, which there form the islands.

*Loch Ailsh* is a shallow lake—the greatest depth being 24 feet—partly enveloped in drift and solid rock. It rests on various zones of Cambrian age, including the quartzite, Fucoïd beds, serpulite grit, and limestone with intrusive igneous materials, all overlying the Ben More thrust-plane. From the covering of drift, it is uncertain whether this lake is a true rock basin. Its surface level is 498·5 feet, and the rock first appears at the outlet at a height of 490 feet above Ordnance datum line.

*Loch Craggie* is a true rock basin, the deepest sounding being 40 feet. The rocky barrier is formed by siliceous schists and mica-schists that are well exposed in the stream below the outlet and by the side of the road along the north bank of the lake. The height of the surface of the water above sea-level is 505·95 feet, and that of the solid rock where the bridge spans the Craggie burn below the outlet is 505 feet. The direction of the ice-movement during the later glaciation was parallel with the long axis of the lake.

*Loch an Daimh* lies along a line of dislocation or fault that has been traced for a long distance in the crystalline schists south-westwards towards the head of Loch Broom. In the streams draining the hill slope on the northmost side the strata are exposed, which there consist of quartzose granulites with intercalations of mica-schist. On the higher part of the declivity the beds dip at gentle angles to the south-east, but on approaching the lake they are thrown into rapid folds parallel with its long axis, and are much crushed and shattered. At its lower end the lake is invaded by cones of alluvium brought down by the streams on either side.

## NOTES ON THE BIOLOGY OF THE LOCHS OF THE SHIN BASIN.

By JAMES MURRAY.

Collections of plankton were made in eight lochs of the basin. The lochs are mainly characterised by the presence of two northern species of *Diaptomus* (*D. laciniatus* and *D. laticeps*), besides the common *D. gracilis*, and by the very numerous Desmids, many of which are of the western type.

Each of the three species of *Diaptomus* was found in five lochs—*D. gracilis* in Lochs Shin, a' Ghriama, Ailsh, Gorm Loch Mòr, and Fiodhaig; *D. laciniatus* in Lochs Shin, a' Ghriama, Merkland, Ailsh, and an Daimh; *D. laticeps* (or a related species) in Lochs a' Ghriama, Ailsh, an Daimh, Gorm Loch Mòr, and Fiodhaig. All three species occurred together only in two lochs (a' Ghriama and Ailsh), while in all the other lochs, except Merkland and an Lagain, there were two species; in Loch Merkland *D. laciniatus* was the only species seen. *D. laticeps* was identified in Lochs a' Ghriama and Ailsh; in Lochs an Daimh, Gorm Loch Mòr, and Fiodhaig, a species of the same group occurred, but as only females or immature males were seen, it is not certain whether they were *D. laticeps* or the very closely related *D. Wierzejskii*.

Among other Crustacea there is little to note—*Holopedium* was only seen in Lochs Shin and a' Ghriama; *Leptodora* in Lochs Shin, a' Ghriama, and an Daimh; *Sida* in Loch a' Ghriama only; *Diaphanosoma* in nearly all of the lochs. Nearly all the *Daphnie* of Loch Fiodhaig were males.

*Ilyocryptus acutifrons*, G. O. Sars, was found in Loch Shin in August, 1903, being previously unrecorded for Great Britain. It was obtained in a shallow bay at the mouth of the Fiodhaig river.

The Desmids of Loch Shin have been fully studied by Messrs. W. and G. S. West.\* On the occasion of our visit the very great abundance, of individuals as well as species, was remarkable, exceeding anything that we had observed in other lochs. In Lochs a' Ghriama and Merkland the species were also very numerous, and on the whole the same as in Loch Shin. In Lochs Ailsh, an Daimh, and an Lagain, few Desmids were seen, but all had some of the western species. In Gorm Loch Mòr and Loch Fiodhaig no Desmids were noted.

Pelagic Rotifera were abundant only in Lochs Shin, a' Ghriama, and Ailsh; in Loch Shin the plankton collections also included many littoral species, which must have been driven out by the stormy weather. *Floscularia pelagica*, Rousset, was in Loch a' Ghriama only. Skeletons of the Heliozoan, *Clathrulina elegans*, were abundant in Lochs Shin and a' Ghriama.

\* See *Journ. Linn. Soc., Bot.*, vol. 35, p. 519, 1903.

## LOCHS OF THE NAVER BASIN.

THERE are five lochs within this basin to be dealt with here, of which the largest is Loch Naver, though Loch Coir' an Fheàrna has a greater depth; a few small lochs within the basin could not be sounded by the Lake Survey for lack of boats. The overflow from Loch na Meide is carried by the Amhainn Bheag and River of Mudale into Loch Naver, and shortly after leaving Loch Naver the river Naver is joined by the river Mallart, bearing the overflow from Lochs a' Bhealaich and Coir' an Fheàrna, while still further on the river Naver is joined by the Langdale burn, bearing the overflow from Loch Syre. Of the total area of the basin (nearly 200 square miles), about 119 square miles, or 60 per cent., drain into these five lochs.

*Loch na Meide* (see Plate LXXI.).—Loch na Meide (or Meadie) lies about 10 miles to the south of Tongue, and about 22 miles to the north of Lairg, which is the nearest railway station. It trends nearly north and south, and is very irregular in outline, the northern portion being narrow, while the southern portion widens out considerably; there is a very narrow and shallow constriction near the middle, which practically cuts the loch into two portions. It is  $3\frac{1}{2}$  miles in length, and has a maximum breadth near the southern end of over a mile, the mean breadth of the entire loch being a quarter of a mile. Its waters cover an area of about 555 acres, or nearly 1 square mile, and it drains an area of 8 square miles. The maximum depth of 63 feet was observed in the wide southern portion of the loch, but towards the eastern shore, about 650 yards from the southern end, and only about 100 yards from one of the small unnamed islands. The volume of water is estimated at 498 million cubic feet, and the mean depth at  $20\frac{1}{2}$  feet. The loch was surveyed on September 25, 1902, when the elevation of the lake-surface was found, by levelling from bench-mark, to be 488.35 feet above the sea.

Loch na Meide is very irregular in conformation, with many small islands in the southern half, the largest of which is named Eilean Mòr. The deepest water was found near the southern end; a sounding in 44 feet was taken about 200 yards from the southern shore, and there is a small area about one-third of a mile in length exceeding 50 feet in



rather shallow, since 70 per cent. of the lake-floor is covered by less than 25 feet of water:—

0 to 25 feet	388 acres	70 per cent.
25 ,, 50 ,,	149 ,,	27 ,,
Over 50 ,,	18 ,,	3 ,,
	<u>555</u> "	<u>100</u> "

The temperature of the surface water at 10 a.m. on the date of the survey was 53°·0 Fahr. The deposits brought up were all very dark (black) muds.

*Loch Naver* (see Plate LXXII).—Loch Naver lies about 5 miles to the south-east of Loch na Meide, with Ben Klibreck to the south rising gently up from the shore of the loch. Altnaharra Inn, at the west end of the loch, is a well-known rendezvous for anglers. On the northern shore Reidhachaisteil and Gruamamor, and on the southern shore Ruighnasealbhaig, are the remains of considerable villages destroyed at the beginning of last century when the crofters were turned out. There are the ruins of Pictish towers near Gruamamor and on the island close to the opposite (southern) shore, and the remains of several artificial crannogs rise towards the surface of the water, in one case reaching above the surface. Loch Naver is broadly sinuous in outline, the general trend being east-north-east and west-south-west, while the upper portion for about a mile runs east and west, and it exceeds 6 miles in length. It is a comparatively narrow loch, the maximum width towards the west end not exceeding two-thirds of a mile, whence the width gradually diminishes towards the east end, the mean breadth of the entire loch being about one-third of a mile, or 6 per cent. of the length. Its waters cover an area of about 1446 acres, or  $2\frac{1}{4}$  square miles, and it drains directly an area of nearly 81 square miles; but since it receives the outflow from Loch na Meide, its total drainage area is nearly 89 square miles. The maximum depth of 108 feet was observed in the wider part of the loch about a mile from the west end. The volume of water contained in the loch is estimated at 2461 millions of cubic feet, and the mean depth at 39 feet. The loch was surveyed on September 24 and 25, 1902, when the elevation of the lake-surface was determined, by levelling from bench-marks, as being 247·6 feet above the sea; when visited by the officers of the Ordnance Survey on June 24, 1870, the elevation was found to be 246·9 feet above sea-level. The highest drift-mark observed was  $4\frac{1}{2}$  feet above the surface of the water at the time of the survey, and it was said that the water might fall to the extent of 4 feet, giving a range in level of about  $8\frac{1}{2}$  feet.

The floor of Loch Naver is rather irregular, as may be seen in the longitudinal section taken along the axis of maximum depth, which

shows how the bottom rises and falls on proceeding from one end of the loch to the other. The 25-foot contour-line is discontinuous opposite the entrance of the Allt Gruama Beag, where the deepest sounding was 24 feet, the water deepening both to the east and to the west. The 50-foot contour is continuous, enclosing an area nearly 4 miles in length, distant from the east end about  $1\frac{3}{4}$  miles, and approaching to within one-third of a mile from the west end; within this area, however, the bottom rises in two places, where soundings of 40 and 43 feet were taken. There is a small isolated 75-foot area opposite Càrn Gruama Beag, based on soundings of 76 and 80 feet, separated from the principal 75-foot basin by an interval of over a quarter of a mile, in which the greatest depth is 62 feet; the main 75-foot area is  $2\frac{1}{2}$  miles in length, and approaches to within three-quarters of a mile from the west end. There are two very small 100-foot areas, based upon isolated soundings of 100 and 108 feet, the former opposite Gruamamor, the latter farther up the loch west of Reidhachaisteil. A short distance to the west of the deepest sounding (108 feet) is a rise of the bottom covered by 40 feet of water already mentioned, and to the north-east near the northern shore is a bank covered by only 1 foot of water surrounded by much deeper water. Off the southern shore at Coill Ach' a' Chuil, towards the east end of the loch, is another bank with 6 feet of water on it, in close proximity to a sounding of 30 feet. The following table gives the areas between the consecutive contour-lines and the percentages to the total area of the loch:—

0 to 25 feet	551 acres	38·1 per cent.
25 „ 50 „	425 „	29·4 „
50 „ 75 „	301 „	20·8 „
75 „ 100 „	167 „	11·6 „
Over 100 „	2 „	0·1 „
	<hr/>	
	1446 „	100·0 „
	<hr/>	<hr/>

Temperature observations taken on September 24, 1902, gave readings of 54° Fahr. at the surface, at 25 feet, and at 50 feet; while at 80 feet the temperature was 53°·5.

*Loch a' Bhealaich* (see Plate LXXIII.).—Loch a' Bhealaich (or a-Vellich, or Vealloch) lies about  $4\frac{1}{2}$  miles to the south of the western portion of Loch Naver, with Ben Klibreck rising between them. It is almost continuous with the larger Loch Coir' an Fheàrna, the connecting stream between them being only about 200 yards in length, and the difference in level less than 2 feet. To the north of the two lochs Ben Klibreck slopes gently up to over 3000 feet, while the ground to the south is not so high, but much steeper; so steep is that around Loch a' Bhealaich (which lies in a very fine corrie) that even at noon

on the date of the survey the sun could not be seen, except by going over to the north-west shore. The two lochs trend in a north-east and south-west direction, and together have a total length of  $4\frac{3}{4}$  miles. Loch a' Bhealaich exceeds  $1\frac{1}{2}$  miles in length, with a maximum breadth of a quarter of a mile. Its waters cover an area of about 175 acres, or over a quarter of a square mile, and it drains an area of nearly 6 square miles. The maximum depth of 80 feet was observed towards the north-east end of the loch. The volume of water is estimated at 238 million cubic feet, and the mean depth at over 31 feet. The loch was surveyed on October 17, 1902, when the elevation of the lake-surface was found to be 572.2 feet above sea-level. The water might rise 2 or 3 feet above, and fall about  $1\frac{1}{2}$  feet below, that level.

The main body of Loch a' Bhealaich is quite simple in conformation, but at the north-east end there is a small expansion of the loch, having a maximum depth of 14 feet, separated from the main body by a constriction in which the depth is 9 feet. The 25-foot area is over a mile, and the 50-foot area over half a mile, in length, the deeper water being contained in the north-eastern half of the loch, the deepest sounding in 80 feet having been taken about a quarter of a mile from the north-eastern shore. The areas between the contour-lines and the percentages to the total area of the loch are as follows:—

0 to 25 feet	77 acres	44 per cent.
25 „ 50 „	69 „	39 „
Over 50 „	29 „	17 „
	<u>175 „</u>	<u>100 „</u>

Temperature observations taken in the deepest part of the loch gave  $48^{\circ}.9$  Fahr. at the surface and at 40 feet, a reading at 76 feet giving  $48^{\circ}.4$ .

*Loch Coir' an Fheàrna* (see Plate LXXIII.).—Loch Coir' an Fheàrna (or Corr, or a-Choire) is a fine sheet of water, well wooded along the south-eastern shore, the Duke of Sutherland's lodge standing at the lower (north-eastern) end. It is over 3 miles in length, and comparatively uniform in breadth, the maximum breadth being half a mile, and the mean breadth over one-third of a mile. Its waters cover an area of about 737 acres (considerably over 1 square mile), and it drains directly an area of about  $18\frac{1}{2}$  square miles, but since it receives the outflow from Loch a' Bhealaich, its total drainage area is about  $24\frac{1}{2}$  square miles. The maximum depth of 151 feet was observed comparatively near the south-west end. The volume of water is estimated at 1886 millions of cubic feet, and the mean depth at nearly 59 feet. The loch was surveyed on October 15 to 17, 1902; the elevation of the lake-surface on commencing the survey on the 15th was found to

be 569·7 feet above sea-level, but the water rose to the extent of 9 inches by the 17th, when Loch a' Bhealaich was surveyed. On the 15th the water was about its lowest level, and might rise 2 or 3 feet.

Loch Coir an Fheàrna is quite simple in conformation, with the deeper water lying towards the south-west end—that is, towards the peninsula separating it from Loch a' Bhealaich, and the fact that in Loch a' Bhealaich the deeper water also approaches the separating peninsula seems to suggest that the two lochs may at one time have been continuous. The contour-lines all enclose continuous areas, approaching much nearer to the south-west than to the north-east end, indicating a more gentle slope towards the north-east. Thus the 100-foot area is distant about three-quarters of a mile from the north-east end, but approaching to within less than a quarter of a mile from the south-west end, and the maximum depth of 151 feet was observed about half a mile from the south-west end. The slope along the south-east shore is as a rule steeper than along the opposite shore, and this is especially the case off Creag Chraobhach, at the position of the deepest sounding, where a sounding in 46 feet was taken about 50 feet from the shore. This is shown in cross-section G-H on the map. The areas between the contour-lines at intervals of 50 feet, and the percentages to the total area of the loch, are as follows:—

0 to 50 feet	343 acres	46·6 per cent.
50 „ 100 „	269 „	36·5 „
100 „ 150 „	124 „	16·8 „
Over 150 „	1 „	0·1 „
	<hr/>	
	737 „	100·0 „
	<hr/>	<hr/>

Temperature observations taken in the deepest part of the loch at 1.30 p.m. on October 16, 1902, gave readings of 50°·0 Fahr. at the surface, at 20 feet, and at 80 feet, and a reading of 49°·8 at 130 feet.

*Loch Syre* (see Plate LXXIV.)—Loch Syre lies about 3½ miles to the north of the east end of Loch Naver, on the high ground between Strath Naver and Loch Laoghal, the last-named loch being only about 1½ miles distant to the west. It is an irregular shallow loch, with several islands in it, and the eastern part is full of stones. From east to west it has a length of nearly three-quarters of a mile, with a maximum breadth of over half a mile. Its waters cover an area of about 106 acres, and it drains an area of over 5 square miles. The maximum depth of 12 feet was observed in the south-eastern part of the loch. The volume of water is estimated at 25 million cubic feet, and the mean depth at 5½ feet. The loch was surveyed on October 1, 1902, when the elevation of the lake-surface was found to be 412·8 feet above the sea; when levelled by the officers of the Ordnance Survey on

July 23, 1870, the elevation was 411.4 feet above sea-level. The level of the loch has been raised over a foot by means of a dam above the first island, and it was proposed to raise it still further to the extent of 2 or 3 feet. At the time of the survey the highest drift-mark observed was about 2 feet above the water, which might fall about a foot.

The floor of Loch Syre is irregular, as might be expected from its extremely irregular outline and many islands. The deepest water was found in the south-eastern angle of the loch, where there is a small area over 10 feet in depth, the deepest cast in 12 feet having been taken about 100 yards from the eastern shore and 150 yards from the southern shore. Between the deepest sounding and the southern shore the bottom rises to 9 feet and sinks again to 11 feet close inshore. The area of the lake-floor covered by less than 10 feet of water is about 97 acres, or 92 per cent. of the entire area of the loch. The temperature of the surface water on the date of the survey was 54°.7 Fahr.

## LOCHS OF THE BORGIE BASIN.

THE three lochs to be dealt with here form a connected series, the overflow from Loch Cùil na Síthe being carried into Loch Laoghal by the Lòn Achadh na h-Aibhne, while Lochs Laoghal and Creagach are almost continuous, the connecting stream being only about 200 yards in length. Of the total area of the basin (about 62 square miles), about 35 square miles, or 56 per cent., drain into these three lochs.

*Loch Cùil na Síthe* (see Plate LXXIV.).—Loch Cùil na Síthe (or Coulside) is a small narrow loch lying over a mile to the west of the head of Loch Laoghal, and about 5 miles to the north of Altnaharra, at the head of Loch Naver. It trends east-north-east and west-south-west, and is very nearly a mile in length, varying little in width, the maximum breadth being about 250 yards. Its waters cover an area of about 58 acres, and it receives the drainage from a comparatively large tract of country, the drainage area being about 9 square miles—an area a hundred times greater than that of the loch. The maximum depth of 14 feet was observed in two places near the middle of the loch. The volume of water is estimated at 19 million cubic feet, and the mean depth at  $7\frac{1}{2}$  feet. The loch was surveyed on September 29, 1902, but the elevation of the lake-surface above the sea could not be determined; a drift-mark was observed over 6 feet above the water, which might fall to the extent of a foot, giving a range in level exceeding 7 feet.

Loch Cùil na Síthe is extremely simple in conformation, and comparatively uniform in depth. The upper portion is being silted up, and is occupied by weeds, and the lower portion is full of stones. The 10-foot contour coincides approximately with the outline of the loch, and encloses an area of about 20 acres, or 35 per cent. of the total area of the loch. The temperature of the surface water on the date of the survey was  $56^{\circ}2$  Fahr., and a reading at a depth of 11 feet gave  $53^{\circ}9$ .

*Loch Laoghal* (see Plate LXXV.).—Loch Laoghal (or Loyal) is distant about  $4\frac{1}{2}$  miles from Tongue and about 6 miles from Altnaharra, the road between these two places running alongside the western shore of the loch throughout its whole length. To the west rises Ben Loyal,

one of the most beautiful of mountains, with picturesque outline, the highest point exceeding 2500 feet; beyond Leitirmhòr the granite is being quarried for building purposes, leaving a great scar on the hillside. To the east of the northern portion of the loch rises Beinn's Tomaine (Ben Stomino) to a height of 1728 feet, along the base of which the shore of the loch is thickly wooded. In outline the loch resembles somewhat a Wellington boot, with the toe pointing in a westerly direction, while the body of the loch trends almost north and south. The loch is  $4\frac{1}{2}$  miles in length, with a maximum breadth of nearly a mile, the mean breadth exceeding half a mile. The waters of the loch cover an area of about 1630 acres, or over  $2\frac{1}{2}$  square miles, and it drains directly an area of over 24 square miles, but since it receives the overflow from Loch Cùil na Sìthe, its total drainage area exceeds 33 square miles. The maximum depth of 217 feet was observed near the foot of the loch, little more than half a mile from the northern shore. The volume of water contained in the loch is estimated at 4628 millions of cubic feet, and the mean depth at  $65\frac{1}{4}$  feet. The loch was surveyed on September 26 to 29, 1902, and the elevation of the lake-surface on commencing the survey was found, by levelling from bench-mark, to be 369.9 feet above the sea; when levelled by the officers of the Ordnance Survey on August 29, 1870, the elevation was found to be 369.2 feet above sea-level. The highest drift-mark observed was  $2\frac{1}{2}$  feet above the surface of the water at the time of the survey, and it was stated that the water might fall to the extent of a foot.

Loch Laoghal contains two deep basins, the larger and deeper in the northern portion of the loch, and the smaller and shallower towards the head of the loch, separated by a shoaling of the bottom about  $2\frac{1}{2}$  miles from the foot of the loch, where there is a slight constriction in the outline. The 50-feet contour-line is continuous, and encloses an area about 4 miles in length, extending from quite close to the northern end to within half a mile from the south-western end. There are two 100-feet basins: the smaller one approaches to within less than a mile from the head of the loch, and is three-quarters of a mile in length, the maximum depth observed therein being 137 feet, about  $1\frac{1}{2}$  miles from the south-west end; the larger one is over 2 miles in length, and approaches to within about 250 yards from the northern end, enclosing the deepest part of the loch. The 150-feet area is about  $1\frac{1}{4}$  miles in length, and distant about a quarter of a mile from the northern end. The 200-feet area is nearly three-quarters of a mile in length, distant less than half a mile from the northern end. The longitudinal section on the map shows how rapidly the water deepens on proceeding from the northern end along the central line of the loch, while the opposite end of the loch is comparatively shallow and the slope of the bottom there gentle; it also shows the considerable rise

of the bottom between the two deep basins. The cross-section G-H is taken at the position of the deepest sounding, and shows a slight rise of the bottom off the western shore from 80 to 75 feet. This section shows a steep offshore slope at both sides of the loch, but more especially off the eastern shore, where a sounding in 78 feet was taken about 80 feet from shore, and this steep slope off the eastern shore is continued to the northward, where a sounding in 48 feet was taken about 60 feet from shore. The soundings taken on the rise between the two deep basins indicate a rather uneven floor; for instance, one line of soundings from west to east shows that the bottom sinks gradually from the western shore to 86 feet, then rises to 60 feet, sinks to 75 feet, rises to 30 feet, sinks slightly again to 32 feet, and then rises towards the eastern shore; a little farther south a sounding was taken in 40 feet between two deeper soundings (54 and 57 feet).

The following table gives the approximate areas between the consecutive contour-lines, and the percentages to the total area of the loch:—

0 to 50 feet	612 acres	38 per cent.
50 ,, 100 ,,	522 ,,	32 ,,
100 ,, 150 ,,	246 ,,	15 ,,
150 ,, 200 ,,	200 ,,	12 ,,
Over 200 ,,	49 ,,	3 ,,
	<u>1629</u> ,,	<u>100</u> ,,

*Temperature Observations.*—Many observations of the temperature of the surface water in Loch Laoghal were taken on September 26, 27, and 29, 1902, and two serial temperatures were taken on September 29, one in each of the two deep basins. The surface temperature varied from 52°·5 to 53°·6 Fahr. The serials gave the following results:—

Depth in feet.	Deepest part of loch.	Southern deep basin.
	Sept. 29, 1902, noon.	Sept. 29, 1902, 2 p.m.
	° Fahr.	° Fahr.
0	53·0	53·6
10	52·5	53·4
15	52·4	...
20	52·5	...
25	52·5	52·9
27·5	...	52·6
30	...	53·6
35	...	52·2
40	...	52·4
50	52·5	52·4
70	52·4	52·3
100	52·4	52·5
125	50·9	...
135	47·8	52·3
145	46·7	...
150	46·5	...
195	46·1	...

These observations show an extreme range throughout the loch amounting to  $7^{\circ}5$ , but the greater part of this range was observed beyond the depth of 100 feet in the deepest part of the loch, the range from the surface down to 100 feet not exceeding  $1^{\circ}4$ . In the southern shallower basin the temperature varied little down to the bottom in 135 feet, there being no decrease in temperature beyond 100 feet, whereas at a depth of 135 feet in the northern deeper basin the temperature was  $4^{\circ}5$  lower than at a similar depth in the southern basin, and the temperature at the bottom of the deeper basin was  $6^{\circ}$  lower than anything observed in the shallower basin.

*Loch Creagach* (see Plate LXXV.).—Loch Creagach (or Craggie) lies immediately to the north of Loch Laoghal and at the same level, the short stream between them having a slight current flowing from Loch Laoghal into Loch Creagach. At the north end of Loch Creagach there is a small expansion of the outflowing river, called Loch Slaim (or Slam), which was not sounded. The general trend of Loch Creagach is nearly north and south, with a slight bend in the outline, the northern portion running towards the north-east. It is over  $1\frac{1}{2}$  miles in length, with a maximum width in the southern portion of half a mile. Its waters cover an area of nearly 300 acres, or nearly half a square mile, and it drains directly an area of  $1\frac{3}{4}$  square miles; but since it receives the outflow from Lochs Laoghal and Cùil na Sìthe, its total drainage area is nearly 35 square miles. The maximum depth of 84 feet was observed near the middle of the loch. The volume of water is estimated at 429 million cubic feet, and the mean depth at 33 feet. The loch was surveyed on September 27, 1902, when the elevation of the lake-surface was found to be identical with that of Loch Laoghal, viz. 369.9 feet above the sea; when levelled by the Ordnance Survey officers on August 27, 1870, the elevation was 369.2 feet above sea-level, as in the case of Loch Laoghal.

Loch Creagach resembles Loch Laoghal in that it contains two deep basins, which are separated by shallower water at the position of the constriction in the outline of the loch towards the northern end. The deeper basin occupies the wide southern portion of the loch, towards the peninsula separating this loch from Loch Laoghal, in which also the deeper water approaches the dividing peninsula, suggesting that at one time the two lochs may have formed a continuous sheet of water. The principal 50-foot area is about three-quarters of a mile in length, distant less than a quarter of a mile from the southern end of the loch. Within this basin there is a small elevation covered by 47 feet of water in the widest part of the loch towards the eastern shore. The maximum depth of the loch (84 feet) occurs a short distance to the north of this elevation, and about three-quarters of a mile from both ends, but towards the western shore, as will be seen in cross-section C-D on the

map. Towards the northern end of the loch lies the second 50-foot area, based on soundings of 50 and 51 feet, and of small extent, the greatest depth recorded on the ridge separating the two deep basins being 20 feet close to the eastern shore. The contour of the bottom is shown in the longitudinal section A-B on the map. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	138 acres	46·4 per cent.
25 „ 50 „	78 „	26·2 „
50 „ 75 „	74 „	24·9 „
Over 75 „	7 „	2·5 „
	<hr/>	<hr/>
	297 „	100·0 „
	<hr/>	<hr/>

The temperature of the surface water on the date of the survey was 54° Fahr., and four readings beneath the surface in the deepest part of the loch gave identical results, viz. 53° at depths of 10, 25, 50, and 70 feet.

## LOCHS OF THE KINLOCH BASIN.

THERE are two lochs to be dealt with here, viz. Loch Chaluum and Loch an Dithreibh, the superfluent waters of which are carried into the Kyle of Tongue by the Amhainn Ceann Locha (or Kinloch river). Loch Chaluum is the only one of several small lochs in the basin which could be sounded, and it flows by the Allt an Dithreibh into Loch an Dithreibh. The two lochs form a complete contrast in outline and conformation of the bottom.

*Loch Chaluum* (see Plate LXXVI.).—Loch Chaluum lies on the south-western flank of Beinn Laoghal, little more than a mile from Loch Cùil na Sìthe in the Borgie basin. It is most irregular in outline and in conformation, with one comparatively large island, and with weeds obstructing many of the bays. Measured in a south-west and north-east direction, it is about three-quarters of a mile in length, with a maximum breadth of half a mile, its waters covering an area of about 96 acres. The maximum depth of 30 feet was observed in the extreme western portion of the loch, the mean depth being estimated at 8 feet, and the volume of water at 33 million cubic feet. The loch was surveyed on September 29, 1902, but the elevation of the lake-surface above the sea could not be determined.

Loch Chaluum is on the whole shallow, only three soundings exceeding 20 feet having been recorded in the most westerly expansion of the loch. There are two 10-foot basins, the principal one extending from the extreme west end of the loch to beyond the island, filling up the south-western expansion of the loch to the south of the island, and enclosing the deepest part of the loch, the smaller one lying in the eastern and south-eastern expansions of the loch, and having a maximum depth of 17 feet. The greater part of the lake-floor is covered by less than 10 feet of water, equal to about 69 acres, or 72 per cent. of the total area.

*Temperature Observations.*—A series of temperatures was taken in the deepest part of the loch, with the following results:—

Surface ... ..	55°·8 Fahr.
2 feet ... ..	55°·7 "
3 " ... ..	55°·4 "
3·5 " ... ..	55°·2 "
4 " ... ..	53°·6 "
5 " ... ..	53°·4 "
10 " ... ..	53°·0 "
20 " ... ..	53°·1 "

This series shows a range of 2°·8, there being a fall of no less than 1°·6 between 3½ and 4 feet.

*Loch an Dithreibh* (see Plate LXXVI.)—*Loch an Dithreibh* (or *Deerie*, or *Derry*) lies less than 3 miles to the south of the head of the *Kyle of Tongue*, with *Ben Loyal* to the east and the lofty *Ben Hope*, a magnificent object in the landscape, to the west. The general trend of the loch is north-north-east and south-south-west, the main body of the loch trending almost north and south, and throwing out an arm towards the north-east. The loch is over 1½ miles in length, the main body being approximately uniform in width, with a maximum breadth of two-thirds of a mile, while the north-eastern arm is much narrower; the mean breadth of the entire loch is nearly half a mile. Its waters cover an area of about 475 acres, or three-quarters of a square mile, and it drains directly an area of 10 square miles; but since it receives the overflow from *Loch Chalum*, its total drainage area is 12¾ square miles. The maximum depth of 157 feet was observed approximately near the centre of the main body of the loch. The volume of water is estimated at 1366 million cubic feet, and the mean depth at 66 feet. The loch was surveyed on October 1, 1902, when the elevation of the lake-surface was found, by levelling from bench-mark, to be 267·45 feet above the sea; when levelled by the officers of the Ordnance Survey on October 26, 1870, the elevation was 267·8 feet above sea-level.

*Loch an Dithreibh* includes two basins—(1) a larger deep basin in the main body of the loch, and (2) a smaller shallower basin in the north-eastern arm, separated by a rise of the bottom on which the deepest sounding was 49 feet. The maximum depth observed in the small subsidiary basin was 59 feet, and the separating ridge is irregular, for a sounding in 21 feet was taken in its central part surrounded by deeper water. The 25-foot contour-line is continuous from end to end of the loch, coinciding approximately with the outline of the loch, but approaching close to the eastern shore off *Creag an Dithreibh* and *Creag na Luath-ghaire*. The 50-foot area is cut into two portions, as already indicated, the main portion approaching close to the southern end of the loch and exceeding 1 mile in length. The 75-foot area is nearly a mile in length, and at its northern border the lake-floor shows conspicuous undulations, giving to the 75-foot contour-

line a strikingly sinuous character. The 100-foot area has a length of three-quarters of a mile, approaching comparatively very close to the southern shore, where a sounding in 115 feet was recorded about 150 yards off shore. The 125-foot area exceeds half a mile in length, and the small 150-foot area, based upon soundings of 151, 152, and 157 feet, occupies an approximately central position. Along the eastern shore the slope of the bottom is in places very steep. Off Creag na Luath-ghaire a sounding of 40 feet was taken about 80 feet off shore, and another sounding in 49 feet about 70 feet off shore, while off Creag an Dithreibh one sounding was taken in 65 feet about 100 feet off shore, and another sounding in 65 feet about 60 feet off shore. This last-mentioned sounding gives an angle of slope exceeding  $45^\circ$ , the fall exceeding 1 foot per foot. The areas between the consecutive contour-lines at equal intervals, and the percentages to the total area of the loch, are as follows:—

0 to 50 feet	204 acres	42.9 per cent.
50 „ 100 „	150 „	31.4 „
100 „ 150 „	113 „	23.9 „
Over 150 „	9 „	1.8 „
	<hr/> 476 „ <hr/>	<hr/> 100.0 „ <hr/>

*Temperature Observations.*—A series of temperatures taken in the deepest part of the loch on the date of the survey gave the following results:—

Surface ... ..	54°.0 Fahr.
25 feet ... ..	53°.5 „
50 „ ... ..	53°.0 „
100 „ ... ..	52°.5 „
125 „ ... ..	48°.6 „
145 „ ... ..	48°.4 „

This series shows a range of  $5^\circ.6$  from surface to bottom, the greatest fall of temperature occurring beyond the depth of 100 feet—a fall equal to about  $4^\circ$  between 100 and 125 feet.

## LOCHS OF THE HOPE BASIN.

THE only loch to be dealt with here is the large Loch Hope, one of the most important and the most northerly of the Sutherlandshire lochs. There are several small hill lochs within the basin, which could not be sounded at the time of the visit of the Lake Survey. The headwaters of the basin take their rise on the flanks of Ben Hee, of Meallan Liath, and of Meall Horn, whose summits attain heights exceeding 2500 feet. The total area of the basin is 75 square miles, of which nearly the whole drains into Loch Hope.

*Loch Hope* (see Plate LXXVII.).—Loch Hope lies close to the eastern shore of Loch Eriboll on the north coast of Scotland, at an elevation of only  $12\frac{1}{2}$  feet above sea-level, so that a slight subsidence would convert it into an arm of the sea and a branch of Loch Eriboll. The natives declare that the sea never enters the loch, though ordinary spring tides attain a point not more than half a mile from the foot of the loch, and at the upper end three terraces are to be seen, and traces perhaps of a fourth. Ben Hope rises very steeply to a height of over 3000 feet to the south-east of the head of the loch, and the ground further north and to the west, though not so high, is also steep close to the shore; some parts of the shores are well wooded. The loch is free from islands, but on the date of the survey a reputed old castle was just showing a few inches above the water about a mile from the foot of the loch. The trend of the loch is almost north and south, and the total length exceeds 6 miles. The two ends of the loch are narrow, but it broadens out in the central portion, where there is a maximum breadth of three-quarters of a mile; the mean breadth of the entire loch is over one-third of a mile. The waters of the loch cover an area exceeding 1500 acres, or  $2\frac{1}{3}$  square miles, and it drains an area exceeding 73 square miles. The maximum depth of 187 feet was observed about midway between the two ends of the loch. The volume of water is estimated at 4032 millions of cubic feet, and the mean depth at  $61\frac{1}{2}$  feet. The loch was surveyed on September 30, 1902, when the elevation of the lake-surface was found, by levelling from bench-mark, to be 12.55 feet above the sea; when levelled by the officers of the Ordnance Survey on August 9, 1858, the elevation was

12·3 feet above sea-level. The highest drift-mark observed was 9 feet above the surface of the water on the date of the survey, and, according to the local ghillie, the water might fall 2 feet lower, giving a total range in level of about 11 feet.

The floor of Loch Hope is somewhat uneven. Proceeding from the lower (northern) end of the loch for a quarter of a mile, one meets with a small 25-foot area, based on soundings of 26, 30, and 32 feet, whence the bottom rises in the vicinity of the reputed old castle already mentioned, which lies toward the eastern shore; off the opposite shore in this locality there were many boulders in the water. Thence proceeding to the southwards, the water rapidly deepens until it attains a depth of 104 feet opposite the entrance of the Allt an Ruighein, about  $1\frac{1}{2}$  miles from the foot of the loch. Thence for a distance of about three-quarters of a mile the bottom rises again until the depth in the centre is 44 feet, with deeper water on both sides. This shoal coincides with a narrowing in the outline of the loch, whence to the south the loch broadens out and the water deepens so rapidly that at a distance of little more than half a mile from the 44-foot sounding the maximum depth of the loch (187 feet) is met with. A section across the loch in the position of the deepest sounding is shown in cross-section C-D on the map. From this position the bottom rises gradually, though irregularly, towards the head of the loch. A section down the centre of the loch along the axis of maximum depth is shown in longitudinal section A-B on the map, which brings out the salient features in the conformation of the lake-floor, but gives no indication of some of the minor irregularities. For instance, the 44-foot shoal already referred to is not shown because a depth of 56 feet occurs nearer the western shore, nor another shoaling covered by 117 feet of water to the south of the deepest sounding. The offshore slope is in some places rather steep—for instance, along the eastern shore, where off the entrance of the Allt a' Mhuilinn a sounding in 53 feet was taken about 60 feet from shore, and off the entrance of the Allt a' Phris Ghil a sounding in 28 feet was taken about 30 feet from shore; also along the western shore about  $1\frac{1}{2}$  miles from the head of the loch, where a sounding in 25 feet was taken about 30 feet from shore. The following table gives the approximate areas between the contour-lines at equal intervals, and the percentages to the total area of the loch:—

0 to 50 feet	723 acres	48·0 per cent.
50 ,, 100 ,,	474 ,,	31·5 ,,
100 ,, 150 ,,	218 ,,	14·5 ,,
Over 150 ,,	91 ,,	6·0 ,,
	<hr/> 1506	<hr/> 100·0
	,,	,,

*Temperature Observations.*—A series of temperatures was taken at

## SUMMARY TABLE.

Giving Details concerning the Lochs in the Naver, Borgeie, Kinloch, and Hope Basins.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. feet.	Mean feet.	Mean percent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
na Meide	488.35	168	3.33	1.17	0.26	7.8	63	20.61	32.7	279	853	498	0.87	8.05	9.3
Naver	247.6	240	6.18	0.66	0.37	6.0	108	39.06	36.2	302	835	2,461	2.26	88.78	39.3
a' Bhealaich	572.2	55	1.60	0.24	0.17	10.6	80	31.20	39.0	106	271	238	0.27	5.86	21.7
Coir' an Fhearna	569.7	114	3.15	0.48	0.37	11.7	151	58.79	38.9	110	283	1,886	1.15	24.48	21.3
Syre	412.8	52	0.70	0.59	0.24	34.3	12	5.48	45.6	308	675	25	0.17	5.34	32.4
Cuil na Síthe	...	46	0.96	0.14	0.10	10.4	14	7.42	53.0	211	398	19	0.06	8.91	99.0
Laoghal	369.9	269	4.46	0.89	0.57	12.8	217	65.21	30.1	109	361	4,628	2.55	33.05	13.0
Creagach	369.9	77	1.57	0.48	0.30	18.8	84	33.17	39.5	99	250	429	0.46	34.83	75.1
Chaluim	267.45	71	0.78	0.56	0.19	24.4	30	7.92	26.4	137	520	33	0.15	2.67	17.8
an Dithreibh	12.55	83	1.55	0.64	0.48	31.0	157	65.93	42.0	52	124	1,366	0.74	12.66	17.1
Hope	...	234	6.13	0.77	0.38	6.3	187	61.47	32.9	173	527	4,032	2.35	73.37	31.2
		1409										15,615	11.06	239.46*	21.7

\* The drainage area of Loch na Meide is included in that of Loch Naver; that of Loch a' Bhealaich in that of Loch Coir' an Fhearna; those of Lochs Cùil na Síthe and Laoghal in that of Loch Creagach; and that of Loch Chaluim in that of Loch an Dithreibh.

3 p.m. on the date of the survey in the deepest part of the loch, with the following results:—

Surface ... ..	54°·6 Fahr.
5 feet ... ..	54°·6 „
10 „ ... ..	54°·5 „
25 „ ... ..	54°·2 „
50 „ ... ..	54°·0 „
100 „ ... ..	53°·3 „
120 „ ... ..	53°·0 „
135 „ ... ..	52°·1 „
150 „ ... ..	49°·2 „

This series shows a range from surface to bottom amounting to 5°·4. The upper layers of water are practically uniform in temperature, the decrease from the surface down to 50 feet being only 0°·6, down to 100 feet 1°·3, and down to 120 feet 1°·6, whereas between the depths of 120 and 150 feet the fall of temperature was 3°·8. It was stated that the loch freezes all over in winter.

The details regarding the lochs in the Naver, Borgie, Kinloch, and Hope basins are collected together in the table on p. 326 for convenience of reference and comparison. From this table it will be seen that in the eleven lochs under consideration over 1400 soundings were taken, and that the aggregate area of the water surface is over 11 square miles, so that the average number of soundings per square mile of surface is 127. The aggregate volume of water contained in the lochs is estimated at about 15,600 millions of cubic feet. The area drained by these lochs is about 239½ square miles, or twenty-two times the area of the lochs.

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#### NOTES ON THE GEOLOGY OF THE DISTRICT BETWEEN LOCH HOPE AND STRATH NAVER.

By B. N. PEACH, LL.D., F.R.S., and J. HORNE, LL.D., F.R.S.

The district extending from Loch Hope to Strath Naver, in the north of Sutherland, has not yet been wholly mapped by the Geological Survey.

The north-western tract, embracing the lower part of Loch Hope, comes within the belt of territory affected by the Post-Cambrian movements to which reference has been made in the description of the geology of the districts of Loch Assynt and Loch Maree.\* Hence, on the hill-slopes on either side of the river Hope, we find various subdivisions of

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\* See pp. 178 and 233.

the Cambrian system, repeated by folds and reversed faults, and overlaid by slices of Archæan gneiss, which resemble portions of the old floor on which the Cambrian strata rest unconformably west of Loch Eriboll and the Kyle of Durness.

East of these displaced masses there is a great succession of crystalline schists stretching eastwards to Strath Naver, which, in the north of Sutherland, are everywhere separated from the rocks to the west by a powerful line of disruption, termed the Moine thrust. They consist of two main types—flaggy quartzose granulites and garnetiferous muscovite-biotite schists with intermediate varieties—the whole evidently representing an altered sedimentary series. Bands of garnetiferous hornblende-schist are intercalated in these granulitic schists, which are, without doubt, deformed intrusive sheets of igneous material. The lithological characters of the strata, the order of succession, and the peculiar system of folding are magnificently displayed on Ben Hope (3040 feet), where the divisional planes generally dip to the east-south-east at angles varying from  $12^{\circ}$  to  $30^{\circ}$ . But in addition to these members of the Moine series, which are now generally regarded as altered sediments, there are belts of massive, hornblentic, and micaceous gneisses resembling the Lewisian types in the north-west of Sutherland. The precise relationship of these two divisions of the crystalline schists has not been definitely ascertained in this district, but it is sufficiently clear that they have been affected by a common system of folding, and in certain localities by common planes of schistosity. From the north coast, these massive basic and acid gneisses of Archæan type stretch southwards along the west side of the Borgie valley to Loch Creagach, near Loch Laoghal, and another belt of somewhat similar materials has been traced from the village of Tongue northwards by Ribigill to Loch an Dithreibh.

After the eastern schists had assumed their present crystalline characters, they were pierced by intrusive masses of granite, which form a picturesque group of peaks on Beinn Laoghal, south of Tongue. The mapping of that area leads to the conclusion that the granite there forms a great sill-like intrusion, which, on the north-east side of the loch of that name, branches off into minor sheets, or apophyses.

On the east side of the Kyle of Tongue there are various small outliers of Old Red Sandstone, largely composed of conglomerate, as, for instance on Cnoc Creagach, on Beinn Bhreac, and on Cnoc an Fhreiceadain, which rest unconformably on the crystalline schists. They contain fragments of the various component members of the underlying platform, together with blocks of Cambrian quartzite and limestone.

*Loch Hope.*—The lower portion of this lake, measuring about 2 miles in length, is floored by thrust masses of Lewisian gneiss and deformed schistose rocks affected by the Post-Cambrian movements, while the

lip of the basin, above the point where the loch discharges into the river Hope, is composed of Lewisian gneiss on the east side and Cambrian quartzites on the west. No rock is visible at the mouth of the lake, nor in the course of the stream that connects it with the sea. On either side of the river Hope there are alluvial terraces, eroded partly out of solid rock and partly out of raised beach deposits. There are the remains of the 100-foot beach by the river Hope, and of the 50-foot beach at the head of the lake; hence it is evident that during their deposition the sea must have extended far up the valley.

The lower portion of the lake lies along a line of fault trending nearly north and south, which is evidently continued northwards along the channel of the river Hope, though concealed by the alluvial deposits. On either side of this line there has been a lateral shift of the outcrops of the various groups of rock, indicating a downthrow to the east. This dislocation has been proved to traverse that portion of land that juts into the loch on the west side about a mile south of Poll Ath-roinn, where the quartzose flagstones of the Moine series have been thrown down against a narrow belt of deformed Lewisian gneiss. Though the whole of Strath Mor (the valley above Loch Hope) has not been mapped by the Geological Survey, it is not improbable, judging from the straight feature, that the fault may be prolonged southwards, and may have been a prominent factor in determining the original course of the valley.

Though no rock is seen at the outlet of the lake, it is not improbable that it may be a rock basin. Its widest and deepest part lies within the area occupied by the eastern or Moine schists (Geological Survey), just above the belts of displaced and deformed Lewisian gneisses and the crushed schistose rocks in association with them. Bounded by the 75-foot contour-line, this upper basin extends for  $1\frac{1}{2}$  miles above the narrows, with an average breadth of one-third of a mile. A second basin, with a maximum depth of 104 feet, occurs further down, opposite Poll Ath-roinn, which is carved out of a belt of Lewisian gneiss and the mylonized rocks above the Moine thrust-plane.

As the surface of the water in Loch Hope is only 12 feet above sea-level, the greater part of the lake is below the level of the sea.

The striæ and the distribution of the drift indicate that during the early and later glaciations the ice moved from the south towards the north, so that the trend of the lake coincides generally with the direction of ice-movement.

*Loch Laoghal, Loch Creagach, and Loch Slaim.*—The rocks underlying this chain of lochs consist of hornblendic gneisses exposed on either side of Loch Slaim, of granulitic micaceous gneisses of the Moine series, and the granite of Beinn Laoghal and Beinn's Tomaine. Along the northern margin of this granite mass the strike of the schists is nearly east and west, the general dip of the foliation planes being towards the south at angles varying from  $20^{\circ}$  to  $70^{\circ}$ . These rocks are

visible at certain localities on either side of Loch Creagach, and on the ridges east and west of the lower end of Loch Laoghal, where they pass underneath the sill-like mass of granite and its apophyses. For a distance of upwards of 2 miles from the foot of Loch Laoghal granite occurs on both banks of the lake, but in the southern portion the granite extends continuously along the west side, while the crystalline schists occur at intervals on the east side.

Though these three lakes are now separated from each other, they may be regarded as one sheet of water, as they are nearly at the same level. The strip between Loch Slaim and Loch Creagach consists partly of moraine matter and partly of the same material arranged in the form of terraces rising to about the 400-foot contour-line. The barrier between Lochs Creagach and Laoghal is composed partly of terraced morainic matter, partly of alluvium brought down by the stream draining the north slope of Beinn's Tomaine, and partly of gravelly material driven along the spit by the prevalent west wind.

An alluvial terrace, about the 400-foot level, connects the three lakes, thereby indicating that they must have been at one time continuous. This feature does not occur in the upper part of Loch Laoghal, where the unmodified moraines extend downwards to the present shore of the loch. It is not improbable, therefore, that the upper portion may have been occupied by a glacier while the barrier of moraines beyond Loch Slaim was being lowered.

But though these lakes are ponded back by moraines at the surface, it would appear that the lower portions of Loch Creagach and Loch Laoghal may be rock basins, for at a distance of about  $1\frac{1}{2}$  miles below Loch Slaim the river Borgie flows over a rocky floor of hornblendic gneiss at a height of 304 feet, while the surface level of the two upper lochs is 369 feet. The difference between these elevations is 65 feet. On referring to the chart of the soundings, it will be seen that the greatest depth of Loch Creagach is 84 feet, of the lower basin of Loch Laoghal 217 feet, and of the upper basin 137 feet. If, then, we assume that the rocky barrier  $1\frac{1}{2}$  miles below Loch Slaim, near Dailaneas, crosses the valley at the same level (304 feet) underneath the drift, then it follows that the depth of water below the rocky barrier is in the case of Loch Creagach 19 feet, of the lower basin of Loch Laoghal 152 feet, and of the upper basin 72 feet. The deepest part of Loch Laoghal occurs where the valley is most constricted, and where the hills on either side are loftiest.

Although no glacial markings have been found in the immediate neighbourhood of the lochs, the striæ in the surrounding district show that the ice-movement during the period of maximum glaciation was slightly west of north. The dispersal of the boulders and the disposition of the moraines indicate that during the later glaciation a confluent glacier moved northwards from the interior, one branch skirting the

western slope of Beinn Laoghal, a second passing through the hollow occupied by the loch of that name, and a third round the eastern slope of Beinn's Tomaine. The stages in the gradual retreat of the mass of ice that moved down the valley of Loch Laoghal are clearly marked by a succession of moraine terraces, which enclose the small lochans shown on the chart to the east of Loch Creagach and Loch Slaim.

*Loch an Dithreibh* is a rock basin lying in hornblendic and micaceous gneisses, whose strike is nearly north and south and nearly parallel to the direction of the lake. They are admirably exposed on the great crag on the east side of the loch. The solid rock is not exposed at the lip of the basin, but at a point in the stream about a quarter of a mile below the outlet at a height of 261 feet, the surface of the loch being 267 feet above sea-level, and the deepest part of the basin being 157 feet.

*Loch Syre*, like many of the lochans east of Loch Laoghal, is surrounded with morainic deposits.

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#### NOTES ON THE BIOLOGY OF THE LOCHS OF NORTH SUTHERLANDSHIRE.

By JAMES MURRAY.

Tow-nettings were taken in seven of the lochs. These include three deep lochs (Hope, an Dithreibh, and Laoghal), two very shallow lochs (Chaluim and na Meide), while Loch Naver is intermediate. The biological phenomena are in accordance with those differences, the plankton of the deep lakes being relatively poor, and similar to that of great lakes in general, the shallow lakes having a large admixture of littoral forms.

All the lochs were rich in algæ, especially Desmids, including many of those conspicuous species of western type, alluded to by Messrs. West, which are so characteristic of the extreme north-western fringe of Europe. The northern species of *Diaptomus*—*D. laciniatus*, *D. laticeps*, and *D. Wierzejskii*—which are so widely distributed in the north of Scotland, Orkney, Shetland, and the western isles, and which are common in many lochs immediately adjacent, both to the east and south, are absent from most of the lochs of this district. *D. laticeps* is in Lochs na Meide and Naver, *D. laciniatus* in Loch na Meide only. *D. gracilis* is in six of the lochs, and in five it is the only species.

In the short lists of organisms following the name of each loch, species of general distribution are omitted, only those being included which are interesting on account of their distribution or rarity.

*Loch Hope*.—*Leptodora*, *Daphnia hyalina* (head rounded), *Diaphanosoma*, *Floscularia pelagica*, *Triarthra longiseta*, *Clathrusina*

*elegans*, *Micrasterias furcata*, *Staurastrum furcigerum*, *Xanthidium subhastiferum*.

*Loch an Dithreibh*.—*Bosmina obtusirostris*, var. *longispina*, *Floscularia pelagica*, *Staurastrum ophiura*, cysts of *Ceratium*. Animal life (both as to individuals and species) was very scarce, while the smaller algæ were conspicuous.

*Loch na Meide*.—*Diaptomus laticeps*, *D. laciniatus*, *Cyclops gigas*, *Daphnia* (galeate), *Ilyocryptus acutifrons*, *Gastropus styliifer* (= *Notops pygmaeus*), *Staurastrum ophiura*, *S. arcticon*, *S. pseudopelagicum*, *Micrasterias apiculata*, var. *fimbriata*. This loch was remarkable for the abundance of both animal and plant life; about eighty species of organisms were found in the first cursory examination. The true plankton was not, however, particularly rich, there being a very large admixture of littoral species. *Ilyocryptus acutifrons* was first observed in Scotland in this loch, though it was afterwards found that it had been collected in Loch Shin at an earlier date.

*Loch Naver*.—*Diaptomus laticeps*, *Bosmina obtusirostris* (small, with long spine), *Floscularia pelagica*, *Gastropus styliifer*, *Staurastrum ophiura*, *S. arcticon*, *S. grande*, *Micrasterias conferta*, *M. furcata* (typical, also a variety having the whole surface covered with hemispherical papillæ of unequal sizes).

*Loch Chalum*.—*Daphnia* (two forms, first with small rounded head, second with very large broad, depressed head, many males), *Synchæta pectinata*, *Gastropus styliifer*, *Polychætus collinsi*, *Staurastrum ophiura*, *S. arcticon*, *S. furcigerum*.

*Loch Laoghal*.—*Bosmina obtusirostris*, var. *longispina*, *Floscularia pelagica*, *Triarthra longiseta*, *Clathrulina elegans*, *Staurastrum pseudopelagicum*, *S. jaculiferum*.

*Loch Creagach* is connected with Loch Laoghal by a wide channel, and stands at the same level. The biology calls for no separate mention.

NOTE ON *Clathrulina elegans*, Cienk.—Skeletons of this animal were abundant in the deep lochs Hope and Laoghal. In an earlier paper\* an attempt was made to account for the presence of these empty shells in so many of the Scottish lochs, and as a general rule only in large ones, on the supposition that they were derived from the shallow waters in which *C. elegans* is known to live, attached to water-plants by a slender stalk. Up till quite recently only empty cases had been found, or at most an occasional shell containing an encysted mass of protoplasm, and on these facts was based the suggestion put forward as to their origin. A fresh aspect is put upon the inquiry by the recent observation that in Loch Lochy, where the animal was abundant in August, 1905, when the loch was visited in company of Prof. Bachmann, most of the shells contained living animals, which extended their pseudopodia and

\* See p. 291.

seemed quite at home. There was in no instance any trace of a stalk. These facts led to the supposition that perhaps the lacustrine form may be a permanent pelagic race, or even a distinct species. Or it may be that the animal is attached when young, and becomes free when adult. There are difficulties in the way of accepting either hypothesis. If it be a true plankton form, we have to explain the absence of living animals from so many of the Scottish lochs in which the skeletons occur, and some of which have been examined at all seasons of the year. If it be a littoral form, and only casual in the plankton, it is still unexplained why the skeletons are, as a rule, only in large lakes.

## LOCHS OF THE BEAULY BASIN.

THE Beauly basin is an important and extensive one, extending across almost the entire width of Scotland, from Beauly firth on the east coast to within about 4 miles from the shores of Loch Duich, and about 6 miles from the shores of Loch Carron, on the west coast. The basin is situated in a very mountainous district, many of the peaks in the central and western part of the basin exceeding 3000 feet, and some of them approaching 4000 feet, in height, while on proceeding eastward towards the outlet of the basin the land becomes gradually less elevated. On the southern boundary of the basin are Tigh Mor (3222 feet), Sgùrr nan Conbhairean (3634 feet), Garbh Leac (3673 feet), Sgùrr nan Ceathramhan (3614 feet), Ciste Dhubh (3218 feet), Carn Fuaraloch (3241 feet), and Sgùrr a' Bhealaich Dheirg (3378 feet); on the western boundary Beinn Fhada (Ben Attow, 3383 feet), Sgùrr nan Ceathreamhnan (3771 feet), Lurg Mhor (3234 feet), and Sgùrr Choinich (3260 feet), on the northern boundary Sgùrr a' Chaoruinn (3452 feet), Bidean an Eoin Deirg (3430 feet), Maoile Lunndaidh (3294 feet), Sgùrr Fhuar-Thuill (3439 feet), Sgorr a' Choir-Ghlais (3552 feet), and Sgùrr Ruadh (3254 feet); while in the central part of the basin are Craig Dhubh (3102 feet), Sgùrr na Lapaich (3773 feet), An Riabhachan (3696 feet), Beinn Fhionnlaidh (3294 feet), Mam Sodhail (Mam Soul, 3862 feet), Carn Eige (3877 feet), Tom a' Choinich (3646 feet), a second peak named Sgùrr na Lapaich (3401 feet), and Tuill Creagach (3452 feet). Besides these heights there are many others which do not attain the 3000-foot level. In the valleys between these chains of mountains lie the lochs which were sounded by the Lake Survey staff. In the most northerly valley, Glen Strath Farrar, there is the connected series consisting of Lochs Calavie, an Tachdaidh, an Gead, Monar, a' Mhuilinn, and Bunacharan; in the central valley, Glen Cannich, the connected series of Lochs Lungard, Mullardoch, and Sealbhag; and in the most southerly valley, Glen Affric, the connected series of Lochs Affric, an Laghair, and Beinn a' Mheadhoin; with the isolated Loch na Beinne Bàine as an outlier situated towards the head of Strath Glass. These valleys all trend in a more or less east-and-west direction, converging towards the north-east, where the river

Beauly is formed by the junction of the river Farrar with the river Glass. The river Glass is formed by the junction of the Amhuinn Deabhaidh (bearing the outflow from Loch na Beinne Bàine) with the river Affric, while the river Cannich is a tributary of the river Glass. The river-systems within the Beauly basin, and the relative positions of the different lochs, are shown on the accompanying index-map (Fig. 50). The area of the entire basin, as measured with the planimeter on the 1-inch Ordnance Survey maps, is about 343 square miles, of which about 215 square miles (or 63 per cent.) drain into these

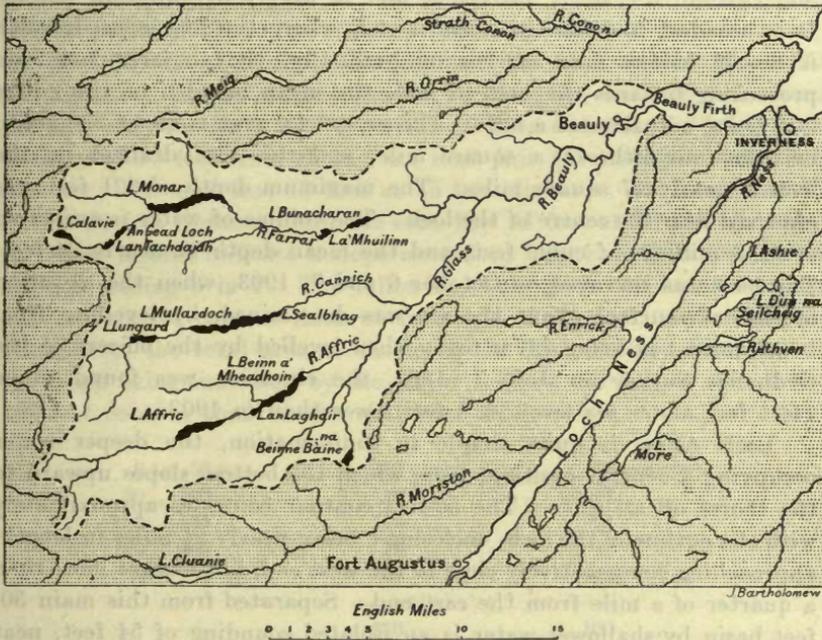


FIG. 50.—INDEX MAP OF THE BEAULY BASIN.

thirteen lochs, as will be seen from the summary table on p. 350. An inspection of the summary table shows, further, that all the lochs exceed half a mile in length, while eight of them exceed a mile in length; the two largest lochs (Mullardoch and Monar) exceed 4 miles in length, and have each an area exceeding a square mile. Seven of the lochs exceed 100 feet in depth, and two of them exceed 200 feet, the deepest one being Loch Monar, with a maximum depth of 260 feet; this loch is also the one containing the largest volume of water. The boundary-line between the counties of Inverness and Ross runs up the centre of Loch Monar for the greater part of its length, and it crosses Loch Mullardoch in its central portion, so that

these two lochs lie partly in Ross-shire and partly in Inverness-shire; four of the others (Lochs Lungard, Calavie, an Tachdaidh, and an Gead) are situated in Ross-shire, and the remaining seven in Inverness-shire. The scenery of the district around the lochs is very fine, and the trout fishing in most of the lochs very good; some of them contain pike also.

*Loch Affric* (see Plate LXXVIII.).—Loch Affric (or Affaric) lies about 26 miles to the south-west of Beauly, which is the nearest railway station, and about 11 miles from Glen Affric Hotel at Cannich, the nearest house of entertainment. The loch trends in a west-south-west and east-north-easterly direction, and is nearly  $3\frac{1}{4}$  miles in length. It is broadest towards the western end, where the maximum breadth is nearly half a mile, narrowing gradually, though irregularly, on proceeding towards the eastern end, the mean breadth of the entire loch being a quarter of a mile. The superficial area is about 526 acres, or over four-fifths of a square mile, and the area drained by the loch is nearly 47 square miles. The maximum depth of 221 feet was observed near the centre of the loch. The volume of water is estimated at 2146 millions of cubic feet, and the mean depth at nearly 94 feet. The loch was surveyed on October 6 and 7, 1903, when the elevation of the lake-surface above the sea was determined, by levelling from bench-mark, as being 747·0 feet; when levelled by the officers of the Ordnance Survey on July 3, 1867, the elevation was found to be 744·1 feet above sea-level, or 3 feet lower than in 1903.

Loch Affric is quite simple in conformation, the deeper water occupying a central position, from which the bottom slopes upward to the shores on all sides. The 50-foot contour coincides approximately with the outline of the loch, enclosing a basin nearly  $2\frac{1}{2}$  miles in length, approaching comparatively close to the west end, but distant more than a quarter of a mile from the east end. Separated from this main 50-foot basin by shallower water is an isolated sounding of 54 feet, near the east end, where the main loch is joined by the little subsidiary basin called Loch Pollan Fearna, in which a maximum depth of 30 feet was observed. The 100-foot basin is  $2\frac{1}{4}$  miles in length, and the 150-foot basin nearly  $1\frac{1}{2}$  miles in length, approaching in each case nearer to the west end than to the east end. The 200-foot basin is about three-quarters of a mile in length, and is approximately equidistant from both ends of the loch, but the deepest sounding in 221 feet was taken towards the west end of the basin, and therefore nearer to the western end of the loch. A section along the centre of the loch from end to end is shown in the longitudinal section A-B on the map, and a section across the loch in the position of the deepest sounding is shown in cross-section C-D. This last section shows a very slight irregularity in the deepest part of the loch, where a sounding in 209 feet was taken between a sounding in 211 feet on the one hand, and the greatest depth of the

loch (221 feet) on the other. Another line of soundings, about three-quarters of a mile further east, shows a shoaling in deep water, where a depth of 122 feet was recorded between a depth of 130 feet on one side and 159 feet on the other. With these exceptions, the various lines of soundings show a regular bottom, with a steep offshore slope in some places along both the northern and southern shores. Thus, proceeding along the northern shore from the east end of the loch, the first line of soundings gave a depth of 40 feet at a distance of 20 feet from shore; the fourth line of soundings gave a similar depth at a similar distance; the fifth line gave a depth of 28 feet at 10 feet from shore; the ninth line gave 47 feet at 30 feet; the next line gave 21 feet at a distance of 20 feet; the next line 84 feet at 60 feet distance; the next 35 feet at 25 feet distance; and the next line 36 feet at 30 feet distance. In like manner, proceeding along the southern shore from the east end, the sixth line of soundings gave a depth of 76 feet at a distance of 50 feet from shore; the next line gave 31 feet at 20 feet distance; the next line 47 feet at 15 feet distance; the next line 33 feet at 20 feet distance; and the next line 34 feet at 30 feet distance. All these figures indicate a slope exceeding 1 in 1, and in one case a slope exceeding 3 in 1. The following table gives the areas between the consecutive contour-lines at intervals of 50 feet, with the percentages to the total area of the loch, the flat-bottomed character of the basin being indicated by the larger zone on the deeper side of the 100-foot contour than on the shallower side:—

0 to 50 feet	195 acres	37 per cent.
50 ,, 100 ,,	89 ,,	17 ,,
100 ,, 150 ,,	125 ,,	24 ,,
150 ,, 200 ,,	70 ,,	13 ,,
Over 200 ,,	47 ,,	9 ,,
	<hr/>	
	526 ,,	100 ,,
	<hr/>	<hr/>

*Temperature Observations.*—A series of temperatures taken at 3 p.m. on October 6, 1903, in the deepest part of the loch, gave the following results:—

Surface ... ..	49°·2 Fahr.
10 feet ... ..	48°·9 ,,
25 ,, ... ..	48°·6 ,,
50 ,, ... ..	48°·0 ,,
100 ,, ... ..	47°·0 ,,
150 ,, ... ..	45°·6 ,,
200 ,, ... ..	44°·8 ,,

The extreme range shown by these observations is only 4°·4 from surface to bottom, the fall of temperature being very gradual.

*Loch an Laghair* (see Plate LXXIX.).—Loch an Laghair lies a little over a mile to the north-east of Loch Affric, and is practically continuous with Loch Beinn a' Mheadhoin, for normally the two lochs stand at the same level, although an easterly gale sets up a strong current through the narrows at Blàr an Àth, in which a depth of 5 feet was observed. The loch trends in a north-east and south-west direction, and is nearly two-thirds of a mile in length. The maximum width exceeds a quarter of a mile towards the western end, whence the loch narrows gradually towards the eastern end. The superficial area of the loch is about 83 acres, and the area draining directly into it nearly 6 square miles, but since it receives the overflow from Loch Affric its total drainage area is about  $52\frac{1}{2}$  square miles, an area over 400 times greater than that of the loch. The deepest sounding in 100 feet was taken in the central part of the loch, but rather nearer to the north-east end. The volume of water is estimated at 135 million cubic feet, and the mean depth at  $37\frac{1}{4}$  feet. The loch was surveyed on October 6, 1903; but the elevation of the lake-surface above the sea could not be determined by levelling, as there was no bench-mark near the loch. The level was estimated at about 703 feet above sea-level.

Loch an Laghair forms a simple basin, the shallower contours coinciding approximately with the outline of the loch, but approaching closer to the northern shore in the eastern half of the loch, where the offshore slope is steepest. The western end is apparently being silted up. The 75-foot area is extremely small, for on each side of the deepest sounding in 100 feet, at a distance represented by twenty strokes of the oar, the depths were 66 and 64 feet respectively. A section across the loch at the position of the deepest sounding is shown in cross-section E-F on the map, and a section along both Loch an Laghair and Loch Beinn a' Mheadhoin is shown in the longitudinal section A-B. The area of the lake-floor in Loch an Laghair covered by less than 50 feet of water is about 63 acres, or 76 per cent. of the total area of the loch. The temperature of the surface water at 3.30 p.m. on the date of the survey was 48°·0 Fahr.

*Loch Beinn a' Mheadhoin* (see Plate LXXIX.).—Loch Beinn a' Mheadhoin (or Beinnavian, or Beneveian) trends generally in a north-east and south-westerly direction, and is over  $2\frac{1}{2}$  miles in length. The loch is fairly uniform in width, the two end portions being somewhat narrower than the central portion, which has a maximum breadth of nearly half a mile, the mean breadth of the entire loch exceeding a quarter of a mile. The superficial area of the loch is about 504 acres, or over three-quarters of a square mile, and the area of land draining directly into it is about  $15\frac{1}{2}$  square miles; but since it receives the superfluent waters from Lochs Affric and an Laghair, the total drainage area is about 68 square miles. The maximum depth of 167 feet was

observed in a central position, but nearer to the eastern than to the western end of the loch. The volume of water is estimated at 1435 millions of cubic feet, and the mean depth at over 65 feet. The loch was surveyed on October 6, 1903, but the elevation of the lake-surface above the sea could not be determined by levelling. The water in the loch was very high on the date of the survey, the level then being estimated at about 703 feet above sea-level, but the normal level is probably about 700 feet.

Loch Beinn a' Mheadhoin is rather complex in conformation, including as it does three deep basins separated by shallower water. Near the western end of the loch is a small basin having a maximum depth of 95 feet, and near the eastern end is a larger basin having a maximum depth of 117 feet, while the largest and deepest basin occupies the central portion. The two ridges separating these three basins may be due to the deposition of material brought down by the streams entering the loch at these places along the northern shore, of which the westerly stream (Amhainn a' Ghlinne Fhiadhaich) is the more important; the maximum depth observed on the western ridge was 69 feet, and on the eastern ridge 97 feet. The 25-foot and 50-foot contours are continuous from end to end of the loch, while the 75-foot contour is broken at the position of the western ridge, and the 100-foot contour is broken at the position of the eastern ridge. The eastern 100-foot basin is nearly half a mile in length, and the main 100-foot basin nearly  $1\frac{1}{2}$  miles in length; within the last-mentioned basin is a long, narrow 150-foot basin, based on soundings of 159, 167, and 154 feet, with an isolated sounding in 156 feet a quarter of a mile farther west. It seems doubtful whether this isolated sounding may not be connected with the principal basin by deep water, and in that case the 150-foot basin would be nearly a mile in length. The deepest sounding in 167 feet was recorded about a mile from the eastern end of the loch, and about  $1\frac{1}{2}$  miles from the western end. The cross-section C-D, in this position, shows a steeper gradient off the northern than off the southern shore; but the soundings, as a whole, afford no evidence of any very steep slopes. The deeper part of the loch has quite a flat-bottomed character, as indicated by the figures in the following table, giving the areas between the consecutive contour-lines:—

0 to 25 feet	98 acres	19.5 per cent.
25 ,, 50 ,,	80 ,,	15.8 ,,
50 ,, 75 ,,	96 ,,	19.0 ,,
75 ,, 100 ,,	174 ,,	34.5 ,,
Over 100 ,,	56 ,,	11.2 ,,
	<u>504</u> ,,	<u>100.0</u> ,,

It will be observed that the largest zone is the one between 75 and 100 feet, and that the area of the lake-floor covered by less than 50 feet

of water is about 178 acres, as compared with 270 acres covered by water between 50 and 100 feet in depth, or 35 per cent. as compared with 53 per cent. In most lakes the arrangement is the reverse of this, the areas between consecutive contour-lines drawn at equal intervals usually decreasing with increase of depth. The temperature of the surface water at the east end on commencing the survey was 50°·0 Fahr., while later in the afternoon, towards the opposite end the surface temperature was 49°·5; but an easterly gale having sprung up, it was found impossible to take serial temperatures beneath the surface.

*Loch na Beinne Bàine* (see Plate LXXXII.).—Loch na Beinne Bàine lies in Guisachan forest, about 4 miles to the south-east of Loch Beinn a' Mheadhoin, and 8 or 9 miles to the west of Invermoriston on Loch Ness. It is irregular in outline, trends in a north-north-east and south-south-westerly direction, and is nearly a mile in length, with a maximum breadth of nearly half a mile. The superficial area is about 154 acres, or a quarter of a square mile, and the area draining into it about 1½ square miles. The maximum depth of 67 feet was observed about a quarter of a mile from the southern end of the loch, midway between an island of stones and the eastern shore. The volume of water is estimated at 190 million cubic feet, and the mean depth at 28½ feet. The loch was surveyed on June 6, 1904, but the elevation of the lake-surface above the sea could not be determined; the height of the water at the sluice was about 2 feet, and at one time the loch appears to have been considerably higher.

Loch na Beinne Bàine forms a simple basin; the 25-foot contour coincides approximately with the outline of the loch, but is deflected at the position of the island of stones off the western shore towards the southern end, while the 50-foot basin, based on soundings of 67, 64, 54, and 52 feet, is contained in the southern half of the loch, and is about a quarter of a mile in length. The soundings indicate in one or two places slight undulations of the lake-floor, but as a rule the slope of the bottom is regular and gentle. The area covered by less than 25 feet of water is about 95 acres, or 62 per cent. of the total area.

*Temperature Observations.*—A series of temperatures taken in the deepest part of the loch gave the following results:—

Surface	...	...	...	...	...	...	...	60°·8 Fahr.
10 feet	...	...	...	...	...	...	...	60°·0 ,,
20 ,,	...	...	...	...	...	...	...	50°·5 ,,
40 ,,	...	...	...	...	...	...	...	47°·6 ,,
60 ,,	...	...	...	...	...	...	...	46°·5 ,,

These observations indicate an extreme range of temperature from surface to bottom amounting to 14°·3, there being a fall of 9°·5 between

10 and 20 feet, which is nearly equal to a fall in temperature of one degree per foot of depth. Reference has elsewhere been made to the large range and rapid fall of temperature observed in Lochs Monzievaird, Achilty, and Dubh,\* and the temperatures here given from Loch na Beinne Bàine afford another instance for comparison.

*Loch Lungard* (see Plate LXXXII.).—Loch Lungard (or Longart, or Glasletter) lies at the head of Glen Cannich, about 5 miles to the north of Loch Affric. It trends east and west, and is  $1\frac{1}{2}$  miles in length, with a maximum breadth towards the west end of one-third of a mile, whence the loch narrows gradually towards the east. The superficial area is about 216 acres, or one-third of a square mile, and the area draining into it is nearly 23 square miles. The maximum depth of 129 feet was observed in a central position, but towards the east end. The volume of water is estimated at 599 million cubic feet, and the mean depth at nearly 64 feet. The loch was surveyed on October 7, 1903, when the elevation of the lake-surface above the sea was found, by levelling from bench-mark, to be 761·3 feet, which is nearly identical with the level observed by the Ordnance Survey officers on October 14, 1867, viz. 761·2 feet. When surveyed the water was about its normal level, and in floods might rise about 3 feet.

Loch Lungard is extremely simple in conformation, the bottom sloping down on all sides towards the deepest part, not the slightest irregularity being indicated by the soundings, while the contour-lines coincide approximately with the outline of the loch. This is shown in both the longitudinal section A-B and the cross-section C-D on the map. The 50-foot basin is  $1\frac{1}{4}$  miles, and the 100-foot basin rather under a mile, in length, and they are comparatively wide, so that the loch is of a flat-bottomed character, as is shown by the following table, giving the areas and percentages between the contour-lines:—

0 to 50 feet	87 acres	40 per cent.
50 „ 100 „	81 „	38 „
Over 100 „	48 „	22 „
	<u>216</u> „	<u>100</u> „

*Temperature Observations.*—The following series of temperatures, taken at 2 p.m. on the date of the survey in the deepest part of the loch, indicates a range of only 1°·2 Fahr. throughout the body of water:—

Surface ... ..	49°·2 Fahr.
25 feet ... ..	49°·0 „
50 „ ... ..	48°·8 „
125 „ ... ..	48°·0 „

\* See p. 276.

*Loch Mullardoch* (see Plate LXXX.)—Loch Mullardoch (or Mulardich, or Moyley) lies less than 2 miles to the east of Loch Lungard, and is practically continuous with Loch Sealbhag, there being a small expansion of the river between them called Loch Ath a' Bhàn, which was not sounded. Loch Mullardoch trends generally in an east and westerly direction, and is somewhat irregular in outline, with a slight bend in the central portion. It exceeds 4 miles in length, and is pretty uniform in width, the maximum breadth being less than half a mile, and the mean breadth over a quarter of a mile. Its waters cover an area of about 756 acres, or considerably more than a square mile, and the area draining directly into it is about  $27\frac{1}{2}$  square miles; but since it receives the outflow from Loch Lungard its total drainage area exceeds 50 square miles. The maximum depth of 197 feet was observed in the eastern portion of the loch, about a mile and a half from the east end. The volume of water is estimated at 2553 millions of cubic feet, and the mean depth at  $77\frac{1}{2}$  feet. The loch was surveyed on October 7, 1903, but the elevation above the sea was not determined; when levelled by the Ordnance Survey officers on November 29, 1866, the elevation of the lake-surface was found to be 704.9 feet above sea-level. On the date of the survey the water was about a foot above the normal level, and two days previously it had been 3 feet higher.

Loch Mullardoch is divided into two deep basins by a shoaling of the water in its central portion, where there is a constriction and bend in the outline, the maximum depth in the western basin being 150 feet, and in the eastern basin 197 feet, the depth on the shoaling being 80 feet. A section across the deepest part of the western basin is shown in cross-section C-D, and one across the deepest part of the eastern basin in cross-section E-F, on the map, and a section along the centre of the loch from end to end is shown in the longitudinal section A-B at the foot of the map. This last-mentioned section brings out the central shoaling referred to, which is apparently traceable to the influence of the streams entering on both sides of the loch at this place, and principally of the Allt Taige, at the mouth of which, on the northern shore, is a considerable delta. The 50-foot contour is continuous, and encloses a basin nearly 4 miles in length. The western 100-foot basin exceeds half a mile in length, separated by an interval of over half a mile from the eastern 100-foot basin, which is one and a half miles in length, and includes a 150-foot basin over a mile in length. All the cross-lines of soundings show a regular bottom, the water deepening gradually from the shore towards the centre, with a steep offshore slope in some places, as, for instance, along the southern shore off Creag Dubh, where a sounding in 24 feet was taken about 20 feet from shore, and off Creag a' Bhaca, at the deepest part of the loch, where a sounding in 94 feet was taken about 100 feet from shore. The following table gives the approximate areas between the consecutive contour-lines at

intervals of 50 feet, and the percentages to the total area of the loch, and indicates the flat-bottomed character of the basin, the comparatively large area of the lake-floor covered by more than 150 feet of water being noteworthy:—

0 to 50 feet	298 acres	39 per cent.
50 ,, 100 ,,	228 ,,	30 ,,
100 ,, 150 ,,	121 ,,	16 ,,
Over 150 ,,	109 ,,	15 ,,
	<u>756</u> ,,	<u>100</u> ,,

*Temperature Observations.*—The following series of temperatures, taken at 4.30 p.m. on the date of the survey in the western basin, shows that the water was nearly uniform in temperature, the extreme range from surface to bottom being only 1° Fahr., the readings down to a depth of 50 feet being identical:—

Surface ... ..	50°·0 Fahr.
10 feet ... ..	50°·0 ,,
25 ,, .. ..	50°·0 ,,
50 ,, ... ..	50°·0 ,,
100 ,, ... ..	49°·5 ,,
150 ,, ... ..	49°·0 ,,

*Loch Sealbhag* (see Plate LXXX.).—Loch Sealbhag lies to the east of, and is, as already stated, practically a continuation of Loch Mullardoch. It trends in a north-east and south-westerly direction, and is two-thirds of a mile in length, with a maximum breadth towards the west end of nearly a quarter of a mile, whence it narrows gradually towards the north-east. Its waters cover an area of about 68 acres, and it drains directly an area of 3½ square miles, but since it receives the outflow from Lochs Lungard and Mullardoch, its total drainage area is nearly 54 square miles—an area nearly 500 times greater than that of the loch. The maximum depth of 56 feet was observed in the widest part of the loch towards the western end, and comparatively near the southern shore. The volume of water is estimated at 61 million cubic feet, and the mean depth at over 20½ feet. The loch was surveyed on October 5, 1903, but the elevation above the sea could not be determined.

The wide western portion of Loch Sealbhag includes a deep basin exceeding 30 feet in depth, which approaches comparatively close to the western end, and is over a quarter of a mile in length. To the north-east of this basin the bottom rises, and falls again on approaching the outfall to a depth of 31 feet, the depth on the rise being 16 feet. The area of the lake-floor covered by less than 20 feet of water is about 39 acres, or 57 per cent. of the total area. The temperature of the surface water on the date of the survey was 50°·5 Fahr.

*Loch Calavie* (see Plate LXXXII.).—Loch Calavie (or Calvie) lies about 6 miles to the north-west of Loch Lungard, and only 7 miles from the head of Loch Carron on the west coast of Scotland, at a high elevation among the mountains, the lower slopes of which are covered with peat. The loch trends in a north-west and south-easterly direction, and is considerably over a mile in length, with a maximum width towards the western end exceeding one-third of a mile, whence the breadth gradually decreases on approaching the eastern end. The superficial area is about 167 acres, or a quarter of a square mile, and the area draining into it nearly  $2\frac{1}{2}$  square miles. The maximum depth of 84 feet was observed in a central position, but rather nearer the western than the eastern end. The volume of water is estimated at 276 million cubic feet, and the mean depth at 38 feet. The loch was surveyed on October 19, 1904, when the elevation was found by levelling from bench-mark to be 1128·35 feet above the sea—a little lower than the elevation as determined by the Ordnance Survey officers on August 14, 1866, viz. 1128·5 feet above sea-level.

Loch Calavie is perfectly simple in conformation, the contour-lines coinciding approximately with the shore-line, though in each case they approach nearer to the western than to the eastern end of the loch, so that the average slope is steeper towards the head of the loch. This is shown in the longitudinal section A-B on the map. The 25-foot basin is nearly a mile, and the 50-foot basin three-quarters of a mile, in length. The soundings give no indication of any steep offshore slopes, and the average slope between the 25-foot and 50-foot contours is less steep than in shallower water, as indicated in the following table by the larger area beyond the 25-foot line:—

0 to 25 feet	55 acres	33 per cent.
25 ,, 50 ,,	62 ,,	37 ,,
50 ,, 75 ,,	39 ,,	24 ,,
Over 75 ,,	11 ,,	6 ,,
	<hr/>	<hr/>
	167 ,,	100 ,,
	<hr/>	<hr/>

*Temperature Observations.*—The following series of temperatures taken in the deepest part of the loch shows that on the date of the survey the whole body of water was practically uniform in temperature, the extreme range being less than 1° Fahr.:—

Surface	... ..	47°·0 Fahr.
40 feet	... ..	46°·3 ,,
75 ,,	... ..	46°·2 ,,

*Loch an Tachdaidh* (see Plate LXXXII.).—Loch an Tachdaidh lies about 2 miles to the east of Loch Calavie, and is almost continuous with Loch an Gead, the stream between them being a very short one,

and the difference in level only  $1\frac{1}{2}$  feet. The term Gedd Lochs is applied to the connected series, consisting of Loch an Gead, Loch an Tachdaidh, and the neighbouring little Loch an Gobhlach, which was not sounded. Loch an Tachdaidh is irregular in outline, trends in a north-east and south-westerly direction, and is nearly two-thirds of a mile in length, with a maximum breadth exceeding one-third of a mile. Its waters cover an area of about 92 acres, and it drains directly an area exceeding 4 square miles, but since it receives the overflow from Loch Calavie, its total drainage area is over  $6\frac{1}{2}$  square miles. The maximum depth of 62 feet was observed in the centre of the north-eastern portion of the loch, near a heap of stones showing above the surface of the water. The volume of water is estimated at 72 million cubic feet, and the mean depth at 18 feet. The loch was surveyed on October 21, 1904; the elevation could not be determined by levelling, but was estimated at about 831.5 feet above the sea.

Loch an Tachdaidh is irregular in conformation as well as in outline, and, besides the island of stones already mentioned, includes four small unnamed islands, the largest of which occupies a central position; the south-western portion is shallow and filled with weeds. The contour-lines are sinuous in character, the deepest part lying between the largest island and the heap of stones, where three soundings exceeding 50 feet in depth were taken. To the south of the largest island, and towards the eastern shore, a sounding in 25 feet was recorded, surrounded by shallower water. The area of the lake-floor covered by less than 25 feet of water is about 74 acres, or 81 per cent. of the total area.

*Temperature Observations.*—The following series of temperatures taken in the position of the deepest sounding shows a range of only  $1^{\circ}2$  Fahr. throughout the body of water, the deeper layers being uniform in temperature:—

Surface	...	...	...	...	...	...	...	46°·2 Fahr.
30 feet	...	...	...	...	...	...	...	45°·0 „
60 „	...	...	...	...	...	...	...	45°·0 „

*An Gead Loch* (see Plate LXXXII.).—An Gead Loch lies to the north-east of Loch an Tachdaidh, and trends in a similar direction, but is more regular in outline and more uniform in width. An Gead Loch is nearly  $1\frac{1}{4}$  miles in length, with a maximum width towards the south-west end of a quarter of a mile. The superficial area is about 110 acres, and the area draining directly into it is about  $2\frac{1}{2}$  square miles, but since it receives the outflow from Lochs Calavie and an Tachdaidh, the total drainage area exceeds 9 square miles. The maximum depth of 30 feet was observed towards the north-eastern end of the loch. The volume of water is estimated at 54 million cubic feet, and the mean depth at  $11\frac{1}{4}$  feet. The loch was surveyed on October 21, 1904, and the

elevation was estimated at about 830 feet above sea-level. The bottom of an Gead Loch is irregular and stony, so much so that in the deeper part no mud could be got, while the shallow western portion is covered with sand. Though irregular, the basin has a flat-bottomed character, for the majority of the soundings were taken in depths exceeding 10 feet, and only three soundings in depths exceeding 20 feet. The area of the lake-floor covered by more than 10 feet of water is about 62 acres, or 56 per cent. of the total area. The temperature of the water was nearly uniform on the date of the survey, a reading at the surface giving 46°·7 Fahr., and a reading at 25 feet 46°·0.

*Loch Monar* (see Plate LXXXI.).—Loch Monar lies at the head of Glen Strath Farrar, little more than a mile to the north-east of an Gead Loch, and is one of the most important lochs in the Beaully basin. In length and in superficial area it is slightly inferior to Loch Mullardoch, but it is the deepest of the series, and contains the largest volume of water. The general trend of Loch Monar is east and west, but with a slight sinuosity in the outline, the length exceeding 4 miles. The width varies considerably, the maximum breadth of nearly half a mile occurring near the west end, the mean breadth of the entire loch exceeding a quarter of a mile. The waters of the loch cover an area of about 750 acres, or over one square mile, and the area draining directly into it is about 41 square miles, but since it receives the overflow from Lochs Calavie, an Tachdaidh, and an Gead, the total drainage area is about 50 square miles. The maximum depth of 260 feet was observed much nearer the eastern than the western end. The volume of water is estimated at 3213 millions of cubic feet, and the mean depth at 98½ feet. The loch was surveyed on October 10, 1903, when the elevation of the lake-surface above the sea was found to be 663·9 feet; when levelled by the officers of the Ordnance Survey on June 20, 1866, the elevation was 662·8 feet above sea-level. At the time of the survey the water was about its normal level, and might rise to the extent of several feet.

Loch Monar is quite simple in conformation, all the contour-lines enclosing continuous areas, and the cross-lines of soundings indicating a regularly sloping bottom from the shores out towards the centre of the loch. The longitudinal section, A-B on the map, along the centre of the loch from end to end shows slight undulations of the lake-floor, the shallowings coinciding with constrictions in the outline. The contour-lines all approach nearer to the eastern than to the western end of the loch, showing a steeper slope in an easterly direction from the deepest sounding, which was taken less than a mile from the east end, or one-fourth of the distance from one end to the other. The off-shore slope is in places very steep, especially along the southern shore at the deepest part of the loch, where near the centre of the loch a

sounding in 104 feet was taken about 120 feet from shore; a little farther east another sounding in 50 feet was taken about 50 feet from shore; still farther east a sounding in 148 feet was taken about 120 feet from shore; and still farther east a sounding in 87 feet about 60 feet from shore. The last-mentioned sounding, which gives a slope of 29 in 20, was taken on the cross-line immediately to the east of the deepest sounding, and the steepest gradient observed off the northern shore was at the opposite end of the same line, where a sounding in 54 feet was taken at about 60 feet from shore. The cross-section C-D on the map is taken at the position of the deepest sounding, and shows a gentle offshore slope, succeeded by a steeper slope on proceeding into deep water, the deeper part of the loch being of a flat-bottomed character. The area enclosed by the 50-foot contour is nearly  $3\frac{1}{2}$  miles in length, being distant from the west end nearly three-quarters of a mile, and extending into the narrow part at the east end off Creag Ghràda; in the expansion of the out-flowing river, opposite Creag Dubh, a depth of 64 feet was observed. The 100-foot basin is 3 miles, the 150-foot basin  $2\frac{1}{2}$  miles, and the 200-foot basin over one mile, in length. The approximate areas between the consecutive contour-lines drawn in at equal intervals, and the percentages to the total area of the loch, are given in the following table, from which it will be noticed that the area of the zone between 150 and 200 feet is larger than that of the two preceding shallower zones:—

0 to 50 feet	293 acres	39 per cent.
50 ,, 100 ,,	134 ,,	18 ,,
100 ,, 150 ,,	99 ,,	13 ,,
150 ,, 200 ,,	138 ,,	18 ,,
Over 200 ,,	86 ,,	12 ,,
	<hr/>	<hr/>
	750 ,,	100 ,,
	<hr/>	<hr/>

*Temperature Observations.*—The following series of temperatures, taken in the deepest part of the loch at 4 p.m. on the date of the survey, shows that the whole body of water varied little in temperature, being, in fact, uniform in temperature down to 100 feet, the extreme range amounting to only  $1^{\circ}2$  Fahr.

Surface ... ..	49°·5 Fahr.
10 feet ... ..	49°·5 ,,
25 ,, ... ..	49°·5 ,,
50 ,, ... ..	49°·5 ,,
100 ,, ... ..	49°·4 ,,
150 ,, ... ..	49°·0 ,,
170 ,, ... ..	48°·5 ,,
200 ,, ... ..	48°·3 ,,

*Loch a' Mhuilinn* (see Plate LXXXII.).—Loch a' Mhuilinn (or Moilie) is a small irregular loch lying about 5 miles to the east of Loch

Monar. A terrace of gravel surrounds the loch, except on the northern shore, where the hill an Carnach rises steeply from the lake-shore. There is a large island named Eilean a' Mhuilinn near the east end, and two smaller islands at the mouth of the inflowing river at the west end. The loch trends in an east-north-east and west-south-westerly direction, and is nearly a mile in length, with a maximum breadth in the centre exceeding one-third of a mile, whence it narrows towards the two ends. The superficial area is about 100 acres, and the area of land draining directly into it is about  $37\frac{3}{4}$  square miles, but since it receives the overflow from Lochs Monar, an Gead, an Tachdaidh, and Calavie, its total drainage area is nearly 88 square miles—an area 550 times greater than that of the loch. The maximum depth of 94 feet was observed in the wide part of the loch towards the northern shore. The volume of water is estimated at 150 million cubic feet, and the mean depth at over 34 feet. The loch was surveyed on October 12, 1903, when the elevation was determined, by levelling from bench-mark, as being 417.65 feet above the sea; when visited by the Ordnance Survey officers on June 1, 1866, the elevation was found to be 417.5 feet above sea-level. A drift-mark was observed 5 feet above the surface of the water on the date of the survey, when the level was about its normal.

Loch a' Mhuilinn consists of a deep central basin, with two small subsidiary shallow basins at the two ends, as shown in the longitudinal section on the map. Towards the west end, immediately to the north of the island at the mouth of the inflowing river, a depth of 25 feet was recorded, separated from the main basin by a rise of the bottom, on which a maximum depth of 12 feet was observed. Towards the east end, between Eilean a' Mhuilinn and the mouth of the outflowing river, a depth of 24 feet was recorded, separated from the main basin by a depth of 3 feet in the narrows between the island and the northern shore. In the main deep basin the contour-lines are continuous and the bottom regular, seven soundings in depths exceeding 80 feet having been recorded to the west and south-west of Eilean a' Mhuilinn, two of them in depths exceeding 90 feet. The area of the lake-floor covered by less than 50 feet of water is about 72 acres.

*Temperature Observations.*—The following series of temperatures taken in the deepest part of the loch shows that the body of water was nearly uniform in temperature on the date of the survey, the extreme range observed being less than 1° Fahr. :—

Surface ... ..	47°·2 Fahr.
10 feet ... ..	47°·0 „
25 „ ... ..	46°·8 „
50 „ ... ..	46°·6 „
90 „ ... ..	46°·4 „

*Loch Bunacharan* (see Plate LXXXII.).—Loch Bunacharan (or

Banchron) lies less than a mile to the east of Loch a' Mhuilinn and about 6 miles east of Loch Monar, and is the final one of the series of lochs in Glen Strath Farrar. The shores are mostly of gravelly debris, forming terraces about 20 feet high, which are best seen along the south shore; the surrounding hills are high and rugged, and well wooded. The loch trends east-north-east and west-south-west, and is  $1\frac{1}{4}$  miles in length, with a maximum width of nearly one-third of a mile, the superficial area being about 157 acres, or a quarter of a square mile. The area draining directly into Loch Bunacharan is only about 4 square miles, but it receives the overflow from Lochs Calavie, an Tachdaidh, an Gead, Monar, and a' Mhuilinn, and its total drainage area is therefore a very large one—about 92 square miles. The maximum depth of 113 feet was observed towards the east end of the loch—less than half a mile from the east end and more than three-quarters of a mile from the west end. The volume of water is estimated at about 343 million cubic feet, and the mean depth at over 50 feet. The loch was surveyed on October 12, 1903, when the elevation of the lake-surface above the sea was found, by levelling from bench-mark, to be 366.15 feet; when levelled by the officers of the Ordnance Survey on June 9, 1866, the elevation was 366.5 feet above sea-level. On the date of the survey the water was about its normal level, and a recent drift-mark was observed 9 feet above the surface of the water, while an older drift-mark was 11 feet above the water-surface.

Loch Bunacharan is irregular in conformation, the lake-floor in the deeper part of the loch rising and falling in a series of undulations. The 25-foot and 50-foot contours are continuous from end to end of the loch, and coincide approximately with the shore-line. The 75-foot contour, however, encloses three distinct basins separated from each other by shallower water, viz.—(1) a very small basin based on a sounding in 83 feet about 300 yards from the western end; (2) a larger basin a quarter of a mile in length, and trending almost north and south, *i.e.*, transversely across the loch, based on soundings in 78, 82, and 88 feet, situated about one-third of a mile from the western end; and (3) the largest and deepest basin, one-third of a mile in length, approaching to within a quarter of a mile from the eastern end, and enclosing a small basin exceeding 100 feet in depth, based on soundings in 105, 111, and 113 feet. Between the second and third basins above noted there is a rise of the lake-floor near the middle of the loch, covered by 43 feet of water, surrounded on all sides by deeper water. These inequalities are indicated to some extent in the longitudinal section A-B on the map, taken along the axis of maximum depth, but most of the cross-lines of soundings show a regular bottom, as shown in cross-section C-D, taken at the position of the deepest sounding. The slope of the bottom seems to be gentle on the whole, the steepest gradient observed being off the northern shore towards the west end,

SUMMARY TABLE.  
Giving Details concerning the Lochs in the Beauty Basin.

Loch.	Height above sea. Feet.	Number of sound-ings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. feet.	Mean feet.	Mean percent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
Affric	747.0	119	3.20	0.46	0.26	8.1	221	93.64	42.4	76	181	2,146	0.82	46.66	56.9
an Laghair...	...	23	0.62	0.28	0.21	33.8	100	37.23	37.2	33	88	1,355	0.13	52.50	403.9
Beinn a' Mheadhoin	...	73	2.64	0.44	0.30	11.3	167	65.36	39.1	83	213	1,435	0.79	67.98	86.0
na Beinne Baine	...	75	0.97	0.40	0.25	25.8	67	28.33	42.3	76	181	190	0.24	1.48	6.2
Lungard ...	761.3	55	1.44	0.34	0.23	16.0	129	63.68	49.4	59	119	599	0.34	22.84	67.2
Mullardoch	...	111	4.16	0.46	0.28	6.7	197	77.52	39.4	111	283	2,553	1.18	50.37	42.7
Sealbhadh	...	33	0.64	0.22	0.17	26.6	56	20.66	36.9	60	164	61	0.11	53.86	489.6
Calavie	1128.35	58	1.12	0.36	0.23	20.6	84	37.91	45.1	70	156	276	0.26	2.31	8.9
an Tachdaird	...	38	0.62	0.37	0.23	37.1	62	17.88	28.8	53	183	72	0.14	6.60	47.1
an Gear	...	52	1.21	0.27	0.14	11.6	260	11.29	37.6	213	566	54	0.17	9.12	53.7
Monar	663.9	117	4.10	0.42	0.29	7.0	360	98.33	37.8	83	220	3,213	1.17	50.06	42.8
a' Mhuilinn	417.65	43	0.84	0.36	0.19	22.6	94	34.15	36.3	47	130	150	0.16	87.82	548.8
Bunacharan	366.15	44	1.26	0.30	0.19	15.1	113	50.11	44.3	59	133	343	0.25	91.94	367.7
		841										11,227	5.76	215.26*	37.4

\* The drainage areas of Lochs Affric and an Laghair are included in that of Loch Beinn a' Mheadhoin; those of Lochs Lungard and Mullardoch in that of Loch Sealbhag; and those of Lochs Calavie, an Tachdaird, an Gear, Monar, and a' Mhuilinn in that of Loch Bunacharan.

where a sounding in 48 feet was taken about 50 feet from shore. The area of the lake-floor covered by less than 50 feet of water is about 80 acres, or 51 per cent. of the total area.

*Temperature Observations.*—The following series of temperatures, taken in the deepest part of the loch, show that the whole body of water was practically uniform in temperature:—

Surface ... ..	48°·2 Fahr.
25 feet ... ..	48°·2 „
50 „ ... ..	48°·0 „
75 „ ... ..	48°·0 „
90 „ ... ..	48°·0 „
110 „ ... ..	47°·9 „

The particulars regarding the lochs in the Beaully basin are collected together in the table on p. 350 for convenience of reference and comparison. From this table it will be seen that in the thirteen lochs under consideration, which cover an area of  $5\frac{3}{4}$  square miles, about 850 soundings were taken, or an average of 146 soundings per square mile of surface. The aggregate volume of water contained in the lochs is estimated at 11,230 millions of cubic feet, and the area draining into them is over 215 square miles, or 37 times the area of the lochs.

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#### GEOLOGICAL NOTES ON THE LOCHS WITHIN THE BASIN OF THE FARRAR.

By B. N. PEACH, LL.D., F.R.S., and J. HORNE, LL.D., F.R.S.

The mapping of the western part of the Beaully basin by the Geological Survey has only been carried southwards to the watershed between Glen Strath Farrar and Glen Cannich, and hence the following notes are confined to the lakes lying within the basin of the Farrar. This area is entirely occupied by the metamorphic rocks of the Highlands, which have been arranged in two divisions—(1) an older series, which has been correlated with the Lewisian or Archæan gneiss of the West Highlands; and (2) a group of crystalline schists, termed the Moine series by the Geological Survey, which are regarded as altered sediments, and are supposed to rest unconformably on the older Lewisian gneiss.

The members of the older series comprise hornblendic and biotite gneisses and ultrabasic masses, together with crystalline limestone, graphite schists and eclogites, which resemble the rocks of Lewisian age in the neighbourhood of Glenelg. The Moine series includes two prominent subdivisions—(1) flaggy and massive quartz-biotite granulites; and (2) muscovite-biotite schists, the latter probably representing an argillaceous phase of sedimentation. In the basin of

the Farrar the general strike of the crystalline schists, with the exception of local variations, is north-north-east and south-south-west, or north-east and south-west—that is to say, obliquely across the course of the main valley.

The basin of the Farrar is traversed by a powerful dislocation, which passes from the Conon valley in a south-west direction by Gleann Chorainn and the head of the river Orrin, thence across Loch Monar to the south-west shoulder of Riabhachan. It forms a well-marked feature, and is accompanied by much brecciation and staining of the rocks, as may be seen along its course to the north-east of Loch Monar. At certain localities, parallel or branching faults, presumably connected with the main dislocation, are met with, which modify to some extent the surface features.

During the period of confluent glaciers, the ice radiating from the mass of high ground south of Loch Monar, embracing Sgurr na Lapaich (3773 feet) and an Riabhachan (3696 feet), and from the heights between that lake and Gleann Fhiodhaig to the north, flowed eastwards down Glen Strath Farrar, and streamed northwards through some of the passes towards the Orrin and Glen Fhiodhaig, and westwards in the direction of the valley of the Ling. At a later stage it escaped only by Strath Farrar. The diverging movement through the various passes is indicated partly by ice-markings and partly by the disposition of the moraines.

*Loch Monar* is a true rock basin carved mainly out of the crystalline schists of the Moine series, modified by the movements accompanying the Strath Conon fault and its branches, to which reference has already been made. The lip of the basin is now about half a mile below the present outlet of the lake, the intervening area being silted up by the alluvium brought down by Allt Coire na Faochaige—a tributary which joins the main stream opposite Monar Lodge. The rocks forming the barrier of the lake are well seen in the gorge of the Garbh-uisge, where they consist of massive siliceous Moine schists, intensely plicated along vertical axes trending north-east and south-west.

In the narrow part of the lake immediately above Monar Lodge there is a small subsidiary basin, which may be accounted for by inequalities in the hardness of the rocks, and by the irregular distribution of the drift on the west side of the loch. The deep part of the main basin coincides with the belt of crushed strata accompanying the Strath Conon fault that crosses the lake near Lub-an-Inbhir and the parallel dislocation above Creag na h-Iolaire. A third fault, trending east and west, enters the loch at the mouth of the Allt nan Uan, which has produced considerable brecciation of the rocks.

The shallow bar near the head of the loch is due to a spit of sand, brought down partly by the Allt Riabhachan and partly by the stream at Pait, which has been distributed by the action of the waves.

The long stretch of alluvium along the Amhainn-an t-Sratha Mhòir indicates that the lake has been silted up for about a mile above its present western limit.

*Loch an Tachdaidh* and *an Gead Loch*.—These lochs lie in the bottom of the valley drained by the Garbh-uisge at Pait, which flows into Loch Monar, and are entirely surrounded by drift deposits of the later glaciation. All the small projections into these lakes are due to moraine heaps, arranged in such a way as to suggest that they are probably the terminal moraines of a lobe of ice that moved westwards towards the basin of the river Ling.

*Loch Calavie* lies in one of the passes through which the ice escaped westwards from the Monar area during the period of confluent glaciers. Though immediately surrounded by moraines and peat, it is evidently in part a rock basin, as the rocky barrier formed of muscovite-biotite gneiss appears in the stream not far below the outlet of the lake. The deepest sounding is 84 feet.

*Loch Bunacharan* and *Loch a' Mhuilinn*.—These lakes are situated in the valley of the Farrar about midway between Loch Monar and Struy. Their long axes seem to coincide generally with the strike of the crystalline schists. In the case of the former lake, its height above sea-level is 366 feet, its greatest depth 113 feet, and the position of the rocky barrier exposed in the stream about one-third of a mile below the outlet is about 360 feet. The surface level of Loch a' Mhuilinn is 417 feet, and the deepest sounding is 94 feet, and as it discharges over solid rock, it is evidently a small rock basin. There is a high terrace round Loch a' Mhuilinn and on the south side of Loch Bunacharan at a level of 440 feet.

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#### NOTES ON THE BIOLOGY OF THE LOCHS OF THE BEAULY BASIN.

By JAMES MURRAY.

The lochs of Beaully valley were surveyed in late autumn, during very severe weather, unfavourable for the study of biology. The lochs in Glen Affric were visited in a time of heavy floods, which raised the lochs several feet while we were working at them. Though the tow-nets were used, there was almost nothing got in them. The lochs appeared to be flushed and washed out by the spate, or else the animals had gone down to quieter water.

Throughout the rest of the basin there was great uniformity, the ordinary universal limnetic Crustacea and Rotifers alone being present, with little call for remark. There was an entire absence of all the northern species of *Diatomus*, and, although Desmids were fairly abundant in most of the lochs, there were none of the western species.

The few species which only occurred in some of the lochs are noted below. These are also generally distributed in summer, their scarcity in these lochs being due to the late season at which they were visited.

*Daphnia*.—In all the lochs where *Daphnia* occurred, it was as the variety *galeata*, a large form with the head angled.

*Holopedium gibberum*.—Only in Lochs Calavie and an Tachdaidh.

*Leptodora kindtii*.—Only in Loch Monar.

*Polyphemus pediculus*.—An Gead Loch.

*Cyclops strenuus*.—Present in most of the lochs. The *Cyclops* in Loch Calavie were red-spotted.

*Diaphanosoma brachyurum*.—Found in four lochs—an Tachdaidh, Bunacharan, Mullardoch, and Lungard.

*Floscularia pelagica*.—Loch Monar.

*Conochilus*.—Both species, *C. unicornis* (the common lake species) and *C. volvox*, were present in Loch Monar.

*Sponge*.—A fresh-water sponge, species not determined, came up attached to the sounding-rod, from depths of 6 or 8 feet, in Loch a' Mhuilinn. The pieces were long, finger-shaped.



Arkaig) is 12 miles in length; five of them exceed 100 feet in depth, and three exceed 300 feet in depth, while one of them (Loch Lochy) exceeds 500 feet in depth. It has been found convenient to include also two small lochs which drain directly into Loch Linnhe, viz., Lochan Lùnn dà-Bhrà on the east and Loch nan Gabhar on the west. Loch nan Gabhar is in Argyllshire, while all the remaining lochs are situated in Inverness-shire. The relative positions of the lochs and rivers within the area under discussion are shown in the little index map (Fig. 51), from which it will be seen that Loch Arkaig drains into Loch Lochy by the short river Arkaig, while the other lochs within the basin drain into the river Spean, which joins the river Lochy shortly after its exit from Loch Lochy, the junction of the two rivers being marked by the pretty falls of Mucomir.

The Lochy basin, only a small portion of which has been mapped by the Geological Survey, lies wholly within the region of the crystalline schists of the Central Highlands. It is intersected by the powerful north-east and south-west fault that traverses the Great Glen from Inverness to the shores of Loch Linnhe. In the area west of this dislocation the rocks, so far as known, consist of quartz-biotite granulites and muscovite-biotite schists, which are believed to represent altered sediments. These are traversed by acid and basic intrusions and numerous veins of granite and pegmatite.

East of the Great Glen several of the metamorphic groups of the Eastern Highlands are represented, including the Perthshire quartzite, black schist, limestone, Ardrishaig phyllites, and the associated quartzite, the beds striking generally in a north-east and south-west direction. The schists are pierced by various masses of igneous rock, of which the most important is the large intrusion of granite forming the lower part of Ben Nevis. It is capped by andesitic lavas, breccias, and tuffs, presumably of Lower Old Red Sandstone age.

*Loch Lochy* (see Plate LXXXIII.).—Loch Lochy is the southernmost of the chain of lochs occupying the Great Glen which were utilized in forming the Caledonian Canal. Its southern end is about 8 miles north of Fort William. It is a straight loch, running nearly north-east to south-west. In form Loch Lochy is a narrow triangle, with the apex at the north end, gradually widening southward to near Bunarkaig, where the greatest breadth is found, after which it rapidly narrows for the remaining 2 miles to the outflow at Gairlochy. A good road runs along the eastern shore, a rough cart-road on the western side, and several stations of the Invergarry and Fort-Augustus railway now give easy access to the loch on the east side. The surroundings are wild, gloomy, and solitary (see Fig. 52). No village is found on its shores, an occasional house being passed on the east side, while the west side is uninhabited, save for one or two distant cots.

The hills on the west rise with a uniform very steep slope to a height of more than 3000 feet (Sron a Choire Ghairbh), broken only by the deep gashes torn by the torrents in the glacial debris, which here extends far up the mountains. On the east the slope is about the same, but the hills less high, the ridge (almost wholly covered with debris) which separates Loch Lochy from Glen Gloy reaching to 2000 feet.

The only important streams feeding the loch are the river Arkaig, bearing the superfluent waters from Loch Arkaig, entering near the lower end, and a large burn coming down Glen Gloy, the rest of

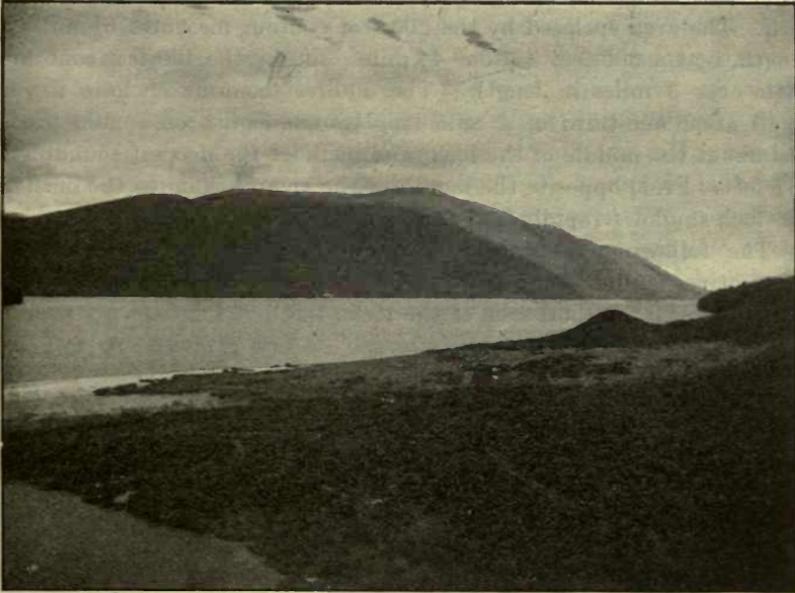


FIG. 52.—LOCH LOCHY, FROM THE SOUTHERN END.

(*Photograph by Mr. James Chumley.*)

the feeders being mere mountain torrents. A very small portion of the overflow of Loch Oich enters Loch Lochy by the Caledonian Canal.

The length of the loch is a little under 10 miles, the greatest breadth  $1\frac{1}{4}$  miles, opposite the mouth of the Arkaig, and the average breadth three-fifths of a mile. The greatest depth is 531 feet, and the mean depth 229 feet. The loch has a superficial area of nearly 6 square miles, and drains directly an area of about 58 square miles, but as it receives the outflow from Loch Arkaig, the total drainage area is nearly 124 square miles. The overflow of Loch Lochy is carried by the river Lochy into Loch Linnhe.

The survey of the loch occupied from April 28 to May 1, 1903; the height of the surface above sea-level on commencing the survey was

found to be 94.24 feet, as compared with 93.2 feet observed by the officers of the Ordnance Survey on July 1, 1870. Loch Lochy contains 37,726 millions of cubic feet of water, or nearly 50 per cent. more than Loch Arkaig, the second largest loch in the basin.

At the north end a small basin, called Ceann Loch, measuring one-half by one-third of a mile, and having a maximum depth of 66 feet, is cut off from the main loch by a narrow channel\* in which the greatest depth is 40 feet.

The main loch is a simple basin, with the U-shaped section characteristic of glacier-formed lakes. All the contours are continuous, those at 50 and 100 feet enclosing areas little less than the total length of the loch. The area enclosed by the 200-foot contour measures  $6\frac{1}{2}$  miles in length, by the 300-foot contour  $4\frac{3}{4}$  miles, and by the 400-foot contour a little over 3 miles in length. The 500-foot contour encloses a very small area, one-third of a mile long by one-eighth of a mile broad, just about the middle of the loch, and includes the deepest sounding in 531 feet. From opposite the mouth of the river Arkaig to the outflow, the loch shallows rapidly and the contours are irregular.

The following table gives the approximate areas between the consecutive contour-lines drawn in at intervals of 100-feet, with the percentages to the total area of the loch:—

0 to 100 feet	923 acres	24.4 per cent.
100 ,, 200 ,,	937 ,,	24.8 ,,
200 ,, 300 ,,	651 ,,	17.2 ,,
300 ,, 400 ,,	571 ,,	15.1 ,,
400 ,, 500 ,,	678 ,,	17.9 ,,
Over 500 ,,	23 ,,	0.6 ,,
	<u>3783</u> ,,	<u>100.0</u> ,,

The flat-bottomed character of the basin is indicated by the comparatively large area covered by water between 400 and 500 feet in depth, an area greater than in the two shallower zones; the zone between 100 and 200 feet, also, is rather larger than the shore zone.

*Temperature Observations.\**—The surface temperature varied from 43°·5 Fahr. to 42°·1. A series taken on April 29 showed the small range from the surface to 425 feet of only 1°·2. It will be seen from

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\* During the past twenty years Sir John Murray has taken many temperature observations in Loch Lochy, and has published and discussed the results in the following papers, to which the reader is referred for further details: (1) "On the Effects of Winds on the Distribution of Temperature in the Sea- and Fresh-water Lochs of the West of Scotland," *Scott. Geogr. Mag.*, vol. 4, p. 345, 1888; (2) "On the Temperature of the Salt- and Fresh-water Lochs of the West of Scotland, at Different Depths and Seasons, during the years 1887 and 1888," *Proc. Roy. Soc. Edin.*, vol. 18, p. 139, 1891; (3) "Some Observations on the Temperature of the Water of the Scottish Fresh-water Lochs," *Scott. Geogr. Mag.*, vol. 13, p. 1, 1897.

the table that the change is very gradual, but quickest in the upper 50 feet, where half of the total range occurs:—

Surface ... ..	42°·7 Fahr.
10 feet ... ..	42°·5 ”
50 ” ... ..	42°·1 ”
100 ” ... ..	42°·1 ”
150 ” ... ..	41°·9 ”
200 ” ... ..	41°·7 ”
300 ” ... ..	41°·7 ”
350 ” ... ..	41°·6 ”
400 ” ... ..	41°·5 ”
425 ” ... ..	41°·5 ”

*Loch Arkaig* (see Plate LXXXIV.).—Loch Arkaig is a long, narrow, curved loch, running nearly due east and west, the lower end about 1 mile west of Loch Lochy and 10 miles north of Fort William.

The lower part of the loch is well wooded, picturesque, and romantic, with hills to north and south reaching well over 2000 feet in height (see Fig. 53). The upper part is barer and grander, the mountains exceeding 3000 feet in height. A road runs along the north side of the loch, deteriorating towards the west end into a rough track which leads to Loch Nevis and Loch Morar. Several wooded islands enhance the charm of the scenery, and on one of these is one of the few nesting-places of the osprey, still occupied by the birds at the time the survey was made. There is very good fishing in Loch Arkaig, and lake trout up to 10 lbs. in weight were taken from the loch while the survey was going on.

Loch Arkaig is 12 miles long, of somewhat irregular outline, but broadest in the middle parts and tapering towards each end. The greatest breadth is nearly a mile, the mean breadth half a mile. The maximum depth is 359 feet, the mean depth  $152\frac{3}{4}$  feet. The surface has an area of  $6\frac{1}{4}$  square miles, and the loch drains an area of 88 square miles. The volume of water is estimated at 26,573 millions of cubic feet.

No large loch drains into Loch Arkaig, but several very small lochs do so, the largest being Loch a' Bhlair, a mile to the north. The chief streams enter at the west end, where a short river brings the drainage of Glens Pean and Dessary, and on the south side, where the stream from Glen Camgharaidh enters near the upper end, and that from Glen Mallie near the lower end. Only mountain torrents enter on the north. The river Arkaig, a mile long, conveys the overflow of Loch Arkaig into Loch Lochy.

When surveyed, in the middle of June, 1902, the height above sea-level was found to be 139·0 feet; the officers of the Ordnance Survey found the elevation to be 139·8 feet above the sea on July 10, 1869.

The basin of Loch Arkaig is nearly simple, the slight irregularities

doubtless correlated with the curving outline. The contours at 50 feet and 100 feet are continuous. A little over 2 miles from the west end of the loch there is an abrupt narrowing, and the loch continues narrow to the end. Corresponding with this the 200-foot contour is broken into two basins. In the narrow western part is a separate 200-foot basin, with a maximum depth of 262 feet; this is only separated from the

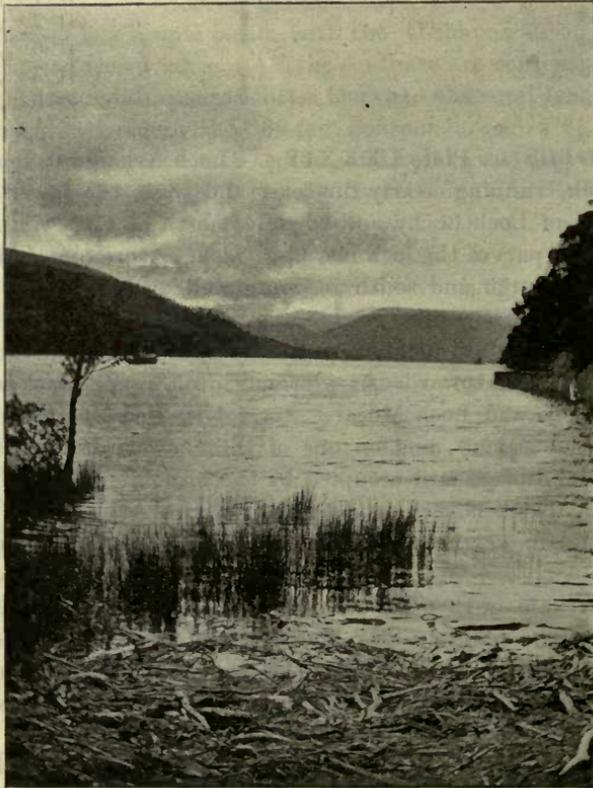


FIG. 53.—LOCH ARKAIG, FROM THE EAST END.

(*Photograph by Mr. James Chumley.*)

main 200-foot basin by a slight shallowing to 183 feet. The main 200-foot basin is about 8 miles long; it includes three areas of over 300 feet, which, however, are only separated by very slight shallowings. The largest of these 300-foot areas is about 2 miles long, is situated just about the middle of the loch, and includes the maximum depth of 359 feet. The others, further to the east, are close together, and of very slight extent. Though the wide portion of the loch, fully 9 miles in length, forms a simple basin, there is not the well-marked U-section found in typical glacier-formed lochs (see cross-section E-F on map).

The following table gives the approximate areas between the contour-lines laid down at intervals of 100 feet, with the percentages to the total area of the loch, and shows a gradually decreasing area with increasing depth:—

0 to 100 feet	1412 acres	35·3 per cent.
100 „ 200 „	1257 „	31·5 „
200 „ 300 „	1073 „	26·9 „
Over 300 „	253 „	6·3 „
	<u>3995 „</u>	<u>100·0 „</u>

Through the kindness of Mr. Thomas Honeyman, factor to Cameron of Lochiel, we have inspected a bathymetrical chart of Loch Arkaig, based upon soundings taken in 1889 by an officer in the German army named Sandler. The chart is drawn to the scale of  $1\frac{3}{4}$  inches to the mile, and the soundings are given in fathoms. A comparison of Sandler's map with the Lake Survey map shows that—(1) Sandler's soundings are much less numerous than those taken by the Lake Survey, and many of his lines were taken in zigzag fashion instead of running at right angles to the axis of the loch; (2) though there is a general agreement between the two maps, the Lake Survey map shows as a rule rather deeper water, position for position; for instance, taking the deepest sounding on each of Sandler's lines, and placing it approximately on the Lake Survey map, deeper soundings occur in the vicinity; thus Sandler's deepest sounding in 55 fathoms (330 feet) approximates to the Lake Survey maximum in 359 feet.

*Temperature Observations.*—The surface temperature in the centre of the loch varied from  $48^{\circ}\cdot3$  Fahr. to  $51^{\circ}\cdot5$  during the three days of the survey; near shore it reached  $52^{\circ}\cdot3$  on June 13. A series taken in the main basin on June 11 showed a range of  $4^{\circ}\cdot7$  from the surface to 280 feet, the greatest variation being observed in the superficial layers of water, as shown in the accompanying table:—

Surface ... ..	49°·4 Fahr.
10 feet ... ..	48°·9 „
25 „ ... ..	47°·5 „
50 „ ... ..	46°·5 „
100 „ ... ..	45°·5 „
150 „ ... ..	45°·0 „
200 „ ... ..	44°·9 „
250 „ ... ..	44°·7 „
280 „ ... ..	44°·7 „

*Loch Pattack* (see Plate LXXXIX.).—Loch Pattack (or Pattaig) lies at a considerable elevation among the mountains which separate Loch Ericht from Loch Laggan. It is only about 2 miles distant from Loch Ericht, though it belongs to a different drainage system, draining by

the river Pattack, some 9 miles long, into the upper end of Loch Laggan. It is a loch of somewhat irregular form, about a mile long by half a mile broad, its long axis running nearly north-east and south-west. The maximum depth is 58 feet, and the mean depth 14 feet. The volume of water is estimated at 106 million cubic feet. The superficial area is about 173 acres, or fully a quarter of a square mile, and it drains an area of 18 square miles. It receives the greater part of the drainage of the east side of the mountain mass, of which Ben Alder (3757 feet) is the highest peak. In this drainage area are three smaller lochs, which were not surveyed. When surveyed in May, 1904, the height above sea-level was estimated (from spot-levels) at 1419 feet.

The basin is quite simple, the contours roughly following the irregular outline of the shore, and the deepest part almost in the centre of the loch. The slopes are gentle, except opposite the mouths of the two rivers, both of which have laid down alluvial promontories, with small islands, from which the incline to the deepest water is rapid. The loch is on the whole shallow, for 78 per cent. of the lake-floor is covered by less than 20 feet of water, and 60 per cent. by less than 10 feet of water.

*Temperature Observations.*—A series of temperatures, taken in the deepest part of the loch, gave 42°·6 Fahr. at the surface, 41°·4 at 25 feet, and 40°·8 at 50 feet.

*Lochan na h-Earba* (see Plate LXXXV.).—The two lochs which bear this name may have formed at no very distant date a single loch, as suggested by the common name and by the appearance of the ground. Be that as it may, they are now two distinct lochs, differing by nearly 10 feet in level. In April, 1873, the Ordnance Survey officers found the elevation of the west loch to be 1151·7 feet, and that of the east loch 1142·3 feet, above sea-level. They lie in a valley which runs nearly parallel to that occupied by Loch Laggan, to the south side of that loch, and distant from it about a mile. Hills of over 3000 feet rise close on the east; on the west they are separated from Loch Laggan by a ridge of between 2000 and 2500 feet in height. The shores are for the most part wooded.

*The West Loch.*—This is the larger, broader, and deeper of the two. It lies at an elevation of about 1150 feet, some 330 feet higher than Loch Laggan. It is fully  $1\frac{3}{4}$  miles in length, rather less than one-third of a mile in greatest breadth, and a quarter of a mile in mean breadth. The greatest depth is 81 feet, the mean depth over  $35\frac{1}{2}$  feet. It has a superficial area of about 263 acres, or less than half a square mile, and drains an area of fully 5 square miles. The volume of water amounts to 408 millions of cubic feet. The loch is fed chiefly by two small streams, coming down from Beinn a' Chlachair, which unite just before entering the loch. A stream, half a mile long, winds through a boggy flat, con-

veying the overflow to the east loch. The long narrow loch is nearly straight. From the centre it narrows to the outflow, but southwestward to the upper end the width is nearly uniform, the end rectangular, straight, and a quarter of a mile across.

The basin is quite simple, none of the contour lines being broken. The contours do not closely follow the shore-line; they narrow more decidedly than the outline from the centre to each end, the slopes being much steeper towards the centre of the loch, where the sections are U-shaped. The deepest part is rather to the east of the centre, and it is curious to note in close proximity an elevation with only 30 feet on it, surrounded on all sides by water exceeding 50 feet in depth.

The approximate areas between the contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	102 acres	38·7 per cent.
25 ,, 50 ,,	85 ,,	32·2 ,,
50 ,, 75 ,,	67 ,,	25·6 ,,
Over 75 ,,	9 ,,	3·5 ,,
	<hr/> <hr/> 263 ,,	<hr/> <hr/> 100·0 ,,

*Temperature Observations.*—A series of temperatures at the deepest part of the loch showed a range of 4°·8 Fahr. from top to bottom. The greater part of this was in the upper 10 feet, the difference between 10 and 60 feet being only 1°, as shown in the following table:—

Surface ... ..	49°·9 Fahr.
10 feet ... ..	46°·1 ,,
20 ,, ... ..	45°·8 ,,
60 ,, ... ..	45°·1 ,,

Near shore the surface temperature was as high as 53°·4.

*The East Loch.*—This is about half a mile distant from the west loch, and nearly 10 feet lower, about 1140 feet above the sea. It is 1½ miles long, a quarter of a mile in greatest breadth, and averages just under one-fifth of a mile in breadth. The maximum depth is 69 feet, and the mean depth 31 feet. It has an area of about 146 acres, or nearly a quarter of a square mile, and it drains an area extending to about 9½ square miles, including that draining into the west loch. The volume of water is 191 millions of cubic feet, or less than half the volume of the west loch. The chief feeder is the stream from the west loch. There enters also at the upper end a branch of the Allt na Magha, the stream which has laid down the delta now separating the two lochs. About the middle of the east shore enters the small stream coming from Loch an Iubhair. The waters of Lochan na h-Earba are discharged by the Allt Lowrag, about a mile long, into Loch Laggan.

The east loch has the same general form as the west loch, long and narrow, broader at the upper end and tapering to the outflow. The

deep water is all towards the upper end, the lower half of the loch being very shallow. The area enclosed by the 50-foot contour is about half the total length of the loch, and in this part the sections are somewhat U-shaped. A slight shoaling is observable opposite the entrance of the stream near the middle of the eastern shore, where, in the centre, the deepest sounding was 52 feet, with depths of 60 feet and over both to the north-east and south-west.

*Temperature Observations.*—Serial temperatures in the deepest part indicated practically the same range ( $5^{\circ}$ ) as in the west loch, and the distribution of temperature was exactly similar, but all parts of the loch were about  $1^{\circ}$  higher:—

Surface ... ..	51°·0 Fahr.
10 feet ... ..	47°·5 "
20 " ... ..	46°·2 "
50 " ... ..	46°·0 "

*Loch Laggan* (see Plate LXXXV.).—Loch Laggan is situated in the southern portion of Inverness-shire, between the Highland and West Highland railways, being about equally distant from the nearest points of each. Dalwhinnie, on the Highland railway, is about  $6\frac{1}{2}$  miles from the upper end of the loch; Tulloch, on the West Highland railway, is about 6 miles from the lower end. The coach road from Kingussie to Tulloch passes along the northern shore. The loch runs nearly north-east and south-west, and occupies a valley lying between the very high mountains of Badenoch on the south-east and an equally high and more extensive mountain mass of the district of Lochaber on the west. The loch is of the usual elongate narrow form of Scottish lochs, narrowest in the central parts, and somewhat expanded towards each end, where deeper water occurs. The outline is very irregular, and the bottom, as shown by the contours, correspondingly irregular. A number of larger and smaller islands are found in the narrower parts of the loch. The length is a little over 7 miles, the greatest breadth two-thirds of a mile, the mean breadth nearly half a mile, the superficial area about 1900 acres, or nearly 3 square miles. The maximum depth is 174 feet, the mean depth 68 feet, and the volume of water about 5600 millions of cubic feet. The loch was surveyed on June 2 and 3, 1902, when the elevation of the lake-surface above the sea was found, by levelling from bench-marks to be 818·6 feet; the officers of the Ordnance Survey found the elevation to be 818·9 feet above sea-level on October 19, 1867. The shores are wooded nearly throughout, and the scenery wild and picturesque (see Fig. 54), the mountains rising abruptly on the north side into a series of peaks, culminating in Creag Meaghaidh, 3700 feet high. On the south-east the high mountains are more distant, Beinn a' Chlachair, over 3500 feet, being 4 miles from the lower end of the loch. Close to the loch on this side, two hills, rather more than 2000

feet in height, separate it from the valley in which lies Lochan na h-Earba. Loch Laggan drains directly an area of 34 square miles, but since it receives the overflow from Loch Pattack and Lochan na h-Earba, its total drainage area is nearly 62 square miles. The principal stream entering the loch is the river Pattack, which drains Loch Pattack and a number of smaller lochs. The Allt Lowrag brings

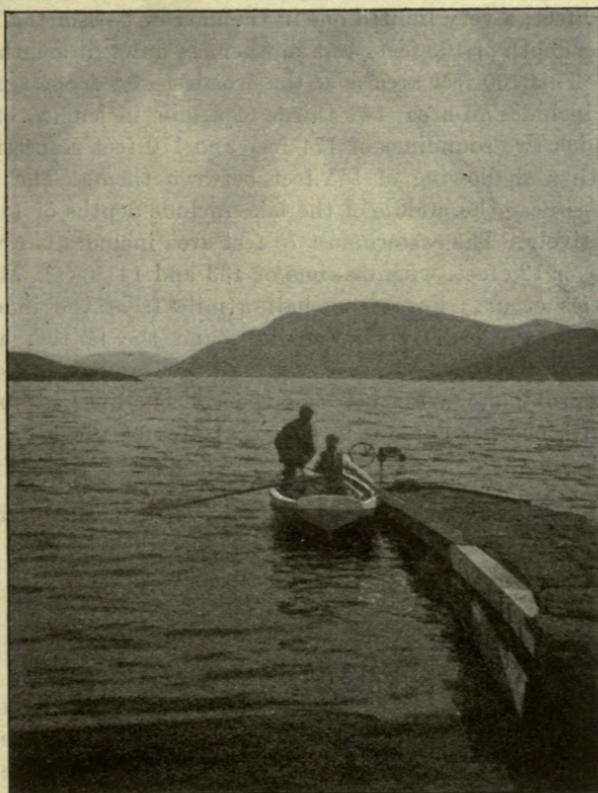


FIG. 54.—LOCH LAGGAN.

(*Photograph by Sir John Murray.*)

the overflow of Lochan na h-Earba. Near Aberarder, in the middle of the north shore, two large burns enter, and there are many smaller streams on this side. The river Spean issues from the loch, and flows into the Lochy close to Loch Lochy.

Contours are drawn for every 25 feet of depth. The bottom is so irregular that only the 25-foot and the 50-foot contours are continuous, and follow approximately the outline of the shore. All the others are much broken up. The 75-foot contour is broken into four distinct

portions; the largest of these approaches the west end of the loch, and is  $2\frac{1}{2}$  miles in length. Two lesser areas, each about two-thirds of a mile in length, occur close together in the narrow middle part of the loch. The 75-foot area towards the upper end of the loch is nearly  $1\frac{1}{2}$  miles in length. The shallowings between these various basins are all opposite the mouths of streams, but in one instance the stream is too small to account for the shallowing, and other larger streams appear to have had no effect on the contours. The largest 75-foot basin includes two areas of over 100 feet, a very limited one in the narrow part of the loch, with a maximum depth of 105 feet, and another,  $1\frac{1}{2}$  miles in length, near the west end. This 100-foot area is at the broadest and deepest part of the lake, and includes an area, two-thirds of a mile in length, of over 150 feet, in which two soundings of 174 feet and 170 feet respectively were taken, with a shallowing of 155 feet between them. The two small 75-foot areas near the middle of the lake include depths of 112 and 114 feet respectively. The easternmost 75-foot area includes two very small basins of over 125 feet, with maxima of 133 and 141 feet. Many lesser irregularities occur. For about half a mile from the inflow of the river Pattack the loch is very shallow, and the bottom and shores are sandy.

The approximate areas between the contour-lines at intervals of 50 feet, with the percentages to the total area of the loch, are given in the following table:—

0 to 50 feet	765 acres	40·3 per cent.
50 „ 100 „	686 „	36·1 „
100 „ 150 „	396 „	20·8 „
Over 150 „	53 „	2·8 „
	<u>1900 „</u>	<u>100·0 „</u>

*Temperature Observations.*—The following series of temperatures, taken towards the east end of the loch at noon on June 3, 1902, indicates a range of only  $1^{\circ}\cdot 2$  Fahr., the greater part of the variation occurring in the upper 10 feet of water:—

Surface ... ..	47°·0 Fahr.
5 feet ... ..	46°·6 „
10 „ ... ..	46°·2 „
20 „ ... ..	46°·0 „
30 „ ... ..	45°·9 „
50 „ ... ..	45°·9 „
70 „ ... ..	45°·8 „
100 „ ... ..	45°·8 „

*Loch Ossian* (see Plate LXXXVI.)—Loch Ossian (or Ouchan) is a narrow loch in a valley running nearly north-east and south-west to the north of Rannoch moor (see Fig. 55). It lies at a considerable

elevation, about a mile north-east of the summit of the West Highland railway, at Corroun station, from which the loch can be seen. The mountains rise to over 3000 feet both on the north-west and south-east. The former solitude is now relieved, since the mansion of Sir John Stirling Maxwell, Bart., has been built on the shore of the loch.

In form Loch Ossian is narrow, with its long axis slightly curved, and of nearly uniform breadth throughout. It is  $3\frac{1}{4}$  miles long, nearly

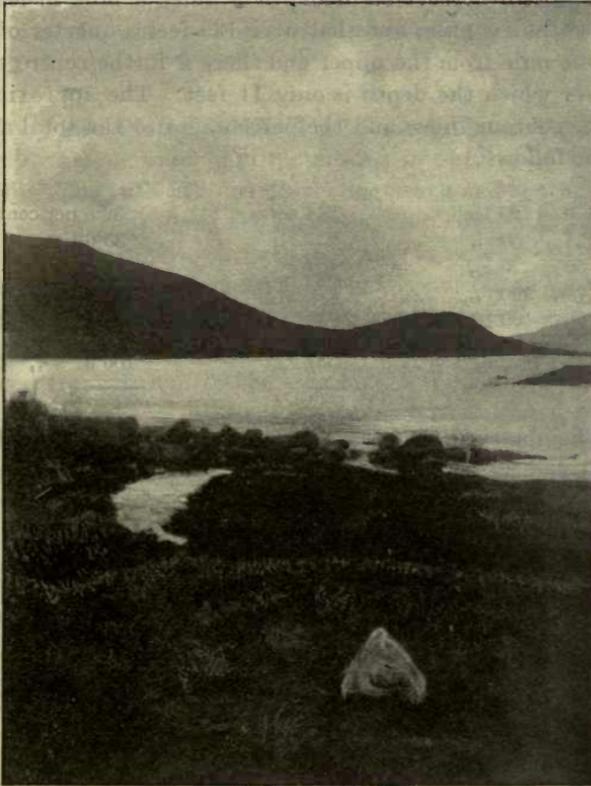


FIG. 55.—LOCH OSSIAN.

(*Photograph by Sir John Murray.*)

half a mile in greatest breadth, and has a mean breadth of about one-third of a mile. The greatest depth is 132 feet, and the mean depth 43 feet. It has a superficial area of just about a square mile, and a volume of 1224 millions of cubic feet. It drains an area of nearly  $10\frac{1}{2}$  square miles, receiving only mountain torrents from the surrounding hills, and flows out by the river Ossian into Loch Ghuilbinn,  $2\frac{1}{2}$  miles to the north. The loch was surveyed on May 14, 15, and 16, 1902, when the height of the water above sea-level was found to be 1268·7

feet; this is nearly identical with the level determined by the Ordnance Survey officers on May 27, 1870, viz. 1268·6 feet.

The bottom of Loch Ossian is very uneven, the transverse, as well as longitudinal, sections being undulate. Only the 25-feet contour follows the line of the shore. The 50-feet contour encloses an area 2 miles in length. The south-western portion of this for three-quarters of a mile is exceedingly narrow. Near the middle of the loch it broadens to a quarter of a mile, and continues broad to near the out-flow. The area over 75 feet in depth is fully a mile in length, that over 100 feet half a mile, and that over 125 feet a quarter of a mile in length. One mile from the upper end there is in the centre of the loch a shoal, over which the depth is only 11 feet. The approximate areas between the contour-lines, and the percentages to the total area of the loch, are as follows:—

0 to 25 feet	214 acres	32·6 per cent.
25 „ 50 „	234 „	35·6 „
50 „ 75 „	104 „	15·8 „
75 „ 100 „	72 „	10·9 „
Over 100 „	33 „	5·1 „
	<u>657 „</u>	<u>100·0 „</u>

It will be observed that the area of the lake-floor covered by water between 25 and 50 feet in depth is larger than the shore-zone covered by less than 25 feet of water.

*Temperature Observations.*—The following temperatures taken at 1 p.m. on May 16, 1902, show a range of less than 1° Fahr.:—

Surface ... ..	44°·3 Fahr.
10 feet ... ..	44°·1 „
25 „ ... ..	43°·7 „
50 „ ... ..	43°·8 „
100 „ ... ..	43°·4 „

*Loch Ghuilbinn* (see Plate LXXXVII).—Loch Ghuilbinn (or Gulbin) is a small and relatively broad loch, lying in the midst of the high mountainous region between Lochs Ericht, Treig, and Laggan. The long axis runs nearly north and south. The surrounding hills rise on all sides into peaks of well over 3000 feet. The loch is fully three-quarters of a mile long, and nearly half a mile in greatest breadth, with a mean breadth of a little over a quarter of a mile. The greatest depth is 49 feet, and the mean depth over 13 feet. The superficial area is about 146 acres, or nearly a quarter of a square mile, and the volume 85 million cubic feet. It receives the drainage of a basin extending to 29 square miles, including Loch Ossian. It is fed chiefly by the river Ossian, which, besides bringing the overflow of Loch Ossian, receives

the drainage of considerable glens both to the east and west. Its outflow is by the river Ghuilbinn, which flows due north about 5 miles and enters the river Spean just below Loch Laggan. The level of the loch is estimated, from spot-levels on the shore, to be 1160 feet above the sea.

Loch Ghuilbinn is a simple basin. The sides slope very gently down to 20 feet, nearly 86 per cent. of the whole area of the loch being less than 20 feet in depth. From 20 to 40 feet the slope of the sides is much steeper. A very small area exceeds 40 feet in depth, only about  $3\frac{1}{2}$  per cent. of the whole. The surface temperature on May 17, 1902, varied from  $45^{\circ}\cdot 0$  to  $45^{\circ}\cdot 3$  Fahr.

*Loch Treig* (see Plate LXXXVIII.).—Loch Treig occupies a deep narrow valley among very high mountains in the region of Lochaber (see Fig. 56). The valley trends nearly due north and south. The West Highland railway runs along the east side, and Tulloch station, whence the coach road goes off towards Kingussie, is only 2 miles from the north or lower end of the loch. There is no road on either side of the loch, nor is there to the south any public road nearer than Kingshouse, at the head of Glenceo, Rannoch station being about equally distant. The old road from Struan to the old Corroul Lodge came to the head of the loch, but is now disused and in bad condition. A cart-road approaches the north end of the loch. The sides of the loch are quite uninhabited, but at or near either end are a few keepers' houses and farms. The mountains rise very steeply on either side, those on the west being higher, rising in a series of peaks, the highest of which (Stob Choir an Easain Mhoir) reaches a height of 3658 feet; on the east the highest peak is Cnoc Dearg, 3433 feet high.

The length is a little over 5 miles, the greatest breadth three-quarters of a mile, mean breadth just under half a mile. The maximum depth is 436 feet, the mean depth 207 feet. The area of the loch is nearly  $2\frac{1}{2}$  square miles, and it drains an area of about 42 square miles. Three streams, considerable only during floods, enter the upper end of the loch; the sides are unbroken by any large stream, but are scored by the torrents which cut through the glacial debris, which here, as at Loch Lochy, extends far up the hillsides. The overflow is carried by the short river Treig into the river Spean at Tulloch. On May 29, 1902, when the survey was finished, Loch Treig was 787·0 feet above sea-level; the level was high in consequence of recent rains. On July 13, 1868, the Ordnance Survey found the height above the sea to be 783·9 feet. In volume Loch Treig comes third among the lochs of the Lochy basin, containing 13,907 millions of cubic feet. This is more than twice the volume of Loch Laggan, rather more than half that of Loch Arkaig, and one-third that of Loch Lochy.

In form Loch Treig is a narrow triangle, broadest towards the south

end, and tapering all the way to the outflow. Half a mile from the north end a rocky promontory, the Rudha Ceann Ard Thonnaich, constricts the loch, but there is no shallowing in the narrows, where the depth is well over 200 feet. The basin is quite simple, all the contours approximately following the shore-line. The steep slope of the hills is continued under water, and there is in most parts but little beach. The axis of the loch is slightly curved, and the line of greatest depth is nearer the west shore. The area over 400 feet deep is very narrow, about 2 miles in length, and at both ends comes very close to the west side, the steepest slopes in the loch being at these points. The



FIG. 56.—LOCH TREIG.

(*Photograph by Mr. T. N. Johnston, M.B., C.M., F.R.S.E.*)

cross-sections in the middle parts of the loch, as at C-D on the map, only show slightly the U-shape which distinguishes glacier-hollowed lochs. The valley is so narrow, relatively to the depth of the loch, that the steep slopes reach far towards the middle, and leave but little comparatively level bottom. Towards the south end, where the loch is broader, and the depth less (from 200 to a little over 300 feet), there is a greater extent of nearly flat bottom, and the U-section is more clearly marked. The approximate areas between the consecutive contours at intervals of 100 feet, and the percentages to the total area of the loch, are given in the following table:—

0 to 100 feet	415 acres	27·0 per cent.
100 „ 200 „	294 „	19·1 „
200 „ 300 „	440 „	28·6 „
300 „ 400 „	256 „	16·6 „
Over 400 „	135 „	8·7 „
	1540 „	100·0 „
	1540 „	100·0 „

The striking characteristic brought out by this table is the large area of the lake-floor covered by water between 200 and 300 feet in depth—an area greater than in either of the two shallower zones.

*Temperature Observations.*—At the early season when Loch Treig was surveyed, the surface was very little warmer than the bottom, the whole difference between the surface and 300 feet, on May 29, when the last series was taken being only 1°·7 Fahr. Five days earlier, May 24, the difference was only 0°·7. In the interval the surface had risen in temperature 1°·6, while at 300 feet the rise was only 0°·6. The three serials are contrasted in the table appended:—

Depth in feet.	May 24, 11·30 a.m.	May 27, 9 a.m.	May 29.
Surface	° Fahr. 41·2	° Fahr. 41·6	° Fahr. 42·8
5	41·2	...	...
10	41·0	41·2	...
20	41·0	41·7	...
30	41·0	...	...
40	...	41·4	...
50	41·0	...	42·0
100	40·9	...	41·8
150	40·8	...	...
200	40·8	...	41·2
250	40·6	...	...
300	40·5	...	41·1

*An Dubh Lochan* (see Plate LXXXIX.).—A very small loch situated about halfway between Loch Treig and the river Spean and a little to the west of the river Treig. It lies at an elevation of 785 to 790 feet above the sea, at the west side of an extensive deposit of gravel and sand, hills of moderate height rising on the west shore (see Fig. 57). It is of somewhat oblong form, diversified by many little bays, and is shallow and weedy towards the south end. It is nearly a quarter of a mile long, and covers an area of about 8½ acres. The greatest depth is 40 feet, and the mean depth 15½ feet. The volume of water amounts to 6 millions of cubic feet. It has a drainage area of about one-sixth of a square mile, receiving only local superficial water. It drains by a small stream northward into the river Spean.

The basin of the loch is quite simple, the deepest part being much nearer the north end, and the longitudinal slope is accordingly quicker at the north end and very gradual towards the south. The temperature of the water on October 18, 1904, was  $46^{\circ}0$  Fahr. at the surface, the same at a depth of 20 feet, and only a trifling fraction less at the bottom,  $45^{\circ}8$ .

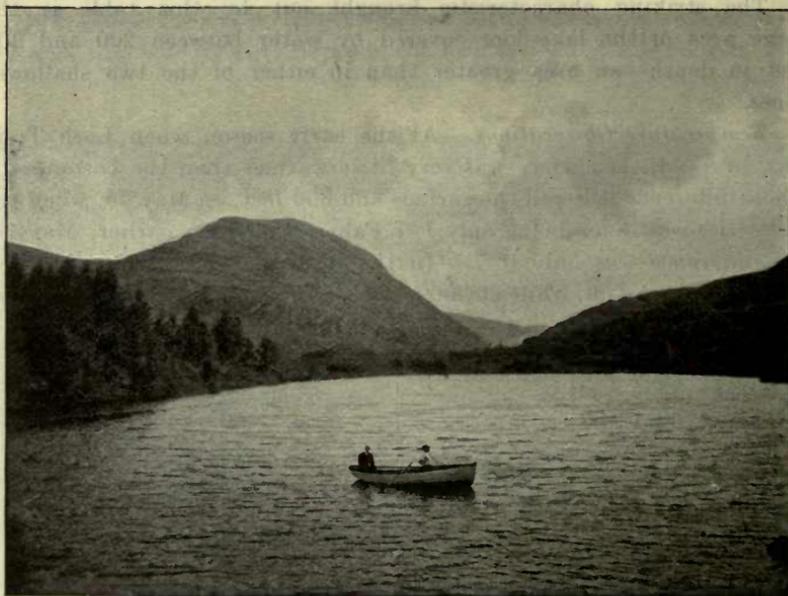


FIG. 57.—AN DUBH LOCHAN.  
(Photograph by Colonel Mainwaring.)

*Lochan Lùnn dà-Bhrà* (see Plate XC).—A very picturesque loch, almost halfway between Fort William and Ballachulish. It is about 5 miles south of Fort William, and is reached by a very rough road, one of General Wade's military roads. It is a narrow loch, with its axis running north-east and south-west. The surrounding hills are of moderate height (1500 to 2000 feet) and grassy, except on the east, where Mullach nan Coirean rises steeply to 3000 feet. Patches of fir wood towards the lower end of the loch enhance the beauty of the scene.

The loch is nearly a mile long and relatively very narrow, the greatest breadth being only about one-sixth of a mile, and the mean breadth one-eighth of a mile. The maximum depth is 25 feet, and the mean depth  $8\frac{1}{2}$  feet. The surface has an area of about 66 acres. The volume of water is 23 millions of cubic feet. It receives the drainage

from an area of over a square mile, by small burns only, and flows out by the Water of Kiachnish into Loch Linnhe.

At the date when surveyed (May 9, 1903) the height above sea-level was 510·1 feet, exactly one foot lower than the elevation determined by the Ordnance Survey officers in May 1867.

The basin of Lochan Lùnn dà-Bhrà is broken by islands, about a quarter of a mile from each end and nearly in the middle of the loch. The island towards the upper end is on a bar, the greatest depth to the north-west and south-east of it being respectively 9 and 8 feet. This bar cuts off a separate small basin, with a maximum depth of 21 feet. The greatest depth of the loch, 25 feet, was found not far to the north-east of this island. North-east from the lower island it is everywhere shallow, nowhere exceeding 7 feet.

The shores of Lochan Lùnn dà-Bhrà are composed chiefly of gravel with boulders, which form many heather-covered mounds. Rock is exposed in many small spots. The stream flows out through a flattish tract, covered with moraine mounds, about half a mile long, and rock was seen in the channel at a distance of about 100 feet from the loch. The promontory below Lundavra farm has been laid down by the stream.

We were told by the local inhabitants that the loch will sometimes freeze all over in a single night, and that small dark trout are abundant in it. There are also some pink-coloured trout, and others silvery like salmon.

The temperature was 48°·0 Fahr. throughout.

*Loch nan Gabhar* (see Plate XC).—Loch nan Gabhar (or Gour) is a little weedy hollow lying close to the sea-shore, and very little above sea-level, on the west side of Loch Linnhe, nearly opposite Ballachulish. It runs nearly east and west, and occupies the southern portion of a large oval alluvial flat, in the midst of which rises an abrupt boss of rock, the Tòrr an Duin, apparently some 70 or 80 feet in height. This alluvial flat is surrounded by steep rocky hills, which form the southern shore of the loch.

The loch is of very irregular form, and interrupted by narrows, bays, and promontories. It is fully half a mile long, one-sixth of a mile in greatest breadth, and one-eighth of a mile in mean breadth. The maximum depth is 5 feet, and the mean depth  $2\frac{1}{2}$  feet. The area of the water surface is only about 45 acres, and it receives the drainage of 13 square miles of country. The height above sea-level, on the date when the survey was made (May 12, 1903), was 7·35 feet, as compared with 7·5 feet observed by the officers of the Ordnance Survey on July 19, 1867.

Loch nan Gabhar receives by the river Gour the drainage of a considerable mountainous stretch of country, bordering Glen Gour,

## SUMMARY TABLE.

Giving Details concerning the Lochs in the Lochy Basin.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.		Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.	Max. feet.	Mean feet.	Mean percent. of max.	Max.	Mean.	Total in square miles.	Ratio to area of loch.				
Lochy	94.24	527	9.78	1.26	0.60	6.1	531	228.95	43.1	97	226	37.726	5.91	123.76	20.9	
Arkaig	139.00	667	12.00	0.87	0.52	4.3	359	152.71	42.5	176	415	26.573	6.24	88.27	14.2	
Pattack	[1419 approx.]	78	1.03	0.48	0.26	25.5	58	14.07	24.3	94	386	106	0.27	18.18	67.3	
Lochan na h-Earba	[1151.7 Apr. 1873]	90	1.80	0.30	0.23	12.8	81	35.62	43.9	117	267	408	0.41	5.26	12.8	
Do. (east)	[1142.3 Apr. 1873]	81	1.27	0.26	0.18	14.2	69	31.11	45.1	97	216	191	0.23	4.27	18.5	
Laggan	818.6	513	7.04	0.66	0.42	6.0	174	67.68	38.9	214	549	5,601	2.97	61.86	20.8	
Ossian	1268.7	176	3.20	0.45	0.32	10.0	132	42.75	32.4	128	395	1,224	1.03	10.36	10.0	
Ghuilbinn	[1160 approx.]	59	0.82	0.40	0.28	34.2	49	13.32	27.2	88	325	85	0.23	29.13	91.3	
Treig	787.0	253	5.10	0.75	0.47	9.2	436	207.37	47.6	62	130	13,907	2.41	42.32	17.5	
an Dubh Lochan	[785 to 790]	31	0.24	0.08	0.06	23.1	40	15.50	38.8	32	82	6	0.01	0.16	16.0	
Linn da-Bhrà	510.1	52	0.86	0.16	0.12	13.8	25	8.44	33.7	182	538	23	0.10	1.13	11.3	
nan Gabhar	7.35	43	0.58	0.16	0.12	21.0	5	2.50	50.0	612	1125	5	0.07	12.82	18.3	
		2570										85,855	19.88	271.18*	13.6	

\* The drainage area of Loch Arkaig is included in that of Loch Lochy; those of Loch Pattack and Lochan na h-Earba in that of Loch Laggan; and that of Loch Ossian in that of Loch Ghuilbinn.

which extends 5 miles west from the loch, among peaks rising to nearly 2500 feet. Two branch glens extend several miles to the north, and one of these brings the overflow of a small loch, Lochan na Beinne Baine, which was not surveyed. As a consequence of the extensive drainage area, the loch is subject to great alterations of level. The river has laid down long spits of sand, and threatens to silt up the loch altogether. A very short stream conveys the overflow to the sea; there is a boss of rock on the north side where it leaves the loch. In volume Loch nan Gabhar is the last in the basin, containing only 5 millions of cubic feet, or one million less than the volume of an Dubh Lochan.

The temperature of the water on May 12, 1903, was 51°·5 Fahr. at the surface and at the depth of 5 feet.

The particulars regarding the lochs in the Lochy basin are collected together in the table on p. 374 for convenience of reference and comparison. From this table it will be seen that in the twelve lochs under consideration, which cover an area of about 20 square miles, nearly 2600 soundings were taken, or an average of 214 soundings per loch, and an average of 129 soundings per square mile of surface. The aggregate volume of water contained in the lochs is estimated at 85,855 millions of cubic feet, or more than one-half of a cubic mile, and the area draining into them is over 270 square miles, or nearly fourteen times the area of the lochs.

*The Red Lochan at Tulloch.*—The Red Lochan, called in Gaelic by a name which signifies "brown eye," is a very small pond lying in an extensive morainic terrace at Fersit, near the north end of Loch Treig. It is only about 30 yards in its longest diameter, and 5 feet deep in the centre, is fed only by rains, and has no outflow except by percolation through the gravel, yet its surface is maintained almost constantly at the same level. The water is always turbid, and varies in colour from dull green to brown or red.

It was first examined by Sir John Murray in May, 1902. The water was then brown; the collection taken with the coarse net very pale yellow; that taken with the fine net a decided red. At that time there were only two very abundant organisms—the larva of an insect, *Corethra*, known as the "phantom larva," and a reddish-coloured rotifer, *Anuræa valga*. There were many other rotifera, entomostraca, and other organisms common in ponds, but none of these were abundant enough to be held responsible for the colour of the water. The collection made with the fine net was examined by Dr. T. N. Johnston and Mr. James Murray. On adding a little formalin, which killed the animals, a blood-red sediment was deposited, which was found to consist chiefly of *A. valga* and myriads of its red eggs. At that time this species seemed to be mainly the cause of the red colour.

Examined at different seasons, the colour was found to vary. In October, 1903, it was very red; in May, 1904, dull brown; in January, 1905, green. On all these occasions the phantom larva was about equally abundant, and none was seen in a more advanced stage of development. The changes of colour are doubtless correlated with the predominance of one or another organism. The *A. valga* is not always red; in May, 1903, it was dull grey in colour. When algæ are swarming, the colour will incline to green. The colour may be affected by the development of certain entomostraca—*Diaptomus gracilis*, for instance, was very abundant, but quite colourless, in May, 1903. Later in the year it becomes brown or red.

There are other ponds in close proximity to the Red Lochan, but none of these shares the turbidity and reddish-brown colour. The peculiarity is probably due to its being more closely shut in. The surrounding rim of gravel is 14 feet above the pond at its lowest part. There is, besides, a fringe of birch trees. The water is stagnant, which favours the growth of certain organisms, particularly *Anuræa valga*. The blood-red larva of *Chironomus*, though abundant, could have no part in causing the red colour, as it was not in the open water, but among the weeds and mud.

Mr. Robertson, the keeper at Fersit, to whom we are indebted for several collections and much information about the loch, states that it is later in freezing than the other ponds in the region. The more active decomposition in the stagnant water would account for this.

The temperature of the water in May is about 45°·0 Fahr. It is said that wildfowl never settle on this pond, and that the common frog cannot live in it.

The following legend was related to Sir John Murray concerning this Red loch:—

“Many centuries ago there lived in these parts a noted hunter named Donnuil. In return for some services rendered to the witch of Ben-Avreich, she offered to deprive the deer either of the sense of sight or of smell, so far as he was personally concerned. He chose to have the deer deprived of the sense of smell, ‘for,’ said he, ‘I can easily cheat their eye.’ The witch, however, told him that in the stomach of the last stag he would kill there would be found a ball of worsted thread. As time passed Donnuil became ill, and, while weak in bed, his daughter told him a fine stag was caught by the horns in some bushes near the house. He asked for his cross-bow, and, although in bed, he shot the stag through his bedroom window. Later on his daughter brought him a ball of worsted which had been found in the stomach of the stag. He knew his end was near; indeed, he died the same evening. On the following morning the Red Lochan had appeared at the place where the stag was killed.”

This story was evidently invented to explain the origin of the Red

loch, and is of the same order as those stories invented to explain why the fox has a bushy tail and why the serpent crawls on his belly.

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NOTES ON THE BIOLOGY OF THE LOCHS IN THE LOCHY DISTRICT.

By JAMES MURRAY.

There is little peculiarity in the biology of the large lakes in the basin, except in that of Loch Lochy. They contain the ordinary fauna of great lakes of low temperature. Most of them were surveyed so early in the season that the water was little above the minimum winter temperature, and the summer crustacea (*Holopedium*, *Leptodora*, &c.) had not arrived. The smaller lochs were warmer, and some of those crustacea were present.

*Loch Arkaig*.—The plankton is almost exactly that typical of large lakes, with hardly any local peculiarity. The larva of *Leptodora*, which we have rarely found, was present. A few examples of the somewhat rare *Latona setifera* were found. A few species of plankton-desmids, chiefly of the genus *Staurastrum*, occurred, but they were less conspicuous than in the lochs farther west.

*Loch Lochy*.—Though the situation of Loch Lochy is so similar to that of Loch Ness, and though the depth in the two lochs is comparable, the plankton of Loch Lochy offers a remarkable contrast to that of Loch Ness. In two different years when the lochs were examined, the plankton in Loch Lochy was found to be much richer. The quantity was many times greater, the species more numerous, but the special feature was the quantity and variety of the phytoplankton. Diatoms were very abundant. *Tabellaria fenestrata*, var. *asterionelloides*, was of more luxuriant growth than had been observed elsewhere, the colonies often making more than two complete turns of the spiral. The rare crustacean *Ophryoxus gracilis* (discovered in Britain in Loch Ness by Mr. D. J. Scourfield) was present. The heliozoon *Clathrulina*, of frequent occurrence in our larger lakes, but usually as skeletons merely, was here abundant and alive, the majority of the examples having the pseudopodia fully extended.

*Lochan na h-Earba*.—The fauna calls for little comment. *Latona setifera* was found in the west loch. Of the summer crustacea, *Holopedium* was in both lochs, *Leptodora* only in the east loch, and *Diaphanosoma brachyurum* only in the west loch. Desmids were conspicuous in both lochs, and included some species which we have not often found.

*Loch Laggan*.—The plankton is quite ordinary, except that it is the only loch of the basin where we observed two species of *Diaptomus*.

One was the common *D. gracilis*, the other difficult to determine, owing to the lack of fully matured examples, but almost certainly *D. laticeps*.

*Loch Ossian and Loch Ghuilbinn.*—The fauna of these lochs is in no way peculiar. Desmids were scarce in Loch Ossian, and abundant in Loch Ghuilbinn, where, among others, *Staurastrum ophiura* occurred.

*Loch Treig.*—*Bosmina obtusirostris* had a very long spine, approaching the variety *longispina*, as found in Loch Morar. This is the only large lake where we found the rotifer *Triarthra longiseta*. Skeletons of *Clathrulina* were abundant. The phytoplankton was fairly rich in species, and about a dozen Desmids were noted.

*An Dubh Lochan.*—This was examined very late in the season. The chief peculiarity noted was the red colour of the *Diaptomus*, a feature found in more marked degree in Lochan Lùnn dà-Bhrà. Desmids were abundant, and the two fine species, *Staurastrum brazilense* and *S. longispinum*, occurred.

*Lochan Lùnn dà-Bhrà.*—The *Diaptomus* in this loch was so deep red that, when the nets were taken out after towing, they seemed to contain blood.

*Loch nan Gabhar.*—From its shallow, weedy character, an abundant fauna would be expected here, yet we found the collections exceptionally poor.

## LOCHS OF THE NESS BASIN.

THE basin of the river Ness is one of the most important of Scottish river-basins, not so much on account of the area drained, which is small when compared with the areas drained by the Tay, Tweed, Clyde, and Spey, for instance, but because it includes within its boundaries the largest body of fresh water in Scotland (Loch Ness), as well as several other large lochs and numerous small ones. The basin extends from the mouth of the river Ness, at the junction of the inner Moray firth with the Beaully firth, in lat.  $57^{\circ} 30'$  N. to lat.  $57^{\circ}$  N., south of Loch Quoich, and from long.  $5^{\circ} 30'$  W., west of Loch Quoich, to long.  $4^{\circ} 10'$  W., south-east of Inverness. The total area, as measured with the planimeter on the 1-inch Ordnance Survey maps, is about 722 square miles, and of this by far the larger portion drains into Loch Ness, for the area draining into the river Ness, and into Loch Ashie which flows directly into the river Ness, is only about 36 square miles. With the exception of Loch Ashie, the superfluent waters from all the lochs within the basin find their way into Loch Ness, so that the total area draining into Loch Ness is about 686 square miles. The area drained by the tributary lochs, excluding Loch Ness, is about 354 square miles, leaving about 332 square miles draining directly into Loch Ness, independent of the other lochs.

The principal river-systems within the basin lie to the west of Loch Ness, viz. the Enrick, which flows through Glen Urquhart into Loch Ness at Urquhart bay, where it is joined by the shorter river Coiltie; the Moriston, with its tributaries the Clunie and the Loyne, which flows through Glen Moriston into Loch Ness at Invermoriston; the Garry, with its tributaries the Quoich and the Kingie, which flows through Glen Garry into Loch Oich at Invergarry, and thence by the Oich into the head of Loch Ness at Fort Augustus. To the south of Loch Ness lies the Tarff, also entering Loch Ness near Fort Augustus; and to the east lies the Foyers, with its tributaries the Breinag and the Fechlin, which flows into Loch Ness at Foyers, and the Farigaig, which enters Loch Ness at Inverfarigaig. Finally, to the north-east of Loch Ness lies the Allt Mor (or Big Burn), draining Loch Ashie, which flows into the river Ness 2 or 3 miles below Inverness, while the river Ness, after issuing from Loch Dochfour, at the northern end of Loch Ness,



(Quoich and Garry) exceed 200 feet in depth, and three other lochs (Oich, Clunie, and nan Lann) exceed 100 feet in depth, while no fewer than twelve others include depths exceeding 50 feet.

The basin lies almost entirely in Inverness-shire, but a small portion of Ross-shire extends within the basin on its western border, the boundary-line running along the centre of West Loch Loyne and for a short distance along the centre of East Loch Loyne, and thence turning northward it crosses Loch Clunie in its central part; thus Lochs Loyne and Clunie lie partly in Ross-shire and partly in Inverness-shire, while the little Loch Beag, at the west end of Loch Clunie, is the only one lying wholly in Ross-shire. The scenery of the basin is varied, and as fine as anything to be seen in the Scottish Highlands: towards the north the ground is low, but proceeding southwards it becomes more elevated, culminating on the south-western borders in several giant peaks exceeding 3000 feet in height, and on the south-eastern borders in mountains slightly less elevated. The district is a veritable sportsman's paradise, the deer-forests, grouse-moors, and fishings (both in river and loch) being of the best. Trout abound in nearly every loch, with salmon and *salmo ferox* in some of the larger lochs, and char in some of the smaller lochs lying to the east of Loch Ness; the fishing in most of the lochs is preserved.

*Loch Ness* (see Plates XCI. and XCII.).—Loch Ness formed the subject of discussion at a meeting of the Research Department of the Royal Geographical Society on January 18, 1904, and preliminary notes on the bathymetry, temperatures, and seiches were published in the *Journal* in October 1904.\* Since then many temperature and seiche observations and supplementary soundings have been taken, and the preliminary measurements and calculations have been carefully revised, the final results being given here. Loch Ness is one of the best known of the larger Scottish lochs, since it forms a considerable part (nearly one-half) of the waterway known as the Caledonian canal, which occupies the great glen running in a north-east and south-west direction from the Moray firth on the east coast of Scotland to Loch Linnhe on the west coast, thus cutting Scotland into two portions. Through the Caledonian canal thousands of visitors are carried each season on the route between Inverness and Fort William, and the splendid scenery of the canal and surrounding district has furnished a theme for many pens. The absence of islands on Loch Ness is a striking characteristic, and gives a touch of monotony to the grand and sombre scene, as one sails up or down; the little Cherry island, lying at the opening of Inchnacardoch bay near the head of the loch, is invisible except at close quarters. Castle Urquhart, on its rocky headland at

\* *Geogr. Journ.*, vol. 24, p. 429.

the south side of Urquhart bay, forms a picturesque and noteworthy landmark.

In his journey to the Western islands of Scotland in the autumn of 1773, Dr. Johnson travelled along the shores of Loch Ness, which, he says, is in some places 140 fathoms deep, and he remarks further that "Natural philosophy is now one of the favourite studies of the Scottish nation, and Loch Ness well deserves to be diligently examined." After the lapse of 130 years this has been done, and it is proposed in this place to summarize the results obtained by the staff of the Lake Survey during their prolonged and "diligent examination" of Loch Ness.



FIG. 59.—GENERAL VIEW OF LOCH NESS FROM BORLUM, NEAR FORT AUGUSTUS, LOOKING NORTH-EAST.

(Photograph by Mr. G. West. From "Proc. Roy. Soc. Edin.," by permission of the Council.)

The survey of Loch Ness was commenced on April 2, 1903, and by the end of that month the preliminary survey was completed, but subsequently, at various periods during the years 1903 and 1904, many additional lines of soundings and numerous isolated soundings were taken, some of them in connection with the work of collecting samples of the deposits from all parts of the loch, others in connection with the work of taking temperatures at various depths in different parts of the loch. The total number of soundings recorded is about 1700, but some of them have been omitted on the accompanying map to avoid overcrowding. On April 1, 1903, the level of the surface of the loch

was determined from bench-marks as being 52.6 feet above the sea, and to this datum-level all soundings have been reduced. A levelling-staff was erected first at Fort Augustus, then at Invermoriston, Foyers, and Temple piers, and the height of the water on this staff was read daily during the progress of the survey, so that the variations in level from day to day, and the variations from the starting-point, were readily known. These staff readings showed that the water fell gradually but irregularly, and by April 15 it was 1 foot lower, and by the 18th it was  $1\frac{1}{2}$  feet lower, than on April 1.

Loch Ness proper may be said to extend from the head of the loch at Fort Augustus to the narrows at Bona ferry, a distance of  $22\frac{3}{4}$  miles following the axis of maximum depth. This figure is inferior to the length of Loch Awe ( $25\frac{1}{2}$  miles), and slightly in excess of the length of Loch Lomond ( $22\frac{3}{8}$  miles); if we regard the small basin of Loch Dochfour, which is continuous with Loch Ness at its northern end, as forming part of the loch, then the total length from the exit of the river Ness to the head of the loch, is about  $24\frac{1}{4}$  miles.

In this place it is proposed to include Loch Dochfour in dealing with Loch Ness; it is a basin about  $1\frac{1}{2}$  miles in length, with a maximum depth of 50 feet in the wide central portion, whence it narrows towards the two ends, the southern narrows leading into Loch Ness, and the northern termination being divided into two branches, the eastern branch forming the river Ness, and the western branch the continuation of the canal. With a strong south-westerly wind there is a surface current from Loch Ness into Loch Dochfour through the narrows at Bona ferry, and, if long continued, the water becomes banked up in Loch Dochfour, and gives rise to a return current along the bottom into Loch Ness; with a strong wind from the north-east the surface current sets in the opposite direction, *i.e.* from Loch Dochfour into Loch Ness. Cut off from the western margin of Loch Dochfour, by embankments carrying the towing-path for the canal, are two small basins, one called Abban water, having a maximum depth of 9 feet, the other without a distinctive name, having a maximum depth of 23 feet; they stand at the same level as Loch Dochfour, the water evidently percolating through the embankments.

Loch Ness may be said to be fairly uniform in breadth, though varying to some extent, but on the whole its shore-line is very regular when compared with other large lochs. The upper portion between Fort Augustus and Foyers for about 10 miles is under a mile in width, except at the opening of Glen Moriston, where the breadth slightly exceeds a mile. The portion between Foyers and Castle Urquhart for about 5 miles is almost exactly a mile in width, while the lower portion between Castle Urquhart and Torr point for about 5 miles exceeds a mile in width. The widest part of the loch is at Urquhart bay, from the mouth of the river Enrick due east to the opposite shore, where the

width is 2 miles. The portion of the loch from Torr point to Bona ferry for about  $1\frac{1}{2}$  miles varies in width from a half to a quarter of a mile, and the central portion of Loch Dochfour is about a quarter of a mile in width. The mean breadth of the entire loch is nine-tenths of a mile, or less than 4 per cent. of the length; a smaller percentage of mean breadth to length has been recorded only in Loch Shiel and Loch Shin, with  $2\frac{1}{2}$  and 3 per cent. respectively.

The waters of Loch Ness cover an area of nearly 14,000 acres, or  $21\frac{3}{4}$  square miles. Among the Scottish fresh-water lochs this is exceeded only by Loch Lomond, which has a superficial area of nearly  $27\frac{1}{2}$  square



FIG. 60.—INCHNACARDOCH BAY, LOCH NESS, SHOWING CHERRY ISLAND AND THE "HORSESHOE" IN THE DISTANCE.

(Photograph by Mr. G. West. From "Proc. Roy. Soc. Edin.," by permission of the Council.)

miles. As already stated the area draining directly into Loch Ness is about 332 square miles, while its total drainage area, including the area draining into all the tributary lochs, is about 686 square miles—an area over thirty times greater than that of the loch.

The maximum depth observed by the Lake Survey staff in Loch Ness was 754 feet, about a mile due south of Castle Urquhart in the centre of the loch. A greater depth than this has been recorded in only one Scottish loch, viz. Loch Morar, which has a maximum depth of 1017 feet, and after Loch Ness come Loch Lomond and Loch Lochy, with maxima of 623 and 531 feet respectively.

The volume of water contained in Loch Ness is estimated at 263,000 millions of cubic feet, or  $1\frac{3}{4}$  cubic miles. In no other Scottish loch does the bulk of water amount to a cubic mile, in fact Loch Ness contains about three times as much water as the two lochs which most nearly approach it in this respect, viz. Loch Lomond with 92,800 million cubic feet, and Loch Morar with 81,500 million cubic feet. The largest volume of water recorded by Dr. Mill among the lakes of the Cumberland district is only 12,250 million cubic feet. As far as we are aware, the volume of water contained in the large lakes of Ireland has not yet been carefully worked out, but, taking Loch Neagh, for instance, which is said to cover an area of 153 square miles (or seven times greater than the area of Loch Ness), and to have a maximum depth of only 48 feet, a rough calculation will show that the bulk of water in Loch Neagh must be less than that in Loch Ness. It seems quite possible, therefore, that Loch Ness may be the largest body of fresh water, not only in Great Britain, but in the United Kingdom.

Correlated with the enormous volume of water in Loch Ness is the high value of the mean depth, which works out at 433 feet for the entire loch. This far exceeds that of Loch Morar, viz. 284 feet, which comes next in this respect. The mean depth of Loch Ness is equal to 57.4 per cent. of the maximum depth—a higher percentage than has been observed in any other large deep loch, the nearest approach to it being in the case of Loch Avich, with a maximum depth of 188 feet and a mean depth of 98 feet, the percentage being 52.4. It is true that in some shallow flat-bottomed basins the percentage of mean depth to maximum depth exceeds that in Loch Ness; as, for instance, Loch Watten in Caithness (70 per cent.), and Loch Bruadale in Lewis (74 per cent.), but the maximum depths are here only 12 feet and 6 feet respectively. Except for Lochs Ness and Avich, in all the deep Scottish lochs, *i.e.* those having depths exceeding 100 feet, the mean depth is less than one-half of the maximum depth, the percentage varying from 19.4 in Loch Shiel, and 19.5 in Loch Lomond, to 49.4 in Loch Lungard, and 49.6 in Loch Suainaval (Lewis).

It has been stated that the surface of Loch Ness stands about 52 feet above mean sea-level, so that by far the greater portion of its floor falls below the level of the sea.

An inspection of the bathymetrical map of Loch Ness shows—(1) the comparative simplicity of the basin; (2) the steep shore-slope throughout the greater part of the loch; and (3) the large area of the lake-floor covered by very deep water. The 100-feet, 200-feet, 300-feet, 400-feet, and 500-feet contours are continuous, and only the 600-feet and 700-feet contours are interrupted by a shoaling opposite the entrance of the river Foyers, probably due to the deposition of material brought down by that river. This shoaling is covered by 515 to 524 feet of water, and both to the north-east and south-west the bottom sinks to depths exceeding 700 feet.

The 100-foot basin is about  $22\frac{1}{2}$  miles in length, the southern extremity approaching to within 100 yards from the shore at the entrance of the river Tarff, and the northern extremity extending into the narrow part of the loch beyond Torr point, approaching to within a quarter of a mile from Bona ferry.

The 200-foot basin is  $21\frac{3}{4}$  miles in length, approaching to within 150 yards from the Monastery boat-house slip at Fort Augustus, and quite close to the south-western shore off the entrance of the river Oich, and extending beyond Torr point on the north to within less than a mile from Bona ferry.

The 300-foot basin is  $20\frac{3}{4}$  miles in length, extending from less than 300 yards from the Monastery boat-house slip on the south to just beyond Torr point, or  $1\frac{1}{2}$  miles from Bona ferry, on the north.

The 400-foot basin is 20 miles in length, distant over a quarter of a mile from the Monastery boat-house slip on the south, and about three-quarters of a mile from Torr point, or over 2 miles from Bona ferry, on the north.

The 500-foot basin is about  $18\frac{1}{2}$  miles in length, distant less than a mile from the Monastery boat-house slip on the south, and about  $1\frac{1}{2}$  miles from Torr point on the north. The southern extremity of this basin differs somewhat from the usual truncate form, partaking of a rectangular character.

The two 600-foot basins are separated by an interval of little over half a mile, and are almost exactly equal in length, both of them slightly exceeding 8 miles in length. The northern one is distant about 2 miles from Torr point, and the southern one less than 2 miles from the Monastery boat-house slip at Fort Augustus.

The two 700-foot basins are separated by an interval of nearly  $2\frac{1}{2}$  miles, the northern one being nearly twice as long as the southern one, and including the maximum depth of the loch—754 feet. The northern basin is  $6\frac{1}{3}$  miles in length, and distant about  $2\frac{3}{4}$  miles from Torr point, while the southern basin is  $3\frac{1}{3}$  miles in length, and nearly 6 miles distant from Fort Augustus. The maximum depth recorded in the southern basin was 739 feet near the southern end of the basin, while towards the northern end of the basin a depth of 735 feet was recorded, the intervening soundings being slightly shallower.

These details show how extremely symmetrical Loch Ness is in all its bathymetrical characteristics. All the contour-lines, except the deepest one, approach rather closer to the southern than to the northern end of the loch, but in the case of the 700-foot contour this is reversed.

The shore-slope on both sides of the loch is nearly everywhere steep. Gradients exceeding 1 in 1 are of frequent occurrence, and in certain places the slope approaches the precipitous. Near the southern end of the loch, off the south-western shore at the entrance of the river Oich, a sounding in 204 feet was taken about 100 feet from shore, but

the steepest slopes were observed off the north-eastern shore in the vicinity of the Horseshoe craig, where a sounding in 236 feet was taken about 100 feet from shore; another in 175 feet about 50 feet from shore; and, off what is known as the Cormorant rock, a sounding in 206 feet was taken about 50 feet from shore. This last-mentioned sounding gives a gradient exceeding 4 in 1, or an angle of about  $15^{\circ}$  from the perpendicular.

The steep shore-slope is further seen by the manner in which the contour-lines of depth as a rule hug the shores, leaving a comparatively very large area of the lake-floor along the central line of the loch covered by very deep water. This is strikingly shown by the fact that nearly one-half of the entire basin is covered by more than 500 feet of water, and over one-third by more than 600 feet of water. In the following table are given the approximate areas in acres between the consecutive contour-lines drawn in at equal intervals of 100 feet, and the percentages to the total area of the loch:—

0 to 100 feet	1892 acres	13·6 per cent.
100 „ 200 „	1340 „	9·6 „
200 „ 300 „	1610 „	11·6 „
300 „ 400 „	1121 „	8·0 „
400 „ 500 „	1329 „	9·5 „
500 „ 600 „	1627 „	11·7 „
600 „ 700 „	2461 „	17·7 „
Over 700 „	2556 „	18·3 „
	<u>13,936</u> „	<u>100·0</u> „

This table brings out several interesting peculiarities when compared with the similar tables published for the other large Scottish lochs. The most remarkable point is that the two deeper zones are larger than any of the other shallower zones, the deepest zone of all, though the interval between the 700-foot contour and the maximum depth is only half the usual interval between the contour-lines, being the largest of all. Such a distribution of the depth-zones has not been observed in any other loch, and is a reversal of the usual rule of the shallowest zone being the largest one, though one or two exceptions to this rule have been recorded, as, for instance, in Loch Treig, where the zone between 200 and 300 feet is larger than either of the two shallower zones, and in Loch Lochy, where the zone between 100 and 200 feet is a little larger than the shore-zone. In the deepest of all Scottish lochs, Loch Morar, the shore-zone is equal to 42 per cent. of the total area, and the second zone between 100 and 200 feet is equal to 13 per cent., while of the deeper zones not one exceeds 9 per cent. of the total area. In Loch Lomond, again, the shore-zone is equal to 68 per cent. of the entire area, and the second zone between 100 and 200 feet is equal to  $16\frac{1}{2}$  per cent., while the deeper zones are in each case less than 6 per

cent. In Loch Ericht the shore-zone is equal to 34 per cent., the second zone between 100 and 200 feet is equal to 25 per cent., and the third zone between 200 and 300 feet is equal to 19 per cent. of the total area, the deeper zones in each case not exceeding 10 per cent. In Loch Tay there is a regularly decreasing percentage in the zones of depth from the shore into deep water, the numbers for each zone at intervals of 100 feet being respectively 30,  $23\frac{1}{2}$ , 21,  $15\frac{1}{2}$ , 9.

*Loch Quoich* (see Plate XCIII).—The largest loch in the basin after Loch Ness. It is very nearly 7 miles in length, and occupies the upper part of Glen Garry, which here runs east and west. It is 9 miles west of Loch Garry, and 15 miles from Loch Oich. It is much nearer the west coast, the head of Loch Hourn being only 4 miles distant. The mountain peaks both north and south reach well over 3000 feet. On the south the highest peak is Sgor Mor (3290 feet). On the north the two peaks of Sgurr a' Mhóraire (3365 feet) and Gleourach (3395 feet) rise to the west and east of Glen Quoich, which branches northward from Glen Garry about the middle of Loch Quoich. On the north Loch Quoich is densely wooded for the greater part of its length.

Loch Quoich is of the usual elongate form of Scottish glen lochs. Its central line is strongly curved, the central part further north than the ends. The height of the loch above sea-level on May 6, 1903, was 556·0 feet; the Ordnance Survey officers, on August 24, 1867, found it to be 555·3 feet. The length, measured in a straight line between the ends, is almost exactly 6 miles; measured along the centre line it is nearly 7 miles. The maximum breadth of three-quarters of a mile occurs just east of the centre. The mean breadth is a little under half a mile. The superficial area of the loch is about 1833 acres, or fully  $2\frac{3}{4}$  square miles, and it contains 8345 millions of cubic feet of water, more than twice the volume of Loch Garry, the loch next to it in size.

Loch Quoich drains an area of 49 square miles, which includes no large lochs, but some very small ones which were not surveyed. Several large burns, rising among the high mountains of the west, enter at the head of the loch; and the Caolie water, flowing in on the north shore, is a fair stream; but the most important inflowing river is the Quoich, which enters about the middle of the north side, and has here by its delta effected a considerable narrowing of the loch. The constriction so produced is the greater because, just opposite the mouth of the river, a high promontory juts out more than a quarter of a mile from the south shore. The shallowing of this constriction is but slight.

The basin of Loch Quoich is simple, with steep and nearly uniformly sloping sides, and very little flat bottom. The contours are all continuous and approximately parallel with the shore-line, except the 200-foot contour, which is slightly interrupted by a shallowing where the maximum is 190 feet, just west of the mouth of the Quoich. The

area of over 200 feet to the west of this is three-quarters of a mile long, and has a maximum depth of 220 feet. The larger area of over 200 feet is 2 miles long, and extends from just west of the narrows eastward. The area of over 250 feet lies well down the loch, coming to within  $1\frac{1}{2}$  miles of the outflow, and includes the maximum depth of the loch, 281 feet. The mean depth of the loch is  $104\frac{1}{2}$  feet. The proper basin of the loch terminates three-quarters of a mile from the lower end of the loch. At this point there is a bend at right angles to the main axis, and there extends a broad, tortuous, shallow section of the loch, with a greatest depth of only 43 feet, and numerous small islands.

As is shown by the narrowness of the areas enclosed by the deeper contours, there is no marked indication of the U-shaped section of valley lochs excavated by glaciers. The promontory opposite the river Quoich, occurring where a great bend of the axis takes place, must have caused a narrowing here before the delta of the Quoich was laid down.

On May 6, 1903, the difference of temperature between the surface and 150 feet was under  $1^{\circ}$ :—Surface,  $41^{\circ}\cdot9$  Fahr.; 50 feet,  $41^{\circ}\cdot2$ ; 150 feet,  $41^{\circ}\cdot0$ .

*Loch Poulary* (see Plate XCIV.).—A long, irregular, narrow loch running east and west in Glen Garry, between Loch Garry and Loch Quoich, about 4 miles distant from the former and 2 miles from the latter. It is little more than a series of expansions of the river Garry, and its limits are accordingly not easy to define. The portion surveyed begins at Eilean Dubh, extends eastward for 1 mile as a narrow channel varying from 9 feet to 23 feet in depth, and then expands into a little basin half a mile long by one-fifth of a mile in greatest breadth. The length of the whole loch is  $1\frac{1}{2}$  miles, and the mean breadth one-tenth of a mile. The area of the surface is about 91 acres, and the drainage area, which includes Loch Quoich, is 82 square miles. The volume of water is 39 millions of cubic feet. The Allt a' Ghobhain, a considerable stream, and some small burns, enter on the north shore. From spot-levels on the shores, the height of the loch above the sea was estimated to be 320 feet. The greater part of the loch is shallow, but in the eastern basin there is deeper water in the centre, forming, however, only a narrow channel. The maximum depth is 47 feet, the mean depth 10 feet.

There was a difference of only  $1^{\circ}$  in temperature between the surface ( $53^{\circ}\cdot8$  Fahr.) and a depth of 40 feet ( $52^{\circ}\cdot8$ ) on September 28, 1903.

*Loch Garry* (see Plate XCV.).—Loch Garry is one of the most important lochs in the basin, being inferior in size only to Loch Ness

and Loch Quoich. It occupies the lower part of Glen Garry, and its lower end is only about 3 miles west of Invergarry on Loch Oich; its direction is about due east and west. Glen Garry is at this part very open, the high hills, Ben Tee, a conspicuous pyramidal hill, 2936 feet in height, on the south, and Meall Dubh (2581 feet) and some lesser peaks on the north, being several miles distant. The sides of the valley rise gradually to the mountains, the lower slopes on both shores of the loch being densely wooded.

Loch Garry is elongate, slightly curved, of nearly uniform breadth for the greater part of its length, but in the eastern part for a mile very irregular and shallow. Its length is 5 miles, its greatest breadth fully half a mile, and its mean breadth one-third of a mile. Its superficial area is about 1117 acres, or  $1\frac{3}{4}$  square miles, and its contents 3794 millions of cubic feet. The drainage area, including Lochs Quoich and Poulary, is 137 square miles. Besides the river Garry, which enters the loch at the west end, some large streams, coming down from the mountain-mass to the westward of Ben Tee, enter on the south, and many smaller streams on the north. Leaving the loch, the river Garry flows 3 miles to the east and enters Loch Oich at Invergarry.

Loch Garry, at the date of the survey (May 2, 1903), was 257.0 feet above sea-level; the Ordnance Survey officers on July 2, 1869, found the elevation to be 257.8 feet above the sea.

In the character of its basin Loch Garry closely resembles Loch Quoich, higher up in the same glen. The main part of the loch, fully  $3\frac{1}{2}$  miles long, is a simple basin. As in Loch Quoich, there is a large portion at the east end, one mile in length, which is quite distinct from the basin, and is of moderate depth.

This eastern part is cut off from the main loch by a large, low, wooded promontory, called the Garbh Eilean (Rough island), and a sandy island (Eilean Bàn), to the south-west of it. An irregular channel, varying from 9 feet to 18 feet in depth, leads to the small eastern basin, which has a small island at each end, and a narrow arm running to the north. This basin has a narrow area half a mile long, over 25 feet in depth, with a maximum depth of 43 feet. At the west end of Loch Garry a narrow offset runs for half a mile westward, with a depth of 5 feet at the mouth, and of 8 to 16 feet within.

The main basin shallows greatly towards each end. The 50-foot and 100-foot contours closely follow the shore, except at the ends. The 150-foot contour encloses but a narrow area  $1\frac{3}{4}$  miles long. This is a good deal nearer the south shore in the greater part of its length, but for half a mile at its west end it recedes far from the south shore, where the slope from 100 to 150 feet is very gradual. A small isolated 150-foot area, based on a sounding in 159 feet, lies to the east of the main 150-foot basin, the deepest sounding in the short interval between them being 146 feet.

Centrally, in the length of the loch, but nearer the south shore, is a small area a quarter of a mile long, over 200 feet deep, with the maximum sounding of 213 feet. The mean depth is 78 feet. The contours show that the slope of the bottom is nowhere very steep, but is steepest at the south side at the deepest part of the loch. There is but little extent of flat bottom at depths of over 150 feet, but where the depth is less than that, especially towards the west end, there is a well-marked flat with steeper sides.

The temperature at the surface was  $42^{\circ}4$  Fahr., and at 170 feet  $41^{\circ}8$ , a difference of only  $0^{\circ}6$ .

*Loch a' Bhainne* (see Plate XCVI.).—A very little loch, high up on the hill to the north of Loch Garry, about 2 miles north of the east end of that loch. It is roughly triangular, with the apex to the south. The hills rise steeply from the loch to the west and north. It is fed by streams coming from Màm a' Chroisg, and the Allt a' Bhainne flows south-eastward 3 miles into the river Garry. The bottom is irregular, the greater part covered by less than 10 feet of water, but there are two holes of over 20 feet, the larger with the maximum of 28 feet close to the east shore, the other with a depth of 27 feet to the south; a sounding of 13 feet between the two.

It is one-third of a mile long, a quarter of a mile in greatest breadth, and one-seventh of a mile in mean breadth. The mean depth is 10 feet. The superficial area is about 32 acres, and the volume 14 millions of cubic feet. The drainage area is nearly 2 square miles. The height above sea-level was estimated at 1060 feet. The temperature at the surface and at 20 feet was  $45^{\circ}0$  Fahr. on May 5, 1903.

*Loch Lundie* (by Garry) (see Plate XCVI.).—A small loch in Glen Garry, on a tributary of the river Garry, about  $1\frac{1}{2}$  miles north-west of Invergarry, on Loch Oich. It is of irregular form, its outline broken by various arms and promontories. A point on the west side, with an island off the east shore (Eilean na Faoileige), cause a narrowing and separate two expansions. From the northern expansion several narrow arms run north-eastward. Loch Lundie is three-quarters of a mile long, by fully one-third of a mile in maximum breadth, with a mean breadth of one-fifth of a mile. The surface has an area of about 109 acres, and the volume of water is 78 millions of cubic feet. The drainage area is about  $3\frac{1}{2}$  square miles. The Allt Lundie comes in on the west, and the Aldernaig burn, soon joined by the Allt a' Bhainne from Loch a' Bhainne, flows south into the river Garry. The height above sea-level, measured by the Ordnance Survey on August 18, 1869, was  $445.4$  feet.

The contour of the bottom is very uneven. The 20-foot contour enters both expansions, keeping closer to the west shore. In both of the expansions there is a depth of 30 feet close to the west side. The

deepest water in the loch is close off the promontory on the west shore and nearly in the narrows. Here is a little area over 40 feet deep, with the maximum of 54 feet. Rock was seen at a number of points on the east and south. There are several small islands, and one of these, north of Eilean na Faoileige, is of rock.

The temperature on May 5, 1903, was almost uniform throughout—at the surface, 46°·5 Fahr.; at 40 feet, 46°·5 Fahr.; and at 50 feet, 46°·6 Fahr.

*Loch Oich* (see Plate XCVII.).—An insignificant loch in point of size, though of considerable length, Loch Oich is commercially important, as it forms the highest portion of the Caledonian canal. As regards length, it comes fifth in the Ness basin, if we exclude the artificial Loch Mhor.

Loch Oich is an exceedingly narrow, straight loch, with its long axis running nearly south-west and north-east. High hills rise on the east, and the dense woods which clothe the west shore, with the islands on its surface, render Loch Oich extremely beautiful (see Fig. 61).

Loch Oich is 4 miles long, and has a maximum breadth of little over a quarter of a mile, and a mean breadth of barely one-fifth of a mile. The superficial area is about 489 acres, or three-quarters of a square mile, and the contents amount to 890 million cubic feet of water. This is about one-half the volume of Loch Clunie, a loch very little longer, and only one-fourth the volume of Loch Garry.

The drainage area of Loch Oich, including as it does Lochs Quoich and Garry, is very large, amounting to 170 square miles. The drainage is brought chiefly by the river Garry, which enters the loch about the middle of the west shore. Only little hill torrents come in on the east. The out-flowing river Oich runs 4 miles north-east to Loch Ness. The level of the loch on May 1, 1903, was found to be 106·0 feet above sea-level; on the Ordnance Survey map the level is given as 104·8 feet above the sea, but the date on which the observation was made is not indicated.

The outline of Loch Oich is constricted at several points, first at Ardrishaig, half a mile from the south end, again a mile further down the loch, and again at the mouth of the Garry, where a great peninsula has been made by the river, and opposite to it long narrow islands. From the mouth of the Garry the width increases to near the overflow. A great part of the loch, equal to 68 per cent. of the entire area, is less than 50 feet in depth. The central part of the loch is shallowest. Opposite the mouth of the Garry the greatest depth is 20 feet, close to the island. There are four areas of over 50 feet. The first of these is close to the north-east end of the loch. It is three-quarters of a mile long, and encloses an area half a mile long over 100 feet in depth. Near the south-west end of this 100-foot area is the maximum depth of the

loch, 154 feet, and near the other end of the area there is a sounding of 129 feet, with a depth of only 108 feet between them. The second 50-foot area is half a mile south-west of the river Garry, and is marked by an isolated sounding of 57 feet. The third 50-foot area begins half a mile from the south-west end, and extends down the loch for a mile. It is the largest basin in the loch, but not so deep as the more northerly one, the greatest depth in it being 133 feet. The fourth 50-foot area is close to the upper end of the loch. It is one-third of a mile long, and is scarcely separated from the larger one, as they are close together, and the depth between is 48 feet. In this fourth basin the greatest depth is 84 feet.

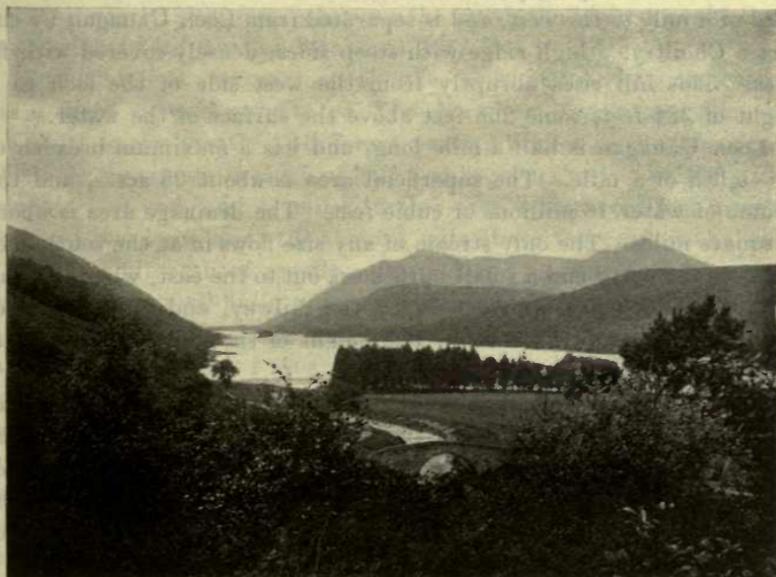


FIG. 61.—LOCH OICH, LOOKING SOUTH-WEST; CALDER BURN IN THE FOREGROUND.  
(Photograph by Mr. G. West. From "Proc. Roy. Soc. Edin.," by permission of the Council.)

*Temperature Observations.*—The following serial temperatures were taken in the deepest part of the loch, series I. on May 1, 1903, and series II. on September 25, 1903:—

	I.	II.
Surface ... ..	44°·9	55°·0 Fahr.
10 feet ... ..	44°·9	54°·0 "
20 " ... ..	44°·8	54°·0 "
30 " ... ..	—	54°·0 "
40 " ... ..	44°·2	53°·8 "
50 " ... ..	—	53°·8 "
60 " ... ..	—	53°·8 "
70 " ... ..	—	53°·8 "
80 " ... ..	43°·9	53°·0 "
90 " ... ..	—	51°·9 "
100 " ... ..	—	49°·8 "
120 " ... ..	—	48°·8 "
130 " ... ..	43°·0	— "

The series taken in May shows a range of barely  $2^{\circ}$  from surface to bottom, while the series taken in September shows a range of over  $6^{\circ}$ , a fall of  $2^{\circ}$  having been recorded between 90 and 100 feet. It will be observed that the whole body of water was warmer in September than it was in the preceding May, the bottom reading in September being  $4^{\circ}$  higher than the surface reading in May, while the difference between the two bottom readings is about  $6^{\circ}$ , and between the two surface readings about  $10^{\circ}$ .

*Loch Uanagan* (see Plate XCVIII.).—Loch Uanagan lies a little more than a mile to the south of Fort Augustus, on Loch Ness. It is a narrow little loch lying parallel to the Caledonian canal, which is one-third of a mile to the west, and is separated from Loch Uanagan by the Torr à Choiltry, a high ridge with steep sides, densely covered with fir trees. This hill rises abruptly from the west side of the loch to a height of 384 feet, some 266 feet above the surface of the water.

Loch Uanagan is half a mile long, and has a maximum breadth of one-eighth of a mile. The superficial area is about 25 acres, and the volume of water 18 millions of cubic feet. The drainage area is about  $1\frac{1}{4}$  square miles. The only stream of any size flows in at the south end, and near the north end a small burn flows out to the east, where a small part of the loch has been cut off by the railway, and joins the river Tarff half a mile to the north. The height of the loch above sea-level on July 2, 1903, was 118·2 feet.

Loch Uanagan is very shallow, the greater part of it less than 10 feet deep. Only one-fifth of the area is over 25 feet in depth, the 25-foot contour enclosing a narrow area one-sixth of a mile long, nearer to the east shore, and the maximum depth of 43 feet is near shore, the slope here being steep. The steep slope of the hill on the west is not continued under water, the loch on that side being shallower.

*Temperature Observations.*—The surface temperature on July 2, 1903, was  $63^{\circ}\cdot 0$  Fahr., and a serial taken at 2.30 p.m. on September 24, 1903, gave the following results:—

Surface ... ..	55°·4 Fahr.
10 feet ... ..	54°·8 "
20 " ... ..	53°·6 "
30 " ... ..	53°·6 "
40 " ... ..	52°·8 "

*Loch Beag* (by Clunie) (see Plate XCIX.).—A small triangular loch about a quarter of a mile west of the upper end of Loch Clunie. It is simply an expansion of the river Clunie, and is at the same level as Loch Clunie. It is one-third of a mile long by one-fifth of a mile broad. The area of the surface is about 26 acres, and the drainage area very extensive, viz. 20 square miles. The volume of water is

13 millions of cubic feet. The basin of Loch Beag is simple, the sides gently sloping, the greatest depth, 29 feet, in the centre of the loch. The channel connecting Loch Beag with Loch Clunie varies in depth from 11 feet to 23 feet.

*Loch Clunie* (see Plate XCIX.).—Loch Clunie (or Cluanie) is a large loch occupying Glen Clunie, which runs east and west, and is the source of the river Moriston. The lower end is about 16 miles distant from Invermoriston, on Loch Ness. The upper end is some 13 miles from Shiel bridge, at the head of Loch Duich, on the west coast, but Loch Hourn is still nearer, only 10 miles as the crow flies. High mountains rise on both sides of the loch, those on the south reaching nearly 2500 feet, while on the north the highest peak, Sgurr nan Conbhairan, 2 miles distant, is 3632 feet in height.

Loch Clunie is very narrow,  $4\frac{1}{4}$  miles in length, and its central line has a slight sigmoid curvature. The shore-line is very irregular, and the width varies greatly at different parts. Widest in the upper part, where the maximum breadth of half a mile occurs at two points, at the extreme west end, and  $1\frac{1}{4}$  miles further east, whence the loch narrows greatly toward the east, till about a mile above the outflow the width is only one-fifteenth of a mile. Beyond this narrow part it expands into a distinct small basin nearly a quarter of a mile in breadth. The mean breadth of the entire loch is just about a quarter of a mile. The superficial area exceeds 1 square mile (about 704 acres), and the drainage area, which includes no other lochs except Lochs Beag and Lundie, is 32 square miles. It is fed by the river Clunie and some large burns on the north shore, very little water entering on the south shore, except the surface drainage. The river Moriston flows out from the east end of the loch. Considering the volume of water, which amounts to 1533 millions of cubic feet, Loch Clunie comes fourth in point of size in the Ness basin (including Loch Ness). In point of length it comes fifth, as Loch Mhor is about half a mile longer, though in volume about 400 million cubic feet less, than Loch Clunie.

The level of Loch Clunie on September 29, 1903, was 605·2 feet above the sea; the Ordnance Survey officers on October 5, 1867, found the level to be 605·9 feet. The water might rise 4 feet above the level on the date of the survey. Above the narrows, 1 mile from the east end of the loch, which cut off a small basin exceeding 50 feet in depth, the basin of Loch Clunie is a simple one. The 25-foot contour closely follows the shore-line, and the 50-foot contour is nearly parallel to it, but much closer on the north, where the slope is steeper. The 100-foot contour is parallel with the others, and encloses a relatively large area, nearly  $1\frac{1}{2}$  miles long by a quarter of a mile in greatest breadth. It is broken into two parts by an unimportant shallowing of 98 feet. The smaller western portion has a maximum depth of 119 feet; the greater

area has a maximum of 123 feet. The mean depth is 50 feet. In the narrows the depth at the western end is 10 feet, and at the eastern end only 6 feet, while half-way between is a hole of 23 feet. The small basin to the east of the narrows is on the whole shallow. Almost in the centre is a shoal where the depth is only 2 feet, and close to this, on the north, is a sounding of 30 feet. The greatest depth in this basin, 53 feet, is between the shoal and the narrows.

Consideration of the contours and the nearly flat bottom shows that there is the U-shaped section associated with glacier-hollowed lochs, though, on account of the moderate depth, it is less clearly defined than in many other large lakes.

A series of temperatures taken in the deep part of the loch showed a uniform reading of  $51^{\circ}\cdot 8$  Fahr. at all depths from 10 feet to 75 feet. The bottom at 100 feet was a little cooler ( $51^{\circ}\cdot 2$ ), and the surface a little warmer ( $52^{\circ}\cdot 0$ ), the total range being thus  $0^{\circ}\cdot 8$ .

*Loch Lundie* (by Clunie) (see Plate XCIX).—A small triangular loch lying immediately to the north of Loch Clunie, about equally distant from either end. The long axis runs nearly east and west, and the greatest breadth is towards the west end. The outline is very irregular, and there are several small islands near the shore.

The height above sea-level on September 30, 1903, was found to be 681·5 feet, some 76 feet above Loch Clunie; the Ordnance Survey officers on August 2, 1869, found it to be 681·9 feet. The length is little under half a mile, and the greatest breadth one-fifth of a mile. The superficial area is about 27 acres, the drainage area nearly 1 square mile, and the contents amount to 9 millions of cubic feet. It receives only some small burns, and is drained by a burn issuing from the south-west corner flowing south a quarter of a mile into Loch Clunie.

Loch Lundie is of no great depth, three-fourths of the superficial area being covered by less than 10 feet of water. The area more than 10 feet in depth is narrow, and passes obliquely across the loch. The greatest depth of 25 feet occurs at the extreme east end of this area, and near shore, in a narrow part of the loch.

The temperature on September 30, 1903, was the same at the surface and at 20 feet, viz.  $54^{\circ}\cdot 0$  Fahr.

*Loch Loyne* (see Plate C).—The two lochs under this name consist of a chain of little basins or expansions of the river Loyne, connected by narrow channels. The valley of the Loyne lies half-way between Glen Clunie and Glen Garry, which are 2 or 3 miles distant. On the north the lochs are separated from Loch Clunie by Beinn Loinne, 2500 feet in height. The hills on the south, though wild and bleak, are not so high. The main road from Tomdoun to Clunie Inns crosses between the two lochs. The valley to the west of the road has an east-and-west

trend, but from the bridge through the east loch to Glen Moriston it runs nearly due north-east. The east loch is much the longer, and is also deeper.

*The West Loch.*—The west loch lies at a height of 719·0 feet above the sea. It is  $1\frac{1}{4}$  miles in length, with a maximum breadth of fully one-third of a mile, and a mean breadth of one-fifth of a mile. It consists of three expansions, all running south from the connecting channel, or, in other words, the north shore is unbroken, but two promontories break the south shore, separating the loch into three bays. The west bay is extremely shallow, with a maximum of 6 feet. Two islands lie off the mouth of the river, and round these and to the north the loch is overgrown with weeds. The channel joining it with the mid bay has a minimum of 5 feet, but deepens to 9 feet in the east. The mid bay has also a maximum of 6 feet. The channel leading east from it is 12 feet deep. The eastern expansion deepens from west to east, the maximum of 19 feet being close to the shore. The area of the surface is about 153 acres, or a quarter of a square mile, and it receives the drainage of 16 square miles. It contains 40 million cubic feet of water. The river Loyne, of which the loch is merely a series of expansions, conveys the overflow to the east loch, half a mile distant and about 13 feet lower.

The surface temperature on May 4, 1903, was 47°·7 Fahr.

*The East Loch.*—East Loch Loyne is more than twice as long as the west loch, and is also about twice as deep, but it is much narrower. There are four principal expansions. The western expansion is extremely shallow, having a maximum depth of 7 feet, and on the date of the survey, when the river was in flood, there was a strong current through. There is an island about the middle of it. The channel leading to the second expansion has a depth of 5 to 9 feet. The second expansion is very small, with a maximum depth of 21 feet, and is joined with the third basin by a channel 5 feet deep. The third basin is much the largest, and has more claim to be called a loch, being  $1\frac{1}{4}$  miles in length, with a maximum breadth of fully a quarter of a mile, and, but for some large and small islands towards the west end, is a simple basin, with contours parallel to the shore. The area over 20 feet in depth is over half a mile long, with depths of 35 feet in two places—the maximum for the whole loch. The easternmost basin is narrow, two-thirds of a mile long, of uneven bottom, with greatest depths of 20 and 21 feet. The length of the east loch, taken in a straight line between the extreme points, is  $2\frac{1}{2}$  miles, the greatest breadth is little over a quarter of a mile, and the mean breadth is about one-seventh of a mile.

The area of the surface is about 272 acres, or nearly half a square mile, the area draining into the loch being about 24 square miles, including the little Loch na Losguinn and West Loch Loyne. The

volume of water is 123 millions of cubic feet. The drainage is chiefly brought by the river Loyne, only small burns contributing a share, the largest entering close to the outflow.

The prominent points on both shores, and the large island, are formed by mounds of boulders and gravel. The only rock seen was at the very narrow channel, with a depth of only 2 feet, at the east end of the largest basin. Here rock was exposed on both sides. The river flows out between an alluvial flat on the north and mounds of glacial debris on the south. The height above the sea was 706·1 feet on November 4, 1904.

The temperature of the surface was 46°·6 Fahr., and at 30 feet 46°·2.

*Loch an Staca* (see Plate CI.).—Loch an Staca is a considerable minor loch, of roughly triangular form, situated on the extensive elevated area which stretches westward from Loch Ness, between Glens Moriston and Urquhart. It is 6 miles distant from Loch Ness. Its longer axis lies nearly north-east and south-west. The undulating moorland rises little above the loch, except on the east, where Meall na Criche, 2224 feet in height, sends a long ridge southward between Lochs an Staca and na Criche.

Loch an Staca is estimated to be 1600 feet above the sea. It is a mile long by two-fifths of a mile broad, with a mean breadth of a quarter of a mile. The superficial area of the loch is about 163 acres, or a quarter of a square mile, and the drainage area  $1\frac{1}{4}$  square miles. The volume of water is 110 millions of cubic feet.

Loch an Staca receives only local surface drainage, and the overflow is carried into Loch Liath by a small burn. The bottom is very uneven, a depth of only 9 feet being found almost in the centre of the loch, with deeper water on all sides. There is a small island close to the west shore. A great part of the bottom, equal to 74 per cent. of the total area, is covered by less than 20 feet of water. Four little depressions occur. The deepest, with the maximum depth of 51 feet, is close to the east shore; another of 32 feet lies to the south-west of this; one of 30 feet close to the west shore north of the island; and one of 30 feet in the centre of the loch, near the north end. At this end is another island. The mean depth is  $15\frac{1}{2}$  feet.

The surface temperature (June 2, 1904) was 56°·5 Fahr.; at a depth of 25 feet it was 52°·0, at 50 feet 48°·9, a total range of 7°·6.

*Loch Liath* (see Plate CI.).—A little roundish loch about a mile to the south of Loch an Staca, on the same plateau. It is about 100 feet lower than Loch an Staca, the drainage from which it receives. The axis of the loch has a north-east and south-west direction. It is barely half a mile long by fully a quarter of a mile broad, with a mean breadth of one-fifth of a mile. The superficial area is about 61 acres, and its

contents amount to 62 millions of cubic feet. The drainage area, which includes Loch an Staca, is 4 square miles. Beyond the burn from Loch an Staca, and another from the hill (2222 feet) on the west, it receives only superficial drainage. The burn Allt Bhlairst flows out to the south-east, and, joining that from Loch na Criche, enters the river Moriston. The basin is quite simple, the deeper water nearer the south-east side, and the maximum depth of 55 feet towards the north-east end.

When surveyed on June 10, 1904, the level was found to be 1494.1 feet above the sea, which differs little from the level determined by the Ordnance Survey officers on May 15, 1869, viz. 1494.4 feet.

The surface temperature was 56°.9 Fahr.

*Loch nam Breac Dearga* (see Plate XCI.).—Situated on the high ground to the west of Loch Ness, about 1½ miles distant from the middle part of that loch. It lies close to the west of Meall Fuarvounie (2284 feet high), which separates it from Loch Ness. The loch is elongate, lying nearly north-east and south-west, and of irregular form, roughly oblong. The surrounding moorland rises little above the loch, except on the east, where the crags of Meall Fuarvounie rise close beside the loch.

This loch was locally reputed to be of great depth, or even supposed to be bottomless. Though we found it to be the deepest loch in this elevated tract between Glen Urquhart and Glen Moriston, its depth was not remarkable, and not greatly in excess of that of Lochs Liath and an Staca in the same district. It is three-quarters of a mile in length, about one-fifth of a mile in greatest breadth, and one-eighth of a mile in mean breadth.

The superficial area is about 56 acres, and drains about two-thirds of a square mile. It contains 60 million cubic feet of water. It is drained by a burn running some 2 miles south-westward, into the Allt nan Saighead (Alltsigh), which also receives the overflow of a host of little lochs, which were not surveyed, and runs into Loch Ness. The height above the sea was estimated at 1570 feet.

The basin is simple, but deepest toward the upper or north end. The lower portion is all under 25 feet in depth. The areas of over 25 feet and over 50 feet pass obliquely across the loch from south to north. The 50-foot contour encloses a narrow area, about a quarter of a mile long, with the deepest sounding, 70 feet, in the middle of the loch, but nearer the north end.

The surface temperature on June 1, 1904, was 52°.9 Fahr.; at 10 feet, 52°.7; at 25 feet, 48°.2; and at 60 feet, 46°.2, giving a total range of 6°.7, the greatest fall being one of 4°.5 between 10 and 25 feet.

*Loch a' Vullan* (see Plate CI.).—A little loch of triangular form, in the elevated hilly country to the west of Loch Ness, and about

6 miles distant from that loch. It is surrounded by moorland, rising but little above the surface of the loch, except on the south, where Meall na Criche rises in a series of low crags to the height of 2224 feet, nearly 500 feet above the loch. The main part of the loch is triangular, with the apex to the north. From the south-west corner an offset runs one-eighth of a mile to the west, narrow at its beginning, and then expanding. The triangular body of the loch is three-eighths of a mile in length, but the greatest length, from the apex to the end of the west offset, is rather more (nearly half a mile). The maximum breadth in the triangle is one-sixth of a mile, the mean breadth one-tenth of a mile. The height above sea-level was estimated from spot-levels to be about 1750 feet.

Loch a' Vullan receives the overflow of a chain of four small lochs, lying to the north-east. The outflow, controlled by a sluice, is by a small burn, going through a chain of small lochs into the river Enrick. The superficial area is about 28 acres, the drainage area two-thirds of a square mile. The volume of water is 15 millions of cubic feet.

There are two basins in Loch a' Vullan. The larger one, forming the triangular part of the loch, is simple, with the contours following the shore, the greater part less than 20 feet in depth, the maximum depth being 27 feet. In the narrows separating the small western basin the depth is 13 feet, and in the basin itself 21 feet. The mean depth is 12 feet.

On June 2, 1904, the temperature at the surface was  $54^{\circ}9$  Fahr., and at 20 feet,  $50^{\circ}0$ .

*Loch Meiklie* (see Plate CII.).—A loch of moderate size and relatively broad, situated in Glen Urquhart, about half-way from Loch Ness to Strath Glass, from each of which it is 5 miles distant. Glen Urquhart is a fertile and well-wooded valley. Both north and south of the loch the hills are densely wooded. On the north they rise gradually to over 1000 feet, while on the south they are steeper, and heights of 1700 feet and upwards are reached little more than a mile from the loch. The long axis runs nearly east and west; the length is just over a mile, and the maximum breadth, towards the west end, is nearly half a mile, the mean breadth being over a quarter of a mile. The maximum depth, which coincides with the maximum breadth, is 45 feet, and the mean depth 22 feet.

The area of the surface is about 200 acres, or nearly one-third of a square mile, the drainage area relatively very great, amounting to nearly 42 square miles, and including many small lochs, of which only Loch a' Vullan was surveyed. The river Enrick is the only important stream flowing into Loch Meiklie, and the outflowing river, still bearing the same name, flows into Loch Ness in Urquhart bay. The surface of the

water on October 3, 1903, was 364·9 feet above the sea; on June 22, 1867, the Ordnance Survey officers found it about 6 feet higher (371·5 feet).

In form Loch Meiklie is approximately oblong. A shallow inlet, formed by the encroachment of the river, runs one-sixth of a mile from the west end. The basin is quite simple, with the slopes everywhere gentle, but steepest towards the north shore at the deepest part. Over one-half of the whole area is less than 20 feet in depth. The volume of water is 193 millions of cubic feet, making Loch Meiklie the ninth in point of bulk in the Ness basin.

The surface temperature on October 3, 1903, was 53°·6 Fahr.

*Loch Aslaich* (see Plate CI.).—An extremely beautiful little loch, about 5 miles west of Loch Ness, surrounded by hills of considerable height, rising to about 2000 feet in the immediate neighbourhood of the loch. On a picturesque wooded island in the loch the members of the Lake Survey had their abode (in a lodge kindly lent by the proprietor), while the lochs of the district were being examined. In form the loch is a narrow oblong, with its long axis running north and south. It is one-third of a mile long, with a maximum breadth of one-seventh of a mile. Its superficial area is about 21 acres (only Lochs Dubh and nan Losganan being smaller), and it drains an area of nearly 2 square miles. This area includes a larger loch (Loch nam Meur), which was not surveyed. Besides the chief feeder, the burn coming from Loch nam Meur, two small burns enter the loch. The river Coiltie has its origin in Loch Aslaich, and flows into the Enrick just where it enters Loch Ness. Its volume is 10 millions of cubic feet; in this respect Lochs Lundie (by Clunie), Laide, Dubh, and nan Losganan, are smaller. The height of the loch above the sea was estimated at 1310 feet. Fully half the superficial area is covered by less than 10 feet of water. The area of more than 20 feet in depth forms a narrow strip along the west side. This comes very near to the south end, and the deepest sounding, 26 feet, is quite close inshore. The mean depth is 11 feet.

On July 2, 1904, the temperature at the surface and at 6 feet was 60°·0 Fahr., and at 18 feet, 56°·3.

*Loch Dubh* (see Plate XCI.).—A very little lochan a couple of miles to the west of Loch Ness and 4 miles south of Glen Urquhart. The shortest loch in the basin, but in all other dimensions the second smallest, since Loch nan Losganan is shallower, narrower, of smaller area and volume. It is obscurely triangular in form, its axis running south-west and north-east, the apex to the north-east. It is situated at a high level, estimated at 1340 feet, amid moorland, rising gradually southward to Meall Fuarvounie (2284 feet). It is nearly one-fifth of a

mile in length, and one-ninth of a mile in greatest breadth. It is only about 8 acres in area, and drains an area of over 100 acres. Its volume is 2 millions of cubic feet, twice that of Loch nan Losganan. It drains by a small burn into the river Coiltie. The basin is simple, with evenly sloping sides, and the deepest sounding of 18 feet almost in the centre.

*Loch Laide* (see Plate XCII.) is a little shallow round loch, measuring just about one-third of a mile in diameter, lying at a considerable elevation among the hills to the west of Loch Ness, near its northern end, above Abriachan, and about  $1\frac{1}{2}$  miles distant. It is surrounded by moorland and low hills, rising on the south side nearly 600 feet above the loch (Carn an Leitire, 1424 feet), within a distance of half a mile. There is no bench-mark nearer to the loch than the summit of this hill. On August 4, 1869, the Ordnance Survey officers found the height above sea-level to be 859·8 feet.

The superficial area of Loch Laide is about 39 acres, and it drains an area of  $1\frac{1}{2}$  square miles. It has a volume of water of 9 millions of cubic feet, only two lochs in the Ness basin (Lochs Dubh. and nan Losganan) being less in volume. It is fed chiefly by one small burn, rising some 2 miles to the south-west, and the overflow is carried by the Allt Loch Laide into Loch Ness at Abriachan. The bottom of Loch Laide is very uneven. The greatest depth, 9 feet, is found close to the east shore. In the centre the depth is only 4 feet, and other soundings of 3 and 4 feet are found far out. There are low islands near shore to the south and west. The mean depth is just over 5 feet, or fully half the maximum depth.

The surface temperature on May 20, 1904, was  $52^{\circ}\cdot 3$  Fahr.; at 5 feet,  $51^{\circ}\cdot 7$ ; and at 8 feet,  $51^{\circ}\cdot 3$ .

*Loch Tarff* (see Plate XCI.)—Loch Tarff is a beautiful loch of triangular form (see Fig. 62) lying high among the hills to the east of Loch Ness, from which it is about a mile distant, and 3 miles north-east of Fort Augustus. There are several large and small islands, some of which are covered with trees. Rocky hills rise on all sides, but to no great height above the loch in the immediate neighbourhood. Beinn a' Bhacaidh (1813 feet) on the north is 850 feet above the loch. The high mountain range, culminating in Corrieyairack, is more distant on the south-east. The outline is almost an equilateral triangle. The shores are undulate. The large Eilean Ban is close to the shore on the north-east. On April 25, 1903, the elevation of the lake-surface was 956·2 feet above the sea, almost identical with that observed by the Ordnance Survey officers on July 17, 1866, viz. 956·3 feet. The greatest diameter measured from north-west to south-east exceeds two-thirds of a mile. The maximum breadth, taken at right angles to the line of greatest

diameter, is fully half a mile, the mean breadth being over one-third of a mile. The superficial area is about 131 acres, and the contents 136 millions of cubic feet. The drainage area is rather over 1 square mile. Some small burns come in from the hills to the north, and the overflow is carried into the Doe burn, a mile to the south-west, and so into Loch Ness.

Loch Tarff is shallow. Though it has a maximum depth of 89 feet, the mean depth is only 24 feet, nearly two-thirds of the area being less than 25 feet deep. The bottom is irregular, there being three separate basins over 25 feet in depth. Two of these are unimportant and lie



FIG. 62.—LOCH TARFF, LOOKING NORTH-EAST.

(Photograph by Mr. G. West. From "*Proc. Roy. Soc. Edin.*," by permission of the Council.)

towards the south-east shore, with maximum depths of 27 and 42 feet respectively. The largest 25-foot area lies to the north-west of Eilean Ban, and stretches from south-west to north-east nearly across the loch, with a breadth of one-fifth of a mile. It encloses a small 50-foot area and a very small area of over 75 feet, both to the north of the centre and nearer the north-east shore, the maximum sounding, 89 feet, being found about half-way between the island and a rocky point north-west from it.

*Temperature Observations.*—A series of temperatures taken in the deep part on April 25, 1903, showed a range of only  $1\frac{1}{2}$  degrees, as shown in the following table:—

Surface ... ..	42°·8 Fahr.
20 feet ... ..	42°·8 „
40 „ ... ..	42°·0 „
80 „ ... ..	41°·3 „

*Loch Knockie* (see Plate XCI).—A loch of moderate size and very irregular form, about a mile east of Loch Ness, opposite Invermoriston. It is a beautiful loch, with great parts of the shores wooded, and several tree-clad islands (see Fig. 63). It is narrow, with the axis running nearly south-west and north-east. The shore-line is undulating. A



FIG. 63.—LOCH KNOCKIE, LOOKING NORTH-EAST.

(Photograph by Mr. G. West. From "Proc. Roy. Soc. Edin.," by permission of the Council.)

large broad bay runs off to the north-west, and there are several smaller bays on the south-east shore. The length is  $1\frac{1}{4}$  miles, the maximum breadth half a mile, and the mean breadth one-fifth of a mile.

The superficial area is about 182 acres, or a little over a quarter of a square mile, and the volume of water 194 millions of cubic feet. It has a very limited drainage area, amounting to only about  $1\frac{2}{3}$  square miles. No large stream flows into it, and a short burn carries the overflow into Loch nan Lann. There is no bench-mark near, but a spot-level on the shore indicates that the loch is a few feet less than 700 feet above the sea.

Loch Knockie is on the whole shallow, as indicated by the low mean

depth,  $24\frac{1}{2}$  feet, and by the fact that two-thirds of the area of the loch is less than 25 feet deep. Both ends are shallow beyond the two narrows which constrict the loch, the deepest part in the north-east portion being 26 feet, and in the south-west portion 32 feet. Both the narrows are 20 feet deep. The central basin between the narrows is deep, and the 25-foot and 50-foot contours follow the shore and enter the west bay. The greater part of the basin is over 25 feet deep, the 50-foot area being nearly half a mile long, but narrow. The 75-foot basin is based on a single sounding in 75 feet, the maximum depth of the loch.

*Loch nan Lann* (see Plate XCI.).—A small loch of relatively great depth, situated between Loch Knockie and Loch Ness, joined with Loch Knockie by a short stream a quarter of a mile long. Loch nan Lann lies due north and south, and is narrow towards the north and broad towards the south end. There is a constriction in the middle of the loch, with a small and shallow expansion to the north of it, and a broad and deep basin to the south. The axis of the loch is considerably curved. The east shore is wooded. The length is nearly three-quarters of a mile, the greatest breadth one-third of a mile, and the mean breadth about one-seventh of a mile. The superficial area is about 65 acres, and the contents amount to 105 millions of cubic feet. The drainage area includes Loch Knockie, and amounts to  $3\frac{3}{4}$  square miles. It is fed chiefly by the burn from Loch Knockie. The outgoing stream leaves the loch at the north extremity, and flows half a mile north-westwards into Loch Ness.

North of the narrows the loch is deeper close to the west shore, and the greatest depth in this part is 41 feet. South of the narrows the expanded portion is a regular and simple basin. The contours are fairly concentric with the sides of the basin, the slope pretty uniform all round, but rather more gradual from 25 to 50 feet. The narrow 100-foot area is an eighth of a mile long, and is a very little to the south-west of the centre. The maximum depth is 109 feet. The loch is approximately 645 feet above the sea.

The temperature at the surface on April 24, 1903, was  $42^{\circ}0$  Fahr.; at 15 feet,  $41^{\circ}8$ ; at 25 feet,  $41^{\circ}3$ ; at 50 feet,  $41^{\circ}0$ ; and at 100 feet,  $41^{\circ}0$ , the whole range being  $1^{\circ}$ .

*Loch Kemp* (see Plate XCI.).—A small loch east of Loch Ness, 3 miles to the south of Foyers. It is of rather irregular form, roughly oblong, with an arm running off to the north, and bays to the east and west. The shore is entirely of rock, and it is surrounded by low hills. The length is half a mile, the greatest breadth a quarter of a mile, the mean breadth scarcely less (one-fifth of a mile). The superficial area is about 68 acres, and the volume of water 77 millions of cubic feet. The drainage area is  $1\frac{1}{2}$  square miles. Two small burns enter to the

south and east, and the outflowing stream goes half a mile north into Loch Ness. On April 23, 1903, the loch was 577·8 feet above sea-level; on August 4, 1869, the Ordnance Survey officers found it to be 577·4 feet.

The bottom is flat, with a central depth of 41 feet. The 25-foot contour closely follows the shore, but does not go into the north arm, in which there is an isolated sounding of 25 feet. The maximum of 51 feet occurs in a little hole close to the shore, in the south-east corner of the loch, the mean depth being  $26\frac{1}{4}$  feet.

Temperature of the surface,  $42^{\circ}\cdot 0$  Fahr.; at 25 feet,  $42^{\circ}\cdot 0$ ; at 50 feet,  $41^{\circ}\cdot 8$ .

*Loch nan Eun* (see Plate CIII.).—A dark and desolate tarn lying at the foot of the wild and bare Cairn Vangie. The loch lies in a deep valley, and a boat was with difficulty transported down the steep hill from the road. Glen nan Eun runs here nearly east and west. The Cumrack burn flowing out from the loch runs to the north-east and becomes the river Foyers. The surface is about 915 feet above the sea. The length is barely half a mile, and the greatest breadth about one-sixth of a mile. The superficial area is about 35 acres, and the contents 15 millions of cubic feet. The drainage area is nearly 4 square miles, and the chief feeder is the nan Eun, coming from the south-west.

Loch nan Eun is somewhat oblong, and is a simple basin of no great depth. The slope of the bottom is steeper on the south, and very gentle on the north. The maximum depth of 21 feet is near the south shore; the mean depth is 10 feet.

On April 25, 1903, the temperature at the surface was  $42^{\circ}\cdot 5$  Fahr., and at 20 feet,  $42^{\circ}\cdot 1$ .

*Loch Killin* (see Plate CIII.).—Loch Killin lies high up among the mountains on the east side of Loch Ness, about 10 miles east of Fort Augustus. It is a narrow loch of moderate size, the valley which it occupies running at that part nearly south to north. On the west the precipitous crags of Creag Acain rise abruptly from the shore of the loch to a height of 1000 feet above its surface. Equally high hills rise more gradually on the east (see Fig. 64).

Loch Killin is narrow to the north and broadens to the south, the maximum breadth of a quarter of a mile being just a quarter of a mile from the south end. The mean breadth is about one-sixth of a mile. The length is considerably over a mile. The loch has a superficial area of about 130 acres, and contains 137 millions of cubic feet of water. Loch Killin has a large drainage area, extending to  $38\frac{1}{2}$  square miles, the river Killin, which enters on the south, bringing the drainage of several large glens. The river flowing out to the north is called the Fechlin, and is one of the chief sources of the river Foyers. At the

head of the glen, 6 miles south of Loch Killin, is Loch na Lairige, which was not visited. The height above sea-level is about 1044 feet.

Loch Killin is of very moderate depth, with a flat bottom. More than half the area of the loch (58 per cent.) is covered by less than 25 feet of water. The area over 25 feet in depth is all south of a little rocky point on the west shore, and is fully half a mile long, the contour following the shore closely. The area over 50 feet in depth, a quarter of a mile long, approaches close to the foot of the cliffs on the west, and the maximum sounding of 67 feet is not far from shore. The mean depth is 24 feet.



FIG. 64.—LOCH KILLIN, LOOKING SOUTH-EAST.

(*Photograph by Mr. G. West. From "Proc. Roy. Soc. Edin.," by permission of the Council.*)

The temperature on April 24, 1903, was almost uniform throughout—surface, 36°·9 Fahr.; 50 feet, 36°·8.

*Loch nan Losganan* (see Plate CIII).—A mere shallow pond with a maximum depth of 7 feet. It is narrowly triangular, its axis curved, and is narrow and elongate to the west. It lies about 4 miles south of Foyers on Loch Ness, and is connected by a small burn with the river Foyers. Though from its elongate form it is not quite the shortest in the Ness basin, in all other respects it is the smallest. In length it is nearly one-third of a mile, and its greatest breadth is one-tenth of a mile. The superficial area is only about 7 acres, its volume only 1 million cubic feet, and its drainage area a quarter of a square mile.

The temperature of the water on April 21, 1903, was 42°·8 Fahr.

*Loch Mhor* (see Plate CIV.).—Loch Mhor is the reservoir for the British Aluminium Co.'s works at Foyers. In its construction advantage was taken of two natural lochs (Garth and Farraline). By means of the dam at the lower end of Loch Garth, the surface of Loch Mhor may be raised to 20 feet above the original level of Loch Farraline, the upper loch. In summer the two lochs may subside to their original levels. The loch is still divided into two portions by a causeway 2 miles from the upper end, and a public road here crosses by a bridge, the water passing by a canal underneath. The loch is rapidly forming a beach by eating away the boulder clay of the fields. These raw cliffs of clay

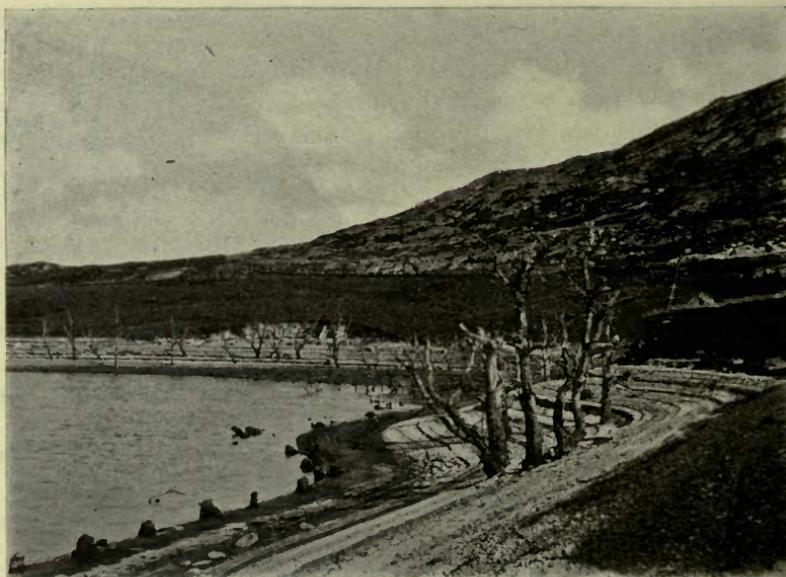


FIG. 65.—LOCH MHOR, SOUTH-WEST END, SHOWING THE SHORE WHEN THE WATER IS LOW, WITH REMAINS OF DEAD TREES.

(Photograph by Mr. G. West. From "Proc. Roy. Soc. Edin.," by permission of the Council.)

are exposed when the loch is below its high level, and portions are continually falling in.

Loch Mhor is of very irregular form, narrow and elongate, running north-east and south-west in Strath Errick, the lower end some 2 miles south-east of Foyers. On the west the country is moorland, with low hills, and many patches of trees on the shore of the loch. On the east the hills are higher, rising to mountains at the distance of a few miles. The west shore-line is of a simple outline, with slight double sigmoid curvature. The east shore is much broken up, several bays and arms running south-eastward. The largest of these is in the middle of the loch, and runs three-quarters of a mile inland.

The loch is nearly 5 miles in length, has a maximum breadth of nearly three-quarters of a mile, and a mean breadth of one-third of a mile. It has a superficial area of  $1\frac{2}{3}$  square miles. The volume of water is subject to great variation, being estimated at the date of the survey (April 24 and 25, 1903) at 1134 millions of cubic feet. It drains an area of about 21 square miles. Few streams of any importance enter the loch. The largest are the Allt na Seabhaig, which formerly flowed into the river Gourag, but was diverted into Loch Garth when the dam was built, and the Aberchaldar burn, which enters the large middle bay on the east. When quite full the reservoir overflows into the Gourag.



FIG. 66.—LOCH MHOR, SOUTH-EAST SHORE, WHEN THE WATER IS LOW; ROCKS THAT HAVE BEEN DENUDED OF THEIR PEAT COVERING EXHIBIT GLACIAL STRIATION.

(*Photograph by Mr. G. West. From "Proc. Roy. Soc. Edin.," by permission of the Council.*)

When surveyed the surface was 638.5 feet above sea-level. In accordance with its artificial origin, the greater part of Loch Mhor is very shallow; deep water is only found in the original natural lochs. Two-thirds of the whole area is less than 25 feet deep.

The basin formed by Loch Farraline before the surface was raised was fully a mile in length and one-third of a mile broad, with a depth of about 40 feet. The breadth has been very little increased by the dam. The depth is now 60 feet. The basin is simple, with uniform contours and gently sloping sides. The 25-foot contour encloses an area of two-thirds of a mile long by one-fifth of a mile broad. The

50-foot area is very narrow, a quarter of a mile long, and a little east of the central line.

The basin of Loch Garth, which was  $1\frac{1}{2}$  miles long by nearly half a mile broad, is of irregular shape. The main part of the loch was oblong, but a long, curved, narrower part branched off to the south. The depth is now 91 feet (the maximum for Loch Mhor). The 25-foot contour almost coincides with the shore-line of the original loch. The 50-foot contour encloses an area  $1\frac{1}{4}$  miles in length, and enters the narrow southern branch. This area is broad for half a mile at the north end, but from there south it is a narrow channel. The 75-foot area is one-third of a mile long, by one-fifth of a mile broad. The mean depth of the whole loch is 24 feet.

*Temperature Observations.*—Series of temperatures were taken in Loch Garth on April 24, and in Loch Farraline on April 25. The higher temperature of Loch Farraline might be due merely to its being taken a day later, as the weather was warm:—

		Loch Garth, April 24, 1903.		Loch Farraline, April 25, 1903.	
Surface	... ..	42°·0	Fahr.	... ..	43°·5 Fahr.
10 feet...	... ..	41°·8	„	... ..	43°·2 „
25 „ ...	... ..	—	„	... ..	43°·0 „
30 „ ...	... ..	—	„	... ..	42°·4 „
40 „ ...	... ..	41°·2	„	... ..	42°·0 „
55 „ ...	... ..	—	„	... ..	42°·0 „
80 „ ...	... ..	41°·2	„	... ..	— „

*Loch Bran* (see Plate XCI.).—Loch Bran is situated in the woods above Foyers, from which it is a mile distant. The shores are wooded, with rock showing in places a little way from the water's edge. There are really two basins at the same level, separated by a narrow neck of land. The loch is very narrow, with the centre line strongly curved. Its length, measured in a straight line, is about three-eighths of a mile, measured round the curve, nearly three-quarters of a mile; the maximum breadth is one-fifth of a mile. The superficial area is about 24 acres, and the volume of water 13 millions of cubic feet. The drainage area is only a quarter of a square mile; the loch receives no streams of any size. The east loch drains into the west loch, and that into the river Foyers by a burn half a mile long. The east loch is much the larger and deeper, but the deep area with a maximum of 50 feet is only a little hole in the middle of the loch. The greatest depth in the west loch is 19 feet. The mean depth of the whole loch is  $12\frac{1}{2}$  feet. The temperature at the surface on April 30, 1903, was 48°·6 Fahr.; at 10 feet, 46°·2; at 20 feet, 45°·0; at 25 feet, 42°·3; and at 50 feet, 42°·2.

*Loch a' Choire* (see Plate CV.).—A little loch lying between Lochs

Dùn na Seilcheig, and Ruthven, and draining into the latter. Low but craggy hills border the loch on the west and north, the crags of Creag Dearg facing the west end. The loch is of somewhat oblong form, with the long diameter east and west. The length is nearly two-thirds of a mile, the greatest breadth one-third of a mile, the mean breadth one-fifth of a mile. The superficial area is about 86 acres, and the volume of water 103 millions of cubic feet. The drainage area is nearly one square mile. Only one stream, the Allt Bhreac, flows in on the north, and at the east end the burn flows out towards Loch Ruthven.

Loch a' Choire is 865 feet above the sea. The bottom forms a simple basin, with the deeper water towards the east end. The 25-foot contour follows the shore-line, except at one point on the north, where a sounding of 18 feet lies far out. The 50-foot area, one-sixth of a mile in length, lies all to the east of the centre of the loch. The maximum depth is 60 feet, and the mean depth  $27\frac{1}{2}$  feet. The temperature at the surface on April 28, 1903, was  $43^{\circ}\cdot 5$  Fahr.; at 25 feet,  $42^{\circ}\cdot 5$ ; and at 50 feet,  $42^{\circ}\cdot 5$ .

*Loch Ruthven* (see Plate CV.).—A loch of fair size, some  $2\frac{1}{2}$  miles east of Loch Ness, opposite Urquhart bay, and half a mile south of Loch Dùn na Seilcheig. It is a narrow loch, with its central line much curved, but having its general direction east to west. Precipitous wooded hills, the Tòrr Mòr and the Torr Beag, rise abruptly from the north shore. On the south the crags of Stac Gorm and Craig Ruthven border the eastern part of the loch, while towards the west the ground is lower and more open.

Loch Ruthven is very narrow in the middle, slightly expanded at the east, and much expanded at the west end. The length is  $2\frac{1}{4}$  miles, the maximum breadth, close to the lower end, fully half a mile, and the mean breadth a quarter of a mile. It has a superficial area of about 368 acres, or over half a square mile, and a volume of 180 millions of cubic feet. The drainage area is 4 square miles. The burn from Loch a' Choire comes in near the upper end of the loch, and there are no other burns of any size. The outflowing stream is the river Farigaig, which falls into Loch Ness at Inverfarigaig.

When surveyed on April 27 and 28, 1903, the loch was 2 feet below a bench-mark, 703·1 on the south shore at the upper end, and would therefore be 701·1 feet above the sea. This figure is at variance with two spot-levels on the north shore, where 687 and 688 feet are marked near the west end, and there is no dam to account for so much difference. The Ordnance Survey, on May 8, 1871, made the level 700·4 feet, only a few inches lower than our measurement. Loch Ruthven is on the whole very shallow, having a mean depth of only 11 feet. The small eastern expansion has a flattish sandy bottom, with a greatest depth of 8 feet.

The narrow part, a mile in length, has a uniform central depth of 14 feet throughout, but in it, just three-quarters of a mile from the upper end of the loch, is an abrupt little hole of very limited extent, where the maximum depth of 42 feet occurs. The western basin has a flattish bottom, with a depth of about 13 feet, and two little depressions of 20 and 25 feet. Rock is exposed on the north shore at the bases of the Torrs, and at several points on the south shore. Though the rock is near all along the south shore, the beach is for the most part of gravel and boulders. The river flows out through a grassy flat.



FIG. 67.—WEST END OF LOCH RUTHVEN, LOOKING EAST.

(Photograph by Mr. G. West. From "Proc. Roy. Soc. Edin.," by permission of the Council.)

The temperature on April 27, 1903, was 45°·0 Fahr. from top to bottom.

*Loch Ashie* (see Plate XCII.).—Loch Ashie is used for the water-supply for the town of Inverness. It is about 6 miles south of the town, and 1½ miles east of Dares, on Loch Ness. It is an elongate loch of moderate size, having the same general direction as the Great Glen. The west shore is bordered for its whole length by Drumashie wood; on the east is a bare woodland stretch little higher than the loch.

Loch Ashie is 1½ miles in length. It is nearly half a mile broad in the middle, and narrows towards each end. The mean breadth is one-third of a mile. Its superficial area is half a square mile, and the

volume of its water 309 millions of cubic feet. It has a drainage area of nearly 3 square miles. Only a few very small burns go into it, and the Allt Mor, its natural outflow at the north end, flows into the river Ness 2 miles above the town of Inverness.

Loch Ashie forms a simple basin, with all the contours following the line of the shore, and the sides everywhere with a uniform gentle slope. The maximum depth of 51 feet is in the centre of the loch. The mean depth is 21 feet.

The surface on April 14, 1903, was 717·75 feet above sea-level, the water just lipping the sill of the sluice at the north end; the Ordnance

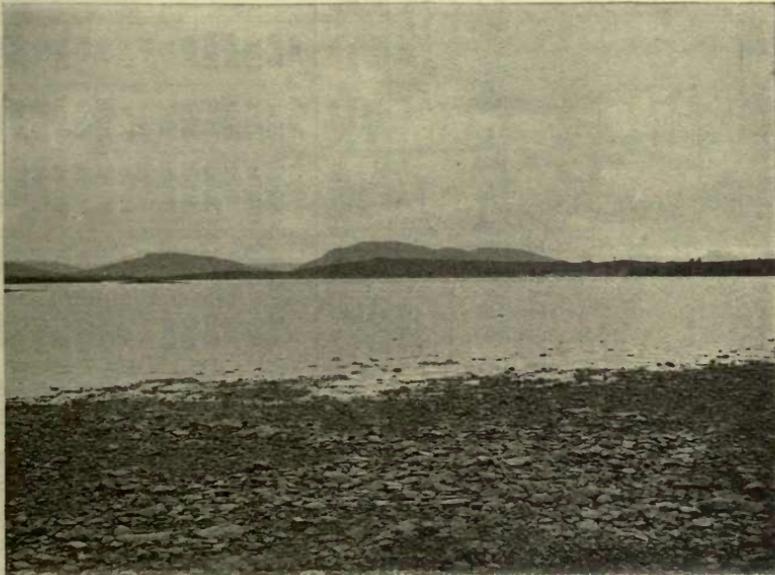


FIG. 68.—LOCH ASHIE FROM THE NORTH-EAST, LOOKING SOUTH-WEST, SHOWING BARREN FLAT AND STONY SHORE.

(*Photograph by Mr. G. West. From "Proc. Roy. Soc. Edin.," by permission of the Council.*)

Survey, on April 6, 1871, found the level to be 716·0 feet above the sea. On the date of the survey the temperature from surface to bottom was 41°·8 Fahr.

The details regarding the lochs in the Ness basin are collected together in the table on pp. 414-415 for convenience of reference and comparison. From this table it will be seen that in the thirty-three lochs about 4400 soundings were taken, and that the aggregate area of the water-surface is  $34\frac{1}{4}$  square miles, so that the average number

SUMMARY TABLE.  
Giving Details concerning the Locks within the Ness Basin.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.		Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. feet.	Mean feet.	Mean percent. of max.	Max.			Mean.	Total in square miles.
Ness	52-60	1693	24-23	1-96	0-90	3-7	433-02	57-4	170	295	263,162	21-78	086-31	31-6
Quoich	556-00	280	6-95	0-80	0-43	6-1	104-60	37-2	131	351	8,345	2-86	49-18	17-2
Foulyry	[320 approx.]	37	1-46	0-20	0-10	6-7	9-90	21-0	164	779	39	0-14	82-18	587-0
Garry	257-00	272	4-90	0-56	0-36	7-3	78-00	36-6	121	332	3,794	1-75	137-33	78-5
a' Bhainne	[1000 approx.]	42	0-36	0-26	0-14	38-9	9-69	34-6	68	196	14	0-05	1-81	36-2
Lundie (Garry).	445-40	103	0-76	0-40	0-22	29-6	16-28	30-1	74	246	78	0-17	3-44	20-2
Oich	[Aug. 18, 1869] 106-00	195	4-02	0-30	0-19	4-7	41-78	27-1	138	509	890	0-76	170-96	224-9
Uanagan	118-20	56	0-52	0-12	0-07	13-5	16-80	39-1	64	163	18	0-04	1-21	30-2
Reag	605-20	27	0-30	0-22	0-13	43-3	11-80	47-2	63	134	13	0-04	20-40	510-0
Clunie	605-20	126	4-28	0-50	0-26	6-0	49-98	40-6	184	452	1,533	1-10	32-29	29-3
Lundie (Clunie)	681-50	28	0-46	0-18	0-09	19-6	7-80	31-2	97	311	9	0-04	0-95	23-8
West Loch Loyne	719-00	67	1-28	0-34	0-19	14-7	5-93	31-2	356	1,140	40	0-24	16-21	67-6
East Loch Loyne	706-10	123	2-75	0-30	0-15	5-6	10-32	29-5	415	1,407	123	0-43	23-87	55-5
an Staca	[1600 approx.]	85	1-02	0-40	0-25	24-5	15-52	30-4	106	347	110	0-26	1-23	4-8

Liath ...	1494-10	43	0.46	0.28	0.21	45.0	55	22.36	40.7	44	109	62	0.10	4.00	40.0
nam Dearga	[1570 approx.]	60	0.74	0.21	0.12	16.0	70	24.43	34.9	56	160	60	0.09	0.60	6.7
a' Vullan	[1750 approx.]	38	0.45	0.18	0.09	21.6	27	12.27	45.4	88	194	15	0.04	0.69	17.2
Meikle	364.90	49	1.10	0.43	0.28	25.9	45	22.10	49.1	129	263	193	0.31	41.32	133.3
Aslaich	[1310 approx.]	38	0.35	0.14	0.09	26.9	26	10.91	42.0	71	169	10	0.03	1.62	54.0
Dubh	[1340 approx.]	20	0.18	0.11	0.07	38.9	18	7.00	38.9	53	136	2	0.01	0.17	17.0
Laide	859.80	62	0.34	0.32	0.18	52.8	9	5.16	57.3	199	348	9	0.06	1.55	25.8
Tarf	[Aug. 4, 1869.]	80	0.69	0.60	0.36	52.5	89	23.89	26.8	41	152	136	0.21	1.20	4.8
Knockie	956.20	123	1.30	0.46	0.22	16.9	75	24.40	32.5	91	281	194	0.28	1.62	6.0
nan Lann	[nearly 700]	56	0.70	0.34	0.15	20.8	109	37.03	34.0	34	100	105	0.10	3.69	36.9
Kemp	[645 approx.]	48	0.52	0.25	0.20	39.1	51	26.23	51.4	54	105	77	0.11	1.53	13.9
nan Eun	577.80	29	0.48	0.18	0.11	23.6	21	9.90	47.1	121	256	15	0.05	3.81	76.2
Killin	[915 approx.]	61	1.12	0.26	0.18	16.2	67	24.15	36.0	88	245	137	0.20	38.45	192.2
nan Losganan	[1044 approx.]	18	0.30	0.10	0.04	12.3	7	3.50	50.0	226	453	1	0.01	0.24	24.0
Mhor (Garth and Far- raline)	638.55	279	4.84	0.64	0.35	7.2	91	24.11	26.5	281	1,060	1,134	1.69	20.77	12.2
Bran	...	49	0.74	0.20	0.05	6.9	50	12.63	25.3	78	309	13	0.04	0.28	7.0
a' Choire	865.00	45	0.61	0.33	0.22	36.1	60	27.55	45.9	54	117	103	0.13	0.94	7.2
Ruthven	701.10	103	2.26	0.54	0.25	11.4	42	11.27	26.8	284	1,059	180	0.57	4.01	7.0
Ashie	717.75	50	1.60	0.44	0.33	20.4	57	21.26	37.3	148	397	309	0.52	2.83	5.4
		4385										280,923	34.25	689.14*	20.1

\* With the exception of Loch Ashie, the drainage areas of all the lochs are included in that of Loch Ness.

of soundings per square mile of surface is 128. The aggregate volume of water contained in the lochs is estimated at 280,923 millions of cubic feet, or less than 2 cubic miles. The area drained by these lochs is about 690 square miles, or twenty times the area of the lochs.

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NOTES ON THE TEMPERATURE OF THE WATER\* IN LOCH NESS.

By E. M. WEDDERBURN, W.S., LL.B.

Regular temperature observations in Loch Ness were begun at Fort Augustus in July, 1903, at the same time as the first limnograph to be used in Scotland was erected. At first the temperature observations were subsidiary to the other observations made in the loch, but gradually their importance increased until the investigation of lake temperatures became one of the principal studies of members of the Lake Survey stationed on Loch Ness. The observations were originally made from a rowing boat by means of the Pullar and Lucas sounding machines and deep-sea reversing thermometers. An endeavour was made to take the observations at regular hours in as nearly as possible the same positions in the loch from day to day, but in stormy weather the keeping of the same position during lengthy observations was attended with considerable difficulty. In September, however, a small decked fishing boat, called the *Rhoda*, was anchored off Fort Augustus in about 300 feet of water. The anchoring of this boat caused some anxiety, but it was ultimately accomplished by means of a large mushroom anchor, which, with the necessary length of chain, was put at the disposal of Sir John Murray through the courtesy of Mr. Davidson, superintendent of the Caledonian canal.

This boat was primarily intended to accommodate the electrical thermometers which were installed, but it came to be very largely used for taking observations by means of mercury thermometers. Lengthy series of observations could be taken in comfort whatever the state of the weather, and with great economy in time. It was possible to use three or four sounding machines and thermometers at once, and consequently a series of observations could be made much more expeditiously than when only one sounding machine was used.

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\* The water of Loch Ness was submitted to analysis by Dr. Tetlow, who found nothing abnormal about the water, except its softness and freedom from mineral matter, the total solids being equal to only 2.9224 parts per 100,000 (1.9012 parts of fixed solids, and 1.0212 parts of volatile solids); the principal constituents are sodium and calcium chlorides, while magnesium chloride, iron, potassium, silicon, carbonic acid, and sulphuric acid are present in traces.

The electrical thermometers were at first intended to furnish the means of observing continuously radiation into and from the loch. The apparatus was not altogether suitable for this purpose, and, being the first installation of its kind in this country, many unforeseen difficulties arose in the manipulation of the instruments, but nevertheless many valuable observations were made by its means. The installation consisted of three platinum resistance thermometers and a Callendar recorder. The boat-house of St. Benedict's Abbey was made available to the Lake Survey by the Lord Abbot of the monastery, and in it were placed the recording instruments. A four-ply cable connected the recorder with the *Rhoda*, which was anchored at a distance of about 300 yards from the boat-house. Many of the difficulties which were experienced arose from this cable; the strain of the wind and the waves was constantly damaging it, and as the *Rhoda* swung round with the wind great care was necessary to prevent the cable fouling with the anchor chain. On the *Rhoda* there were three large drums, on which there were wound the leads for the resistance thermometers. By these drums a thermometer could be lowered to any desired depth, and then connected to the shore-cable by means of mercury cup connections, and a continuous record of the temperature at that depth could thus be obtained. It was intended to lower each of the three thermometers to a different depth, and connect them successively with the recorder, and so to get a series of readings at these depths, but the sluggishness of the recorder made this method of observation undesirable.

Temperature observations were taken at various points along Loch Ness. At times members of the survey were stationed at Invermoriston, Foyers, Inverfarigaig, Whitefield, and Dores. At other times a steam launch was chartered, and cruises made up and down the loch, taking observations *en route*, but this method of observation was very slow. The speed of the launch was about six miles an hour, and, as the loch is 24 miles in length, about eight hours were spent in steaming alone; assuming that six series of observations were taken, each lasting over half an hour, the observations at one end of the loch were taken six or seven hours later than at the other end. It was found that in this time the distribution of temperature in the loch might alter very greatly, and therefore observations made in this manner might give a very erroneous idea of that distribution.

The observations in Loch Ness were discontinued by members of the Lake Survey in September, 1904, but the work was taken over by the monks at Fort Augustus (in particular by Father Cyril von Dieckhoff and Father Odo Blundell), and continued by them until April, 1905, so that the observations extend over a period of nearly two years. The actual number of observations made in that time was about 12,000, and these have been discussed by the writer in papers communicated

to the Royal Society of Edinburgh.\* The results arrived at are briefly as follows:—

The yearly cycle of changes in a loch such as Loch Ness is very much the same from year to year. Fig. 69 shows graphically what may be called the typical curves for each month of the year, being drawn from the monthly means of the temperature readings during the period of the observations. From these curves it appears that in September there is the greatest quantity of heat in the loch. Thereafter the loch cools gradually till March or April, when the water again begins to gain heat. This is the time when the mean air temperature begins to be higher than the surface temperature. From May till August the increase in temperature at various depths proceeds regularly, and the typical curves representing the temperature of the water to a depth of 200 feet are practically straight lines. Below that depth it is probable that the temperature increases less rapidly in proportion to the depth, but even in the deepest waters of Loch Ness there is a range in temperature of about 2° Fahr. The lowest recorded temperatures in the deepest parts of the loch are in April, and the highest in the middle of November. During the period in which the loch gains heat, the most remarkable changes are those taking place at and near the surface. Rapid changes are of frequent occurrence, and are probably due to convection currents. On one occasion the temperature at the point of observation rose 6° Fahr. in two minutes.

When the mean air-temperature falls below the surface temperature, which is usually in August, the loch begins to part with its heat. This is shown in the change of type in the typical curve for September. The surface layers lose heat, while lower down the water still continues to rise in temperature; as already mentioned, the highest temperature at 700 feet was observed in November, or about three months after the loch began to lose heat. In August the discontinuity between the upper and lower layers of the loch usually becomes well marked. As the upper layers of water become colder, there is a layer at the surface of nearly uniform temperature, and of gradually increasing depth. Below this layer there is a sudden change of temperature—a discontinuity layer—below which there is the colder water in the loch. As the season advances this discontinuity layer gradually sinks lower, and the layer of uniform temperature above it increases in depth, until finally the whole loch is of nearly uniform temperature.

Before the discontinuity layer makes its appearance, the currents produced by winds are distributed through the whole loch. There is

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\* "The Temperature of the Fresh-water Lochs of Scotland, with special reference to Loch Ness, with an appendix containing observations made in Loch Ness by members of the Scottish Lake Survey," *Trans. Roy. Soc. Edin.*, vol. 45, p. 407 (1907); "An Experimental Investigation of the Temperature Changes occurring in Fresh-water Lochs," *Proc. Roy. Soc. Edin.*, vol. 27, p. 2 (1907).

the surface current, directly produced by the wind, carrying the warm surface water along with it, and the return current, to take the place of the water blown along the loch, is spread throughout the whole depth

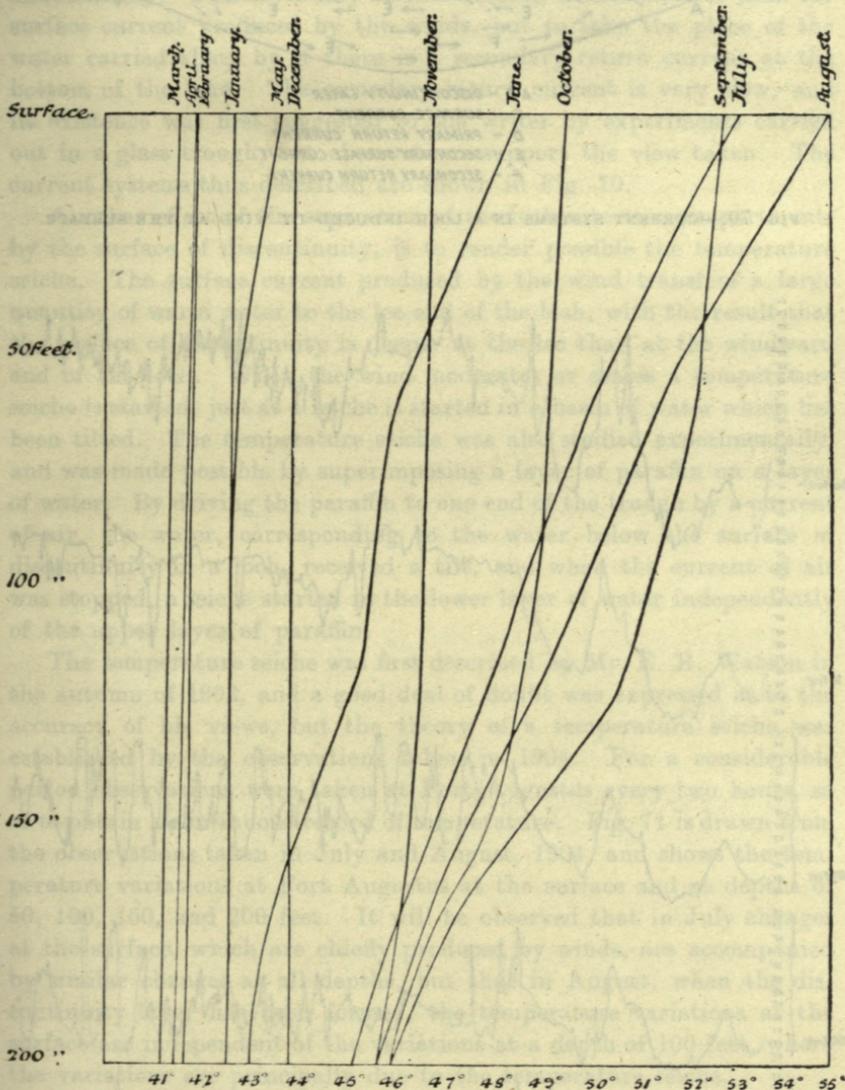


FIG. 69.—TYPICAL MONTHLY CURVES OF TEMPERATURE IN LOCH NESS.

of the loch. But when the discontinuity layer has formed, the loch is divided into two current systems. Above the discontinuity layer there is the surface current produced by the wind, and the return current also takes place above the discontinuity layer, without directly affecting the

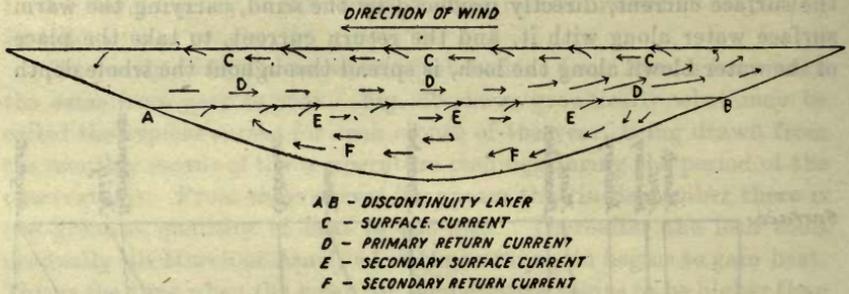


FIG. 70.—CURRENT SYSTEMS IN A LOCH INDUCED BY WIND AT THE SURFACE.

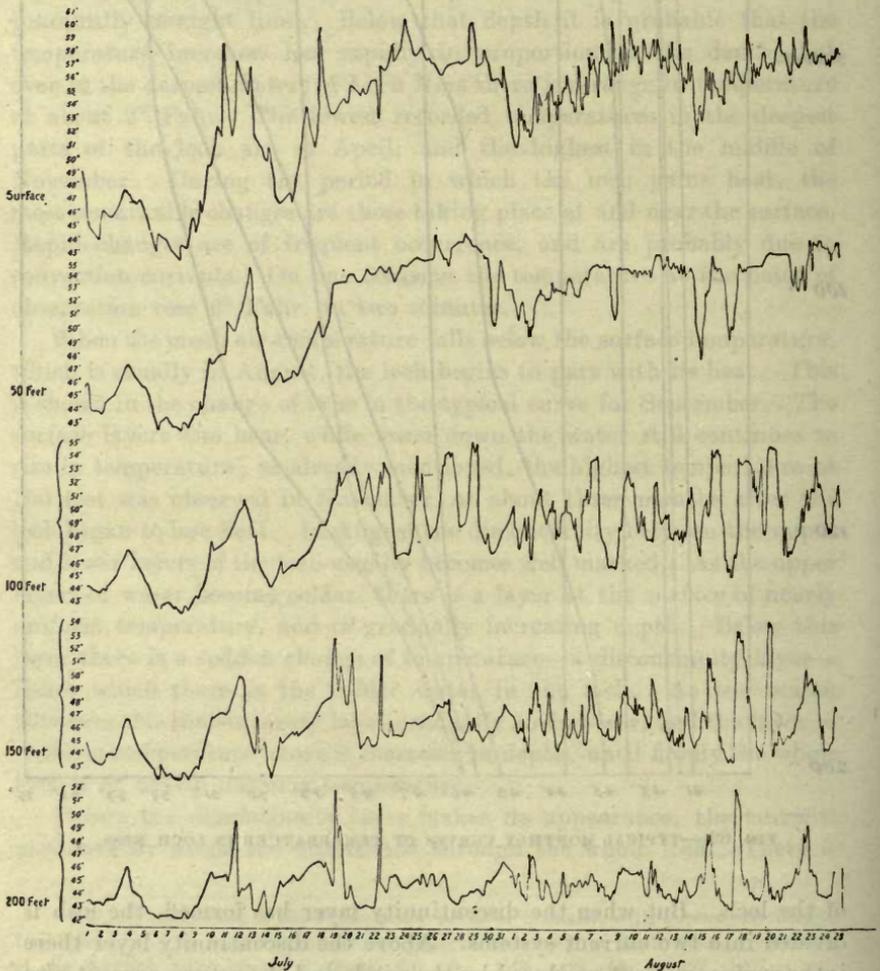


FIG. 71.—TEMPERATURE VARIATIONS IN LOCH NESS AT FORT AUGUSTUS DURING JULY AND AUGUST 1904.

deeper waters. This return current, however, acts on the water below the discontinuity layer just as the current of wind acts on the natural surface of the loch, and a secondary current is produced at the surface of discontinuity. This secondary surface current is much slower than the surface current produced by the winds, but to take the place of the water carried along by it there is a secondary return current at the bottom of the lake. The secondary return current is very slow, and its existence was first suggested to the writer by experiments carried out in a glass trough, but observations support the view taken. The current systems thus described are shown in Fig. 70.

Another effect of the separation of the loch into two compartments by the surface of discontinuity, is to render possible the temperature seiche. The surface current produced by the wind transfers a large quantity of warm water to the lee end of the loch, with the result that the surface of discontinuity is deeper at the lee than at the windward end of the loch. When the wind moderates or ceases a temperature seiche is started, just as a seiche is started in a basin of water which has been tilted. The temperature seiche was also studied experimentally, and was made possible by superimposing a layer of paraffin on a layer of water. By driving the paraffin to one end of the trough by a current of air, the water, corresponding to the water below the surface of discontinuity in a loch, received a tilt, and when the current of air was stopped, a seiche started in the lower layer of water independently of the upper layer of paraffin.

The temperature seiche was first described by Mr. E. R. Watson in the autumn of 1903, and a good deal of doubt was expressed as to the accuracy of his views, but the theory of a temperature seiche was established by the observations taken in 1904. For a considerable period observations were taken at Fort Augustus every two hours, so as to obtain a continuous record of temperature. Fig. 71 is drawn from the observations taken in July and August, 1904, and shows the temperature variations at Fort Augustus at the surface and at depths of 50, 100, 150, and 200 feet. It will be observed that in July changes at the surface, which are chiefly produced by winds, are accompanied by similar changes at all depths, but that in August, when the discontinuity layer has been formed, the temperature variations at the surface are independent of the variations at a depth of 100 feet, where the variations are principally due to the temperature seiche.

Observations made at the two ends of the loch further support the theory, as showing that the layer of discontinuity was in general rising at one end when it was falling at the other end. Continuous records obtained from the Callendar recorder are also easily explained by the temperature seiche. Rough calculations were made of what should be the period of this seiche, based on the assumption that the loch contained two layers of water of different but uniform density. The observed

period varied with the time of year, according to the depth of the discontinuity layer, and was from two to three days, which agrees remarkably with the periods obtained by calculation.

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NOTES ON THE SEICHES OF LOCH NESS.

By E. M. WEDDERBURN, W.S., LL.B.

In June 1903, observations on seiches were begun in Loch Ness by the erection of a Sarasin limnograph in the boat-house of St. Benedict's Abbey, Fort Augustus. This instrument worked well during the period it was in use, and some good records of seiches were obtained. The largest seiche recorded by it occurred on November 21, 1903, and had an amplitude of about  $4\frac{1}{2}$  inches, but after about two days it was disturbed by the starting of another seiche.

In the summer of the succeeding year a second Sarasin limnograph was erected at Inverfargaig, but it did not work satisfactorily—perhaps owing to the exposed situation—and the records obtained were consequently not looked upon as being entirely trustworthy, although, as was to be expected, they pointed to a node in the neighbourhood of Inverfargaig.

Observations were also made by means of Forel's plemyrometer, but owing to the exposed character of the shore all along Loch Ness, observation by this means was very difficult. It is unfortunate that the index limnograph subsequently used by Professor Chrystal had not been designed while work was being carried on in Loch Ness.

The observed periods of the uninodal and binodal seiches in Loch Ness are approximately 31.5 and 15.3 minutes respectively. Loch Ness thus belongs to that class of basins in which the period of the binodal seiche is less than half the period of the uninodal seiche. The periods for Loch Ness have not been calculated according to Chrystal's theory—an exceedingly laborious piece of work, which it is hoped will yet be undertaken—but the writer has every reason to believe that calculation would agree with observation in this case also; for the basin of Loch Ness is convex at Foyers, where the floor of the loch rises some 200 feet, and, moreover, the sudden shallowing which takes place in the loch from Dores to Bona has the effect of increasing the ratio between the periods of the uninodal and binodal seiches. This is seen in the Lake of Geneva, where there is also a shallowing at one end of the lake, and where the period of the uninodal seiche is more than double the period of the binodal seiche.

Seiches of shorter period were also of frequent occurrence, notably a seiche with a period of about 8.8 minutes, of which some remarkably pure records were obtained, although they were of small amplitude.

Embroideries on the curves were common, and were attributed to a long swell on the loch, to the wash of steamers, and frequently to the opening of lock-gates on the canal at Fort Augustus.

With the view of gaining information on the effect of small variations in atmospheric pressure, a Dines's sensitive barograph was obtained.\* Records from an ordinary Richard barograph had indicated sudden barometric changes as a frequent cause of seiches, and the records of the sensitive barograph supported this view to a certain extent, although on some occasions the loch seemed unresponsive to changes in atmospheric pressure. On other occasions, however, the limnograph record seemed to be an accurate reproduction of the record obtained by means of the sensitive barograph.

Loch Ness from its size proved to be rather unwieldy from the point of view of seiches, so that when, in the summer of 1905, the investigation of seiches was undertaken by Prof. Chrystal, he made his headquarters on Loch Earn, and gathered much information as to the cause of seiches from his observations.†

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#### NOTES ON THE DEPOSITS OF LOCH NESS.

By G. W. LEE, D.Sc., and L. W. COLLET, D.Sc., with Analyses of Selected Samples by A. WILSON, F.I.C.

About sixty samples of the deposits covering the floor of Loch Ness were collected by the members of the Lake Survey staff from various parts of the loch, and were examined according to the methods used in the *Challenger* Office for the study of marine deposits.

They may be classed as follows:—

- (1) *Dark grey mud*, from the deep basin opposite Urquhart bay;
- (2) *Ferruginous mud*, from the part of the Invermoriston deep basin opposite Horseshoe craig;
- (3) *Peaty mud*, from the south-west end of the Invermoriston deep basin;
- (4) *Yellow-grey clay*, from off Inverfarigaig and off Cherry island; and
- (5) *Brown sand*, from shallow water off Urquhart bay.

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\* The purchase of this instrument was facilitated by a grant from the Moray Bequest to the University of Edinburgh.

† For further details the reader is referred to the following papers:—“On the Hydrodynamical Theory of Seiches, with a Bibliographical Sketch,” by Prof. Chrystal, *Trans. Roy. Soc. Edin.*, vol. 41, p. 599 (1905); Calculation of the Periods and Nodes of Lochs Earn and Treig, from the Bathymetric Data of the Scottish Lake Survey,” by Prof. Chrystal and E. M. Wedderburn, *Trans. Roy. Soc. Edin.*, vol. 41, p. 823 (1905); “An Investigation of the Seiches of Loch Earn by the Scottish Lake Survey,”; Part I. “Limnographic Instruments and Methods of Observation,” by Prof. G. Chrystal; Part II, “Preliminary Limnographic Observations on Loch Earn,” by James Murray, *Trans. Roy. Soc. Edin.*, vol. 45, p. 361 (1906).

(1) *Dark Grey Mud.*

The eleven samples of this mud are homogeneous and coherent when dry. A typical sample from 740 feet, opposite Urquhart bay, has the following mineralogical composition:—

*Minerals* (25 per cent.), mean diameter 0·1 millimetre. Of these particles quartz is the most abundant, often coloured red by a coating of iron oxide. Orthoclase, chloritic minerals, and limonite are also present.

*Fine washings* (75 per cent.), composed of vegetable matter (15·89 per cent.) and clayey matter with fine mineral particles and limonitic matter (59·11 per cent.).

*Chemical Composition.*

Total Silica	...	...	...	...	...	...	62·36
Ferric oxide	...	...	...	...	...	...	12·27
Alumina	...	...	...	...	...	...	9·38
Lime	...	...	...	...	...	...	tr.
Magnesia	...	...	...	...	...	...	tr.
Loss on ignition	...	...	...	...	...	...	15·89
							<hr/>
							99·90
							<hr/> <hr/>

The high percentage of silica is due to the great proportion of quartz. The alumina is due to the presence of felspar and clayey matter. The defect 0·10 per cent. is probably due to the fact that the alkalis have not been estimated.

(2) *Ferruginous Mud.*

This type of sediment is limited to the part of the Invermoriston deep basin opposite Horseshoe craig. One of the samples was found after examination to be composed of:—

*Minerals* (29 per cent.), essentially represented by ferruginous grains, which are accompanied by quartz, orthoclase, chlorite, and hornblende. These mineral particles are angular, and have a mean diameter of 0·12 millimetre.

*Fine washings* (71 per cent.), composed of vegetable matter (18·46 per cent.), and fine minerals (52·54 per cent.) belonging to the species mentioned above.

*Chemical Composition.*

Total silica	...	...	...	...	...	...	37·44
Ferric oxide	...	...	...	...	...	...	24·48
Alumina	...	...	...	...	...	...	15·12
Lime	...	...	...	...	...	...	2·16
Magnesia	...	...	...	...	...	...	1·80
Loss on ignition	...	...	...	...	...	...	18·46
							<hr/>
							99·46
							<hr/> <hr/>

The defect 0·54 per cent. is to be sought for in the alkalis.



Comparing the results of the investigation of these two samples, it will be seen that as the depth increases both the percentage and the diameter of the minerals decrease, the proportion of vegetable matter also decreasing.

The high percentage of lime in the second analysis is probably due to fragments of shells.

(4) *Yellow-grey Clay.*

One sample was taken off Cherry island in 95 feet, and eight samples off the south-east coast, east of Inverfarigaig, in 250 feet. This is very clayey in character, being soft to the touch and plastic when wet, coherent when dried, and taking in the latter state a light brown streak if rubbed with a hard smooth body.

The Cherry island sample is made up of:—

*Minerals* (1 per cent.), angular, mean diameter 0.1 mm.: quartz, orthoclase, chlorite, and ferruginous matter.

*Fine washings* (99 per cent.), composed of clay and very fine mineral particles.

	<i>Chemical Composition.</i>						
Total silica	...	...	...	...	...	...	58.42
Ferric oxide	...	...	...	...	...	...	9.51
Alumina	...	...	...	...	...	...	24.58
Lime	...	...	...	...	...	...	0.52
Magnesia	...	...	...	...	...	...	3.74
Manganese	...	...	...	...	...	...	2.11
Copper oxide	...	...	...	...	...	...	0.65
Loss on ignition	...	...	...	...	...	...	0.59
							<u>100.12</u>

One of the eight other samples is made up of:—

*Minerals* (29 per cent.), angular, mean diameter 0.1 mm.: quartz and decomposed felspar, with a decomposed ferruginous mineral.

*Fine washings* (71 per cent.), composed of vegetable matter (4.2 per cent.) and clay and mineral particles (66.8 per cent.).

	<i>Chemical Composition.</i>						
Total silica	...	...	...	...	...	...	50.94
Ferric acid	...	...	...	...	...	...	14.76
Alumina	...	...	...	...	...	...	19.80
Lime	...	...	...	...	...	...	6.58
Magnesia	...	...	...	...	...	...	3.61
Loss on ignition	...	...	...	...	...	...	4.20
							<u>99.89</u>

In these analyses the lime and magnesia probably belonged to some ferro-magnesian mineral, which was subsequently transformed into what is given here as "decomposed ferruginous mineral," the advanced state of decomposition preventing its determination.

(5) *Brown Sand.*

To four samples of sediment dredged in 30 feet near the west coast of Urquhart bay we give the name of Brown Sand. One of the samples has the following composition:—

*Minerals* (69 per cent.), angular, mean diameter 0·2 mm., mostly made up of quartz, coloured reddish by a coating of iron oxide. Decomposed mica, hornblende, and plagioclase are also represented. The sand contains a few small fragments of rocks, 1 to 3 millimetres in diameter.

*Fine washings* (31 per cent.), composed of vegetable matter (4·4 per cent.) and fine mineral particles (26·6 per cent.). There is no clayey matter.

*Chemical Composition.*

Total silica	...	...	...	...	...	77·62
Ferric oxide	...	...	...	...	...	3·60
Alumina	...	...	...	...	...	5·20
Lime	...	...	...	...	...	5·88
Magnesia	...	...	...	...	...	2·20
Loss on ignition	...	...	...	...	...	4·40
						<hr/>
						98·90
						<hr/> <hr/>

The alumina, lime, and magnesia are most likely due to the mica and hornblende, whilst the defect of 1·10 per cent. might represent the alkalis.

*Conclusion.*

Loch Ness includes two deep basins separated by a barrier formed by the delta of the Foyers river. The muds from the south-western or Invermoriston basin contain a large amount of vegetable or peaty matter, brought down the lake probably by the rivers Tarff and Oich, with mineral particles coming from the disintegration of the rocks, transported by the streams. Small concretions of peroxide of iron and dioxide of manganese were dredged at one station. The muds often gave the characteristic reaction of manganese. On the slopes the muds are sandy, and of a red-brown colour, due to the presence of oxide of iron.

The muds from the north-eastern or Urquhart basin contain far less vegetable matter than those from the south-western basin, which may be due to the Foyers barrier retaining the vegetable matter in the upper basin. In the north-eastern basin the vegetable matter increases with the depth, which is contrary to what is observed in the south-western basin. Off Urquhart bay the contour-lines approach each other very closely, and the vegetable matter brought down the lake by the river Enrick is carried towards the deeper part of the basin. Great differences are observed in the muds from the slopes on the two sides of the loch. On the north-western slope we find especially a red

sandy mud, coming without doubt from the washing out of the shore, composed of Old Red Sandstone. On the south-eastern slope we have a fine yellow clay, with fragments of rocks and large mineral particles without vegetable matter. The deposition of the clay in this position may be due partly to the strong prevailing westerly winds of Loch Ness giving rise to waves and currents, which would carry the fine clayey matter brought down by the Inverfarigaig river towards the south-eastern shore. Three stones from a depth of 100 feet, opposite Inverfarigaig pier, were covered with a dark ring of manganese dioxide, marking out the line between the mud and water, as was pointed out by Sir John Murray and Mr. Robert Irvine in their valuable paper: "On Manganese Oxides and Manganese Nodules in Marine Deposits."\*

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#### MIRAGES ON LOCH NESS.

A kind of mirage is one of the most familiar phenomena on Loch Ness, especially in winter and spring. It is best seen in the morning. Distant objects, such as the steamers plying on the lake, appear as though raised above the surface and floating in the air.

The most constant feature of the Loch Ness mirages is seen at promontories some miles distant. The shore-line at the promontories, though really nearly parallel with the horizon, is caused by the mirage to appear to form an angle with the horizon. When this angle is great (say  $60^\circ$  or more), the promontories appear like overhanging cliffs. When the angle is very acute, they seem to be suspended over the horizon. Objects which are known to be below the horizon are brought into view. The receding steamer, after sailing out of sight, will reappear miles further away, raised high above the loch and looking very large. The promontory at Dores appears as a conspicuous island in the middle of the loch. The fathers in the Benedictine Monastery at Fort Augustus tell that on one occasion a snow-covered mountain appeared over the end of the loch. These phenomena are best marked at a distance of several miles from the observer. The steamer, sailing away from the observer, seemed, at the distance of a mile or more, to leave the surface of the loch and sail up into the air. Signs of the mirage were sometimes to be distinguished at lesser distances. Standing on the deck of the Lake Survey yacht *Rhoda*, when the eyes would be 7 or 8 feet above the water, there could often be seen on the rocks of the nearest parts of the shore a conspicuous horizontal line, looking just like a high-water mark.

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\* *Trans. Roy. Soc. Edin.*, vol. 37. p. 721 (1894).

In the reports of the Balatonsee Commission, mirages of a similar nature are discussed. Von Cholnoky explains how they arise through the formation of a lower stratum of warmer air, heated from the lake. In shallow lakes like Lake Balaton, the mirage is essentially a summer phenomenon. The lake remains warm during the night when the air cools.

In Loch Ness the converse is the case. The great body of water maintains a moderate temperature throughout the year. In summer the lake rarely attains to 60°·0 Fahr., and so the air may frequently remain as warm as the lake, though mirages may occur after any cold night. In winter the lake maintains a high temperature, rarely falling below 42°·0 or 43°·0 Fahr., and thus the air will fall to a much lower temperature almost every night, and a well-marked layer of warmer air be formed by morning over the surface of the lake, giving rise to the mirage.

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“STORM-WEATHER” AT FORT AUGUSTUS.

Notes communicated by DOM CYRIL VON DIECKHOFF.

The general features of well-developed “storm-weather” are low barometer, dry haze, wind usually south-east, blowing in isolated gusts (“isolated” with regard to space and time), low strata of cloud forming along lines parallel to the Great Glen, small cumuli forming rapidly in the air and drifting towards the north-west, where they mass and form large strata, often of very dark and threatening appearance. Little or no rain falls during the perfect type, but rain often comes when it breaks up. These small cumuli are well known as indications of gales from the south-east, and are called by the local sailors “Pack-merchants” (*i.e.* pedlars). There are various sub-species of this kind of weather, especially one where the wind is constantly shifting in every direction, the clouds all the while coming from the south-east.

In another type there is a north-east wind (warmer than the ordinary north-east wind), while the clouds come from the south-east. On these occasions the height of the lowest cloud is never much above 3000 feet. There are often several layers at different heights, all in a north-east to south-west direction—even alto-stratus pieces lie occasionally in this direction; their motion is usually very slow; cirrus comes slowly from the south-west.

“Storm-weather” may occur at any time of the year. The strongest gales, or at least the fiercest gusts, which we get on the loch, come from the south-east. On very rare occasions there has been noticed a kind of reverse to the “storm-sky” during a north-west wind.

## NOTES ON THE GEOLOGY OF THE NORTH-EAST PART OF THE NESS BASIN.

By B. N. PEACH, LL.D., F.R.S., and JOHN HORNE, LL.D., F.R.S.

Only a small portion of the Ness area has been mapped by the Geological Survey. It is situated in the north-east part of the basin, and includes the tract at the mouth of Loch Ness and on either side of the river issuing from that loch. It comprises a small part of Loch Ness, Loch Dochfour, Loch Ashie, Loch Abban, and Loch Laide.

The geological structure of the northern part of the Ness basin is well defined. The basin is traversed by the great fault that runs along Loch Ness, which is continued north-eastwards to Tarbat Ness, thus giving rise to the prominent cliff bounding the Moray firth in the Black isle. This powerful dislocation, which has been a line of weakness in the earth's crust at successive geological periods and is evidently related to the earthquake movements that periodically affect the Inverness district at the present time, has a marked downthrow to the south-east. The exact position of the line of fault in the Ness valley is concealed by superficial deposits, but its course probably extends from near the western shore of Loch Ness at Lochend, north-east by Loch Dochfour, Dunean cottage, and Kinmylies, to the Beaully firth east of Kessock ferry.

The effect of this great dislocation in the Ness valley is to let down the Old Red Sandstone strata on the south-east side against the crystalline schists and gneisses of Dochfour hill, the Abriachan granite, and the basal conglomerates and sandstones of Dunean hill and Craig Leach on the north-west. The schistose rocks of Dochfour hill, which are pierced by the Abriachan granite, consist of quartz-biotite granulites and felspathic gneisses traversed by numerous veins of pegmatite. Occasional lenticles of garnetiferous hornblende-schist are associated with the gneisses, and a band of limestone also occurs in the schistose series at Blairnahenachrie, west-north-west of Dochgarroch. From their lithological characters, these crystalline schists have been referred to the Moine series of the Geological Survey, the members of which are regarded as altered representatives of sedimentary deposits.

The triangular area of Old Red Sandstone on the west side of the valley of the Ness, extending from Dochgarroch north-east to Clachnaharry, and west to the Bunchrew burn, consists of coarse conglomerates and grits that dip to the north-west, and are overlain by sandstones, flags, and shales. Along their western margin they are bounded by a fault, with a downthrow to the east, which is probably a branch of the great dislocation running along Loch Ness.

On both sides of the valley of the Ness there is abundant evidence of intense glaciation of the region. On the elevated plateau west of the Ness valley the direction of the ice-movement varied from  $25^{\circ}$  to  $35^{\circ}$  north of east. The ice that issued from the Great Glen flowed more or less parallel to the long axis of Loch Ness, that is, in a north-easterly direction, but the trend became more easterly as it approached the basin of the Moray firth. There is a widespread covering of boulder clay, with scattered groups of moraines, along the ridge extending from Dores north-east by Culloden moor. There is also a remarkable development of fluvio-glacial gravels, high river terraces, and remains of raised beaches at the mouth of Loch Ness, on both sides of the valley of the Ness, and on the south shore of the Beaully firth.

Loch Ashie is a shallow lake surrounded by drift, with a fine series of moraines on its eastern side. Loch Laide also occupies a hollow in the drift, with small exposures of crystalline schists in places near its margin. Loch Abban lies in a hollow in the stratified deposits at the mouth of Loch Ness, which may be of fluvatile origin.

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#### NOTES ON THE BIOLOGY OF THE LOCHS OF THE NESS BASIN.

By JAMES MURRAY.

Collections of plankton were made in twenty-seven lochs in this basin. With the exception of the lochs in the Great Glen itself, most of these lochs are at a considerable elevation, occupying the high tableland on the east of Loch Ness, or the higher mountainous tract on the west.

The situation of the lochs in two alpine masses, separated by the deep cleft of the Great Glen, gives rise to some peculiarities in distribution, most marked in the species of *Diaptomus* and the more conspicuous plankton Desmids.

A number of species were only collected on one side of the Great Glen. These peculiarities are probably due to the fact that the lochs to the east of Loch Ness were surveyed in spring or early summer, when the water was still cold, while those to the west were surveyed after midsummer, when they were about at the maximum temperature.

*Diaptomus gracilis* was here, as elsewhere, almost universal, but was not seen in several of the eastern lochs.

*D. laticeps* was in Loch Ness and the other lochs in the Great Glen. It was not seen in any loch to the west, but was frequent in lochs to the east of Loch Ness. In Loch Ness the blue *Diaptomus* (identified by

Mr. Scourfield as *D. laticeps*) is somewhat small and pale in colour. In other districts, and especially in hill lochs, it is of larger size and brighter colours—blue or occasionally red. There is some doubt as to the identity in all cases, and naturalists have given different identifications of the Loch Ness animal.

*D. laciniatus*, in contrast to *D. laticeps*, was only found to the west of the Glen, in lochs high above the sea. To the east, though it was not in any of the lochs surveyed, it was in some lochans at a great elevation on Carnahoulin.

*Desmids*.—The conspicuous plankton desmids, which constitute probably the most distinctive feature of the western Scottish plankton are not very well represented in the lochs of the Ness basin. There are few species, but they include several of the largest and most beautiful. They show no marked preference for the one side of the Glen more than the other, but the greatest number of species is in Loch Aslaich, which lies west of Loch Ness.

*Micrasterias apiculata*, var. *imbriata*, was in Loch Aslaich, and the var. *brachyptera* was found only once in Loch Ness.

*M. radiata*, Hass (*M. furcata*).—This very local species was in Loch Aslaich.

*Staurastrum furcigerum*, Bréb.—In Loch Bran, at Foyers.

*S. longispinum* (Bail).—In Loch Aslaich and several neighbouring lochs.

*S. ophiura*, Lund.—Loch Ness and Loch Aslaich.

*S. sexangulare* (Bulu).—Loch Garth, near Foyers.

*S. brasiliense*, Nordst.—Loch Aslaich.

*Euastrum verrucosum*, Ehr., *Micrasterias papillifera*, Bréb., *Xanthidium antilopeum* (Bréb.), *Staurastrum gracile*, Rolfs, *Staurastrum lunatum*, var. *planctonicum*, West, and one of the beaked *Closteria*, which I identify as *C. setaceum*, Ehr., are the most generally distributed desmids in the basin.

*Crustacea*.—Apart from the Calanidæ, a few of the Crustacea appear to be local in the district.

*Sida crystallina*.—Only seen in Loch Ness and Loch Aslaich.

*Diaphanosoma brachyurum*.—Only noted in the lochs of the Great Glen and some lochs to the west. The eastern lochs were doubtless surveyed before its season.

*Holopedium gibberum*.—Noted in scarcely half the lochs, but those on both sides of the Glen and at all elevations.

*Leptodora* was only seen in the lochs of the Glen and Loch Tarff; *Polyphemus* in the Glen and some lochs to the west; *Bythotrephes* in the Glen and Lochs Tarff and Ruthven to the east.

*Rotifera*.—*Conochilus unicornis* was generally distributed; *C. volvox* only in Lochs Ness, Laide, and Knockie.

*Floscularia pelagica*.—Lochs Ness, Oich, and Uanagan.

*Synchaeta pectinata*.—Lochs Oich and Uanagan.

*Anopus testudo*.—Lochs Ness and Uanagan.

*Triarthra longiseta*.—In five lochs on the east side of the basin; apparently a cold-water species.

*Gastropus stylifer*.—Loch Ness and five lochs to the east, and Loch Aslaich to the west.

*Sarcodina*.—*Clathrulina* was not seen except in the lochs of the Great Glen. *Nebela bicornis*, West, though found in Loch Ness, was not got in the plankton, but while dredging in the shallow water of Inchnacardoch bay.

*Loch Ness*.—Loch Ness was made the subject of a more thorough, though still far from exhaustive, biological investigation than any other Scottish loch. A very large proportion of all the lacustrine organisms known in Scotland have been found in this loch.

The great majority of the species in all the larger groups—Crustacea, Rotifera, Sarcodina—have been got in Loch Ness, the only large group not very fully represented being the desmids. Some of the small groups have hardly been studied, except in Loch Ness, and it is the only loch the abyssal fauna of which is fairly well known.

To give any detailed account of the hundreds of species found in the loch would traverse too much the same ground as the general report on the Biology of the Scottish Lochs. There will therefore be given here simply an epitome of the biology, and a comparison with the other lochs in the Ness basin.

*The Plankton*.—The plankton is the average plankton of Scottish lakes, with a very small admixture of the more local species. It is very poor in species, and always very small in quantity. No approach to "flowering" of the water has been noted. The greatest quantity was collected in late autumn, 1903, during the night, when a considerable migration from the deeper water to the surface evidently took place, as the quantity collected during the preceding day was much less. The plankton varies little throughout the year, a fact probably correlated with the low annual range of temperature, which is less than 20°·0 Fahr., while the upper limit of about 60°·0 is rarely touched.

About half the species of Crustacea remain all the year round, those which are absent in winter being *Bythotrephes*, *Polyphemus*, *Leptodora*, and *Diaphanosoma*. *Holopedium* was noted by Mr. Scourfield, but was never found during the systematic investigation afterwards. *Diaptomus laticeps*, Sars, appears to persist all the year round, and was found carrying eggs in March, when the temperature is at its lowest. *Clathrulina* was generally present, and *Volvox* occasionally.

There is a great contrast between Loch Ness and Loch Lochy in the relative abundance of the phytoplankton. Loch Lochy is very rich,

and Loch Ness very poor. The two lochs are only some 10 miles apart, and are apparently under almost identical conditions. Loch Lochy, being in an almost uninhabited district, should be purer than Loch Ness, but a slight pollution is generally favourable to vegetable growth.

*Littoral region.*—Though there are only a few sheltered bays in Loch Ness where littoral vegetation can establish itself, the microfauna and microflora found among the larger vegetation are very considerable, and constitute, indeed, the chief part of the species in the loch.

A great many of the animals extend downwards to a very considerable depth, and about 40 species (exclusive of Rhizopods), including many Crustacea, Rotifers, Tardigrada, Worms, and the larvæ of many insects, have been collected as far down as 300 feet. Shells of all the Rhizopods extend to the greater depth, and many live at greater depths than 300 feet.

In Inchnacardoch bay Mr. Scourfield found *Ophryoxus gracilis* for the first time in Britain; and the rare *Ilyocryptus agilis*, previously known in several places in England, was got in the same locality.

*Abyssal region.*—In Loch Ness a large proportion of the littoral species extend to about 300 feet in depth, probably because of the very steeply sloping sides. Those species only are considered as truly abyssal which are generally distributed over the mud, into the deepest part of the loch. A small association of animals is found thus distributed, and the abyssal region, being defined as the bottom where this association is found almost free of admixture, must be considered to begin at about 300 feet. Exclusive of Rhizopods, there are about a dozen animals constantly found in this region, comprising—1 Mollusc, *Pisidium pusillum*, Gmel.; 3 Crustacea, *Cyclops viridis*, Jurine, *Candona candida*, Müll., and *Cypria ophthalmica*, Jurine; 3 worms, *Stylodrilus gabretæ*, Vejd., *Automolus morgiensis* (Du Plessis), and an undetermined Oligochæte; 1 insect, *Chironomus* (larva); several Infusoria, parasites on the Molluscs and Crustacea.

Several other species occur casually at great depths, such as *Hydra*, *Limnæa*, *Lynceus affinis*, and *Proales daphnicola*.

A small char, *Salmo alpinus*, was dredged at a depth of over 500 feet.

Larvæ of *Tanypus* and some other diptera are frequent, but less constant than *Chironomus*.

*Rhizopods.*—Dr. Penard has identified about 40 species and varieties from depths of more than 300 feet. They thus constitute the greater part of the species in our abyssal region, but their presence there is of little special interest, and there are only some half a dozen species and varieties which are doubtfully supposed to be peculiar to deep lakes.

*Summary of the Number of Species.*

	Species.		Species.
Mollusca ... ..	5	Dinoflagellata ... ..	3
Hydrachnida ... ..	1	Phanerogamia ... ..	33
Tardigrada ... ..	22	Equisetaceæ ... ..	1
Insects ... ..	6	Lycopodiaceæ ... ..	1
Crustacea ... ..	55	Characeæ ... ..	2
Rotifera ... ..	151	Mosses ... ..	6
Gastrotricha ... ..	2	Hepatics ... ..	2
Worms ... ..	12	Florideæ ... ..	2
Cœlenterata ... ..	2	Chlorophyceæ ... ..	46
Infusoria ... ..	11	Myxophyceæ (Report in prepara-	
Sarcodina ... ..	67	tion) ... ..	—
Mastigophora ... ..	3	Bacillariaceæ... ..	20

We have thus a total of 453 species recorded for Loch Ness, excluding all Vertebrata, blue-green Algæ, and some other groups on which no work has been done. The Hydrachnida, Insecta, Worms, Infusoria, Chlorophyceæ, and Diatoms have all been insufficiently studied, and the lists could be easily increased.

VOLUME II

PART II







## LOCHS OF THE BRORA BASIN.

WITHIN this basin (see Index Map, Fig. 1), the principal loch is Loch Brora, which was the only one surveyed. The numerous small hill-lochs could not be sounded at the time of the visit of the Lake Survey for lack of boats. The area drained by the river Brora and its tributaries is very large, extending from the mouth of the Brora, on the east coast of Sutherland, to the flanks of Ben Armine on the north and of Meall a Fhuarain on the west, and exceeding 120 square miles, nearly the whole of which drains into Loch Brora.

*Loch Brora* (see Plate I).—Loch Brora is situated about 3 miles from the shores of the North Sea at Brora, amid beautiful scenery; the Carrol Rock overlooking the central part of the loch is very steep, and forms a fine object. It contains salmon and trout. An island in the southern part of the loch (Eilean nam Faoileag) was formerly used as a stronghold, and the ruins of several Pictish towers are to be found in the neighbourhood. The loch is divided into three portions by the alluvium brought down by the streams, and the Allt Smeoral is rapidly pushing out its alluvium into the loch to form another barrier. The general trend of the loch is in a N.N.W. and S.S.E. direction, but the axis is slightly sinuous, so that the lower portion runs almost north and south, while the upper portion runs north-west and south-east. Loch Brora is over  $3\frac{1}{2}$  miles in length, with a maximum breadth towards the head of the loch of nearly half a mile, the mean breadth being less than a quarter of a mile. Its waters cover an area of about 560 acres, or nearly one square mile, and, as already stated, its drainage area is very large, nearly 140 times the area of the loch. The maximum depth of 66 feet was observed near the middle of the loch, about  $1\frac{1}{2}$  miles from the head, and about 2 miles from the foot, of the loch. The volume of water contained in the loch is estimated at 553 millions of cubic feet, and the mean depth at over  $22\frac{1}{2}$  feet. The loch was surveyed on October 22, 1902, when the elevation of the lake-surface above the sea was determined by levelling from bench-mark as being 92·9 feet; when visited by the officers of the Ordnance Survey on July 25, 1870, the elevation was found to be 91·3 feet above sea-level. The highest drift-mark observed on the date of the survey was 7·2 feet above the surface of the water, and the water may fall about 2 feet below the level on that date, giving a variation in level exceeding 9 feet.



laid down by the Allt Smeoral projects into the loch, the deepest water to the south-east being 59 feet, and to the north-east 64 feet, while on the shoaling the greatest depth observed was 50 feet. There are two 50-foot basins: the larger, in the most northerly expansion of the loch, is three-quarters of a mile in length, and the smaller, in the third expansion from the foot of the loch, is one-third of a mile in length. The areas between the contour-lines, and the percentages to the total area of the loch, are as follows:—

Feet.	Acres.	Per cent.
0 to 25	376	67·2
25 „ 50	130	23·2
over 50	54	9·6
	560	100·0

*Temperature Observations.*—Several readings at the surface on the date of the survey gave a range of  $1^{\circ}5$  Fahr., from  $44^{\circ}3$  to  $45^{\circ}8$ , and a series taken in the deepest part of the loch at 4·15 p.m., gave the following results:—

Surface	...	...	...	...	...	...	45°·8 Fahr.
10 feet	...	...	...	...	...	...	45°·8 „
20 „	...	...	...	...	...	...	46°·0 „
45 „	...	...	...	...	...	...	45°·0 „
65 „	...	...	...	...	...	...	45°·0 „

This series shows a range of only  $1^{\circ}$  from surface to bottom, while lower readings were recorded at the surface than beneath the surface, so that the body of water was evidently in process of being cooled down from the summer maximum to the winter minimum.

## LOCHS OF THE HELMSDALE BASIN.

THIS large basin extends from the shores of the North Sea at Helmsdale to the flanks of Ceann Garbh and Cnoc nan Tri-Clach on the north, and of Creag na h-Iolaire and Ben Armine on the west, the total area being about 220 square miles. The ten lochs within this basin that were sounded by the Lake Survey Staff, viz., Lochs an Ruathair, Coire nam Meann, Leum a' Chlamhain, Araich-Lin, Truid air Sgithiche, nan Cuinne, a' Chlàir, Baddanloch, Allt an Fhearna, and na Moine, all lie towards the headwaters of the basin, while the river Helmsdale, after leaving the lochs, flows through a large tract of country before reaching the sea, and with its many tributaries drains the larger portion of the basin. The area draining into the lochs under consideration is about 82 square miles, as will be seen from the summary table, while the area draining into the river Helmsdale irrespective of these lochs is about 138 square miles. In this respect the Helmsdale basin contrasts strongly with the Brora basin, where the river Brora, after leaving Loch Brora, drains a very small area—not more than 3 square miles. The loch nearest the source of the river Helmsdale is Loch an Ruathair, the stream issuing from which, on being joined about a mile from the loch by the Knockfin river, receives the name of Helmsdale. A short distance seawards the river Helmsdale is joined by the Claggan Burn, bearing the overflow from Lochs Coire nam Meann, Leum a' Chlamhain, and Araich-Lin, and still a little farther on it is joined by the Allt Ach' na h-Uai', bearing the overflow from the remaining lochs in the basin already mentioned.

This series of lochs is interesting on account of the variation in their outlines, most of them departing from the usual long and narrow form characteristic of Scottish lochs, while one of them is almost circular in outline.

*Loch an Ruathair* (see Plate II).—Loch an Ruathair (or Loch-an-Ruar) is situated close to the Highland Railway line between Kinbrace and Forsinard stations. It is a good fishing loch, containing trout and char, amid pretty surroundings, with Creag Sail a' Blàthaich (1139 feet), and Meall a' Blùirich (1331 feet), rising off the north-western shore, overshadowed by the peaks of Ben Griam Mhòr and Ben Griam Bheag, which attain an elevation of nearly 2000 feet, farther distant in the same direction, while to the south-east the Knockfin heights exceed 1400 feet.

The trend of the loch is almost north and south, the outline being somewhat oblong. The loch exceeds  $1\frac{1}{2}$  miles in length, with a maximum breadth of over three-quarters of a mile, the mean breadth being over half a mile. It is thus a very wide loch in relation to the length, the greatest width being one-half, and the average width one-third, of the length. Its waters cover an area of about 523 acres (over three-quarters of a square mile), and it drains an area fourteen times greater, an area of  $11\frac{1}{4}$  square miles. Seventy soundings were taken, the maximum depth of 26 feet being observed towards the southern end and nearer the western shore. The volume of water contained in the loch is estimated at 304 million cubic feet, and the mean depth at  $13\frac{1}{3}$  feet, or one-half of the maximum depth. The loch was surveyed on October 3, 1902, when the elevation of the lake-surface was found to be 414·8 feet above the sea; when levelled by the officers of the Ordnance Survey on July 28, 1869, the elevation was nearly identical: 414·5 feet above sea-level.

Loch an Ruathair is a comparatively shallow and flat-bottomed basin. The 10-foot contour-line coincides approximately with the outline of the loch, but the area enclosed by the 20-foot contour is peculiar in form, consisting of a main body situated in the southern portion of the loch, sending out two prolongations in a northerly direction. These prolongations approach the eastern and western shores respectively, while the central parts in the northern half of the loch are occupied by slightly shallower water. The deepest sounding of 26 feet was taken in the centre of the main body of deep water above referred to, about one-third of a mile from the southern end of the loch. The slope of the bottom is moderately steep off the western shore near the southern end, where soundings of 10 and 12 feet were recorded about 100 feet off-shore, but elsewhere the soundings indicate a very gentle slope. The flat-bottomed character of the loch as a whole is shown by the following table, giving the areas between the contour-lines, and the percentages to the total area:—

Feet.				Acres.		Per cent.
0 to 10	...	...	...	169	...	32
10 „ 20	...	...	...	251	...	48
over 20	...	...	...	103	...	20
				523		100

A series of temperatures taken in the afternoon of October 3, 1902, gave identical readings at the surface, at 10 feet, and at 18 feet, viz.  $53^{\circ}0$  Fahr.

*Loch Coire nam Meann* (see Plate II).—Loch Coire nam Meann (or Coire nam Mang) lies about 4 miles to the north-west of Loch an Ruathair, at the foot of Ben Griam Mhòr. It is a good fishing loch, the trout being very large, but is preserved. This loch is nearly circular in outline, with a maximum diameter of over half a mile, covering an area

of about 120 acres, and receiving the drainage from an area of three quarters of a square mile. Its superfluent water is carried by a short stream into the neighbouring Loch Leum a' Chlamhain, lying less than a quarter of a mile to the east. The maximum depth of 33 feet was observed comparatively close to the south-eastern shore. The volume of water is estimated at 60 million cubic feet, and the mean depth at  $11\frac{1}{2}$  feet. The loch was surveyed on October 20, 1902, but the elevation above the sea could not be determined; when visited by the officers of the Ordnance Survey on June 10, 1870, the elevation was found to be 800.5 feet above sea-level.

Loch Coire nam Meann forms a simple basin, but the north-western portion is comparatively shallow, the deeper water occurring in the south-eastern portion, the deepest sounding having been recorded less than 200 yards from that shore. The deep water, however, is of limited extent, for only 15 per cent. of the lake-floor is covered by more than 20 feet of water, while about one half of the lake-bottom is covered by less than 10 feet of water, as shown in the following table:—

Feet.	Acres.	Per cent.
0 to 10	58	49
10 „ 20	48	36
over 20	18	15
	119	100

The temperature of the surface water at 3 p.m. on October 20, 1902, was 45°.0 Fahr.

*Loch Leum a' Chlamhain* (see Plate II.).—Loch Leum a' Chlamhain (or (Leum-na-Clavan, or Leum-a-Chamblain) is a fine fishing loch, like its neighbour Loch Coire nam Meann, famous for the large size of its trout and for the heavy baskets frequently recorded; like its neighbour also it is strictly preserved. Ben Griam Mhòr lies to the south, and Ben Griam Bheag to the east. The outflowing water is carried by the Allt Airidh-dhamh into Loch Araich-Lin. The loch trends nearly north and south, and is  $1\frac{2}{3}$  miles in length. It varies greatly in width, with a constriction in the central part, the maximum breadth exceeding half a mile towards the northern end of the loch, the mean breadth being one-third of a mile. Its waters cover an area of about 350 acres, or over half a square mile, and it drains directly an area of nearly four square miles, but since it receives the outflow from Loch Coire nam Meann its total drainage area is about  $4\frac{3}{4}$  square miles. The maximum depth of 51 feet was observed near the southern end of the loch, while towards the northern end a depth of 50 feet was recorded. The volume of water is estimated at 298 million cubic feet, and the mean depth at  $19\frac{1}{2}$  feet. The loch was surveyed on October 20, 1902, but the elevation above the sea could not be determined; when levelled by the Ordnance Survey

officers on June 10, 1870, the elevation of the lake-surface was found to be 770·0 feet above sea-level.

Loch Leum a' Chlamhain consists of two deep basins placed respectively towards the two ends of the loch, separated by shallower water near the central part of the loch. The separation does not, however, coincide with the narrowest part of the loch, in which a depth of 30 feet was found, but occurs farther to the south, where the greatest depth recorded was 24 feet. The 10-foot and 20-foot contour-lines enclose continuous areas, but the deeper contours enclose the two deep basins referred to. The smaller but deeper basin lies near the southern end of the loch, the deepest sounding of 51 feet having been recorded about 350 yards from the southern shore, while the larger basin lies towards the northern end, the greatest depth therein (50 feet) having been recorded about 600 yards from the northern shore. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

Feet.				Acres.		Per cent.
0 to 25	...	...	...	254	...	72·7
25 ,, 50	...	...	...	90	...	25·7
over 50	...	...	...	6	...	1·6
				350		100·0

Temperature observations on the date of the survey gave identical readings of 46°·0 Fahr. at the surface, at 10 feet, at 20 feet, and at 40 feet.

*Loch Araich-Lin* (see Plate II.).—Loch Araich-Lin (or Arichlinie or Ari-cliny) is situated about three-quarters of a mile to the south-west of Loch an Ruathair, and about  $3\frac{1}{2}$  miles to the south-east of Loch Leum a' Chlamhain. It contains trout and char, but the fishing is preserved. It is a shallow lake, trending nearly north and south, and three-quarters of a mile in length by one-third of a mile in maximum breadth, while the mean breadth is a quarter of a mile. Its waters cover an area of about 117 acres, and it drains directly an area exceeding 10 square miles, but since it receives the outflow from Lochs Leum a' Chlamhain and Coire nam Meann, its total drainage area is about 15 square miles—an area eighty times greater than that of the loch. The maximum depth of 7 feet was observed in several places in the southern portion of the loch and along the eastern shore. The volume of water is estimated at 23 million cubic feet, and the mean depth at  $4\frac{1}{2}$  feet. The loch was surveyed on October 3, 1902, when the elevation of the lake-surface was found by levelling from bench-mark to be 451·8 feet above the sea; when visited by the Ordnance Survey officers on July 27, 1869, the elevation was 451·4 feet above sea-level. The highest drift-mark observed on the date of the survey was about  $3\frac{1}{2}$  feet above the surface of the water, and the local boatman stated that the water might fall about  $1\frac{1}{2}$  feet, giving a range in level of about 5 feet.

Loch Araich-Lin is a shallow flat-bottomed basin, apparently in process of being silted up. Along the western shore the water is shallower

than along the opposite shore, and at the mouths of the inflowing streams banks of alluvium are being laid down. The majority of the soundings gave depths of 5, 6, and 7 feet, the area of the lake-floor covered by more than 5 feet of water being about 65 acres, or 56 per cent. of the total area of the loch. The temperature of the surface water at 11.30 a.m. on October 3, 1902, was 50°·8 Fahr.

*Loch Truid air Sgithiche* (see Plate II.).—Loch Truid air Sgithiche (or Truderscaig) lies at the base of Ben Armine, amid beautiful surroundings, about 9 miles from Kinbrace station, on the Highland Railway. It is a splendid trout loch, but the fishing is preserved. In outline it is triangular, with the apex pointing in a north-east direction. The outflowing stream, the Allt an Lòin Tharsuinn leaves the loch at the apex of the triangle, and flows into Loch nan Cuinne lying about a mile to the north-east. Loch Truid air Sgithiche is nearly a mile in length, with a maximum width of nearly two-thirds of a mile, the mean breadth being one-third of a mile. Its waters cover an area of about 186 acres, and it drains an area of about 8 square miles. The maximum depth of 12 feet was observed about halfway down the loch, but towards the eastern shore. The volume of water is estimated at 47 million cubic feet, and the mean depth at rather less than 6 feet. The loch was surveyed on October 18, 1902, but the elevation above the sea could not be determined; when levelled by the officers of the Ordnance Survey on August 23, 1870, the elevation of the lake-surface was 425·9 feet above sea-level. The boatman stated that the water might rise about a foot above, and fall a foot below, the level on the date of the survey.

Loch Truid air Sgithiche is on the whole shallow and flat-bottomed, with weeds growing in the western angle of the loch. Only four of the soundings gave depths exceeding 10 feet, and these lie towards the eastern shore, the deepest sounding in 12 feet having being recorded about 200 yards from that shore. The majority of the soundings were taken in depths between 5 and 10 feet, as is borne out by the following table showing the areas between the contour-lines and the percentages to the total area of the loch:—

Feet.				Acres.		Per cent.
0 to 5	...	...	...	72	...	38·5
5 „ 10	...	...	...	101	...	54·3
over 10	...	...	...	13	...	7·2
				186	...	100·0

The temperature of the surface water at 1 p.m. on October 18, 1902, was 44°·5 Fahr.

*Loch nan Cuinne* (see Plate II.).—Loch nan Cuinne (or nan Cuidhean, or na-Cuin, known locally as Rimsdale Loch) is closely connected with Loch a' Chlàir and Loch Baddanloch, the outflow from Loch nan Cuinne

being carried into Loch a' Chlàir by a stream, Uidh Bheag, less than 100 yards in length, the difference in the level of the two lochs being only half a foot. It is a good trout loch, but the fishing is preserved. The island shown on the Ordnance Survey map in the central part of the loch, near the southern end, was indicated by only a few reeds at the time of the survey. Loch nan Cuinne is a large but comparatively shallow loch, trending north and south, and 3 miles in length. It varies greatly in width, the northern portion being very narrow, while in the central portion at the outflow the loch widens out and attains a maximum breadth exceeding three-quarters of a mile; the mean breadth is over one-third of a mile. Its waters cover an area of about 734 acres, or considerably more than 1 square mile, and it drains directly an area of over 22 square miles, but since it receives the outflow from Loch Truid air Sgithiche, its total drainage area exceeds 30 square miles. The maximum depth of 28 feet was observed in the wide central part of the loch, but nearer the eastern than the western shore. The volume of water is estimated at 396 million cubic feet, and the mean depth at nearly  $12\frac{1}{2}$  feet. The loch was surveyed on October 18, 1902, when the elevation of the lake-surface was found to be 395.0 feet above the sea, and 6 inches higher than Lochs a' Chlàir and Baddanloch.

Loch nan Cuinne is simple in conformation. The 10-foot area is continuous from end to end, though the contour-line is here and there of a sinuous character, with a shallow patch round the island near the southern end, while the 20-foot area occupies the wide central portion of the loch, and is nearly a mile in length. The deepest sounding in 28 feet was taken about 300 yards from the eastern shore. The areas between the contour-lines, and the percentages to the total area of the loch, are as follows:—

Feet.	Acres.	Per cent.
0 to 10	299	40.7
10 „ 20	317	43.2
over 20	118	16.1
	<hr/> 734	<hr/> 100.0

Temperature observations taken at 3 p.m. on the date of the survey gave  $46^{\circ}.5$  Fahr. at the surface and at a depth of 10 feet, while a reading at 20 feet gave  $47^{\circ}.0$ .

*Loch a' Chlàir* (see Plate II.).—Loch a' Chlàir (or nan Clar) is continuous with Loch Baddanloch, the passage between them being about 200 yards across and having a depth of 5 feet. The entire sheet of water trends in a north-west and south-east direction, and is  $3\frac{1}{4}$  miles in length, covering an area exceeding 2 square miles. The fishing, both trout and char, is preserved, and the surroundings very fine, several lofty peaks being visible, including Morven to the south-east, Ben Griam to the north-east, Ben Armine and Ben Klibreck to the south-west, Ben Hee to the west, and Ben Hope and Ben Loyal to the north-west. Loch a' Chlàir is somewhat

crescent-shaped, with the concave side to the south; the length from east to west exceeds  $1\frac{1}{2}$  miles, the maximum width in a north and south direction being  $1\frac{1}{3}$  miles, while the mean breadth is over three-quarters of a mile. Its waters cover an area of about 750 acres (or considerably over 1 square mile), and it drains directly an area of 13 square miles, but, since it receives the outflow from Lochs nan Cuinne and Truid air Sgithiche, its total drainage area is about  $43\frac{1}{4}$  square miles—an area 37 times greater than that of the loch. The maximum depth of 32 feet was observed approximately midway between the eastern and western shores, but much nearer the southern than the northern shore. The volume of water is estimated at 446 million cubic feet, and the mean depth at over  $13\frac{1}{2}$  feet. The loch was surveyed on October 17, 1902, when the level of the surface water was found to be 394·5 feet above the sea; when visited by the Ordnance Surveyors on July 22, 1869, the elevation of the lake-surface was 392·2 feet above sea-level.

Loch a' Chlàir forms a simple basin; the 10-foot contour-line coincides approximately with the outline of the loch, but the deeper contours approach more nearly to the southern shore, the deepest sounding in 32 feet having been taken about 350 yards from that shore. The area of the lake-floor covered by less than 10 feet of water is about 265 acres, or 35 per cent. of the total area of the loch, while the area covered by more than 25 feet of water is about 38 acres, or 5 per cent. The temperature of the surface water on the date of the survey was  $47^{\circ}\cdot 2$  Fahr., while readings at 10 feet and at 25 feet gave  $47^{\circ}\cdot 0$ .

*Loch Baddanloch* (see Plate II.).—Loch Baddanloch (or Badenloch, or Baden) is nearly  $1\frac{3}{4}$  miles in length from north-west to south-east, having a maximum width at the northern end of nearly a mile, narrowing gradually towards the opposite end, the mean breadth exceeding half a mile. Its waters cover an area of about 634 acres, or 1 square mile, and it drains directly an area of 6 square miles, but since it receives the outflow from Lochs Truid air Sgithiche, nan Cuinne, and a' Chlàir, as well as from Loch Allt an Fhearna, next to be considered, its total drainage area is over  $51\frac{1}{3}$  square miles. The maximum depth of 42 feet was observed about halfway down the loch, but rather nearer the south-western than the north-eastern shore. The volume of water is estimated at 479 million cubic feet, and the mean depth at  $17\frac{1}{3}$  feet. The loch was surveyed on October 15, 1902; the elevation is, of course, identical with that of Loch à Chlàir. It may be noted that in the interval of two days between the surveys of the two lochs, the water rose to the extent of 2 feet, but the soundings laid down on the maps have been referred to the same datum level.

Loch Baddanloch is simple in conformation, with few minor undulations of the lake-floor. The 10-foot contour agrees with the course of the shoreline, and the deeper contours are approximately centrally placed. The

deepest sounding in 42 feet was taken about 400 yards from the south-western shore. The area covered by less than 10 feet of water is about 154 acres, or 24 per cent. of the total area of the loch, while the area covered by more than 25 feet of water is about 113 acres, or 18 per cent. Temperature observations on the date of the survey gave identical readings at the surface, at 10 feet, and at 25 feet, viz. 48°·0 Fahr.

*Loch Allt an Fheàrna* (see Plate II.).—Loch Allt an Fheàrna (or Loch an Alltain Fhearna, or Loch Alt-an-Fearn) lies about half a mile to the west of Loch Baddanloch, into which it flows by the Uidh a' Chlàrain. It is pear-shaped, narrowing from the south-east towards the north-west, and is nearly a mile in length, with a maximum width of over half a mile, the mean breadth exceeding one-third of a mile. Its waters cover an area of about 212 acres, or one-third of a square mile, and it drains an area of 2 square miles. The maximum depth of 36 feet was observed approximately in the centre of the wide part of the loch, that is to say, nearer the south-eastern than the north-western end. The volume of water is estimated at 132 million cubic feet, and the mean depth at  $14\frac{1}{3}$  feet. The loch was surveyed on October 18, 1902, but the elevation of the lake-surface could not be determined; when visited by the officers of the Ordnance Survey on December 3, 1870, the elevation of the lake-surface was found to be 432·6 feet above the sea. A drift-mark was observed 1 foot above the water on the date of the survey.

Loch Allt an Fheàrna is quite simple in conformation, the bottom sloping down on all sides towards the deepest part, which lies in the south-eastern part of the loch, the deepest sounding in 36 feet having been taken about 450 yards from the south-eastern shore. The slope of the bottom is on the whole steeper off shore than in the deeper water, as is shown in the following table giving the areas between the consecutive contour-lines, and the percentages to the total area of the loch:—

Feet.				Acres.		Per cent.
0 to 10	...	...	...	68	...	32
10 „ 20	...	...	...	99	...	47
20 „ 30	...	...	...	34	...	16
Over 30	...	...	...	11	...	5
				212		100

Temperature observations taken in the deepest part of the loch at 2.30 p.m. on October 18, 1902, gave identical readings at the surface, at 17 feet, and at 34 feet, viz. 46°·0 Fahr.

*Loch na Moine* (see Plate II.).—Loch na Moine (or Achnamoine) lies about  $2\frac{1}{2}$  miles from Kinbrace station on the Highland Railway, and about  $1\frac{1}{2}$  miles to the south-east of Loch Baddanloch, the overflow from which is carried into it by the An Ei' Mhor. It is a small shallow loch, remarkable

## SUMMARY TABLE.

Giving Details concerning the Lochs lying in the Brora and Helmsdale Basins.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. Feet.	Mean. Feet.	Mean per cent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
Brora ... ..	92.9	159	3.53	0.49	0.22	6.2	66	22.68	34.4	282	822	553	0.88	120.84	188.1
an Ruathair ... ..	414.8	71	1.54	0.79	0.53	34.4	26	13.34	51.3	313	614	304	0.82	11.24	13.7
Coire nam Meann ... ..	800.5	18	0.54	0.51	0.33	61.1	33	11.60	35.2	86	246	60	0.19	0.78	4.2
Leum a' Chlamhain	[June 10, 1870] 770.0	49	1.62	0.55	0.34	21.0	51	19.54	38.3	168	438	298	0.55	4.71	8.5
Araich-Lin ... ..	451.8	50	0.75	0.32	0.24	32.5	7	4.45	63.6	566	890	23	0.18	15.03	82.1
Truid air Sgithiche	425.9	46	0.84	0.60	0.34	40.5	12	5.83	48.6	370	761	47	0.29	7.97	27.5
nan Cuinne ... ..	[Aug. 23, 1870] 395.0	100	3.00	0.78	0.38	12.7	28	12.88	44.2	566	1280	396	1.15	30.17	26.2
a' Chhàir ... ..	394.5	59	1.53	1.32	0.77	50.0	32	13.65	42.7	252	592	446	1.17	43.24	37.0
Baddanloch ... ..	394.5	72	1.70	0.96	0.58	34.1	42	17.33	41.5	214	518	479	0.99	51.35	51.9
Allt an Fhearna ... ..	432.6	36	0.88	0.59	0.38	42.7	36	14.31	39.7	129	325	132	0.33	2.06	6.2
na Moine ... ..	[Dec. 3, 1870] 376.6	40	0.83	0.23	0.17	20.5	8	4.61	57.7	548	951	18	0.14	55.78	398.4
	[July 19, 1869]	700										2756	6.69	202.89*	30.4

\* The drainage area of Loch Araich-Lin includes the area draining into Lochs Coire nam Meann and Leum a' Chlamhain; that of Loch na Moine includes the area draining into Lochs Truid air Sgithiche, nan Cuinne, a' Chhàir, Baddanloch and Allt an Fhearna.

on account of the large area draining into it—an area 400 times greater than that of the loch. The fishing includes both salmon and trout, but is preserved. The loch trends in a west-north-west and east-south-east direction, and is nearly a mile in length, with a maximum breadth of a quarter of a mile. Its waters cover an area of about 88 acres, and it drains directly an area of about  $4\frac{1}{2}$  square miles, but since it receives the overflow from Lochs Baddanloch, Allt an Fheàrna, a' Chlàir, nan Cuinne, and Truid air Sgithiche, its total drainage area exceeds  $55\frac{3}{4}$  square miles. The maximum depth of 8 feet was observed approximately in the centre of the loch. The volume of water is estimated at 18 million cubic feet, and the mean depth at over  $4\frac{1}{2}$  feet. The loch was surveyed on October 14, 1902, but the elevation of the lake-surface could not be determined; when levelled by the Ordnance Survey officers on July 19, 1869, the elevation was found to be 376.6 feet above the level of the sea. Loch na Moine is quite simple in conformation, the water deepening gradually on all sides towards the centre, with weeds growing along the south-western shore and many stones in the narrow portion at the south-eastern (outflow) end. The flat-bottomed character of the basin is shown by the fact that an area of about  $46\frac{1}{2}$  acres, or 53 per cent. of the total area of the loch, is covered by more than 5 feet of water.

Temperatures taken at 1 p.m. on the date of the survey gave identical readings ( $48^{\circ}0$  Fahr.) at the surface and at a depth of 6 feet.

In the eleven lochs in the Brora and Helmsdale basins, as shown in the opposite table, 700 soundings were taken, and the aggregate area of the water-surface is 6.69 square miles, so that the average number of soundings per square-mile of surface is 104.

The aggregate volume of water contained in the lochs is estimated at 2756 millions of cubic feet. The area drained by these lochs is about 203 square miles, or over thirty times the area of the lochs.

## LOCHS OF THE WICK BASIN.

THERE are three lochs within this basin which were sounded by the Lake Survey, viz. Lochs Scarmclate, Watten, and Hempriggs; there were no boats on the few smaller lochs, of which the most important are the Loch of Toftingall, lying to the south-west of Loch Watten, and the Loch of Yarehouse, lying to the south-west of Loch Hempriggs. The basin is a fairly large one, extending from Wick bay on the east coast of Caithness to Sordal hill on the north-west, and to Stemster hill on the south-west, the larger portion being drained by the Wick water and its tributaries independently of the lochs under consideration. The outflow from Loch Scarmclate is carried by the Quoynee burn into Loch Watten, thence into the sea at Wick by the Wick water, which is joined a short distance from the head of Wick bay by the burn of Newton, bearing the outflow from Loch Hempriggs. The lochs are characterized by their shallowness, although one of them (Loch Watten) covers a larger superficial area than any other of the Caithness lochs; they contain trout, but the fishing is preserved.

*Loch Scarmclate* (see Plate III).—Loch Scarmclate (or Scarmclett, or Stemster) is situated about 7 miles to the south-east of Thurso, and over a mile to the north-west of Loch Watten, surrounded by cultivated land, the margins of the loch being swampy and reedy. The loch is somewhat triangular in outline, with the apex pointing to the south-east, and nearly a mile in length, with a maximum breadth exceeding half a mile. The superficial area is about 190 acres, or less than one-third of a square mile, and the drainage area about 7 square miles. The floor of the loch is practically uniform in depth, about one-half of the soundings being taken in 5 feet of water, which was the maximum depth observed. The volume of water is estimated at 21 million cubic feet, and the mean depth at half the maximum depth. The loch was surveyed on October 7, 1902, and the elevation of the lake-surface above the sea was determined as being 89.5 feet, which is half a foot higher than the elevation determined by the officers of the Ordnance Survey on February 28, 1871, viz. 89.1 feet. The water in the loch was high on the date of the survey, and a drift-mark was observed about a foot above the surface of the water, but the range in level is apparently very small. The deposits covering the lake-floor are brown muds, except over a small area to the south of the island,

where the deposit is white and calcareous, and it was a regular practice some few years ago to dredge the loch to the south of the island, and to use the mud for marling the land.

*Loch Watten* (see Plate III.).—Loch Watten, the largest of the Caithness lochs, is situated about midway between Wick and Thurso, the railway between those places running along its northern shore, and the main road skirting its southern shore. The loch trends in a north-west and south-east direction, with a slight sinuosity in the outline, the upper portion being narrower than the main body of the loch, and bending in a northerly direction. It is 3 miles in length, with a maximum breadth towards the lower end of three-quarters of a mile, the mean breadth being about half a mile. Its waters cover an area of about 930 acres, or about  $1\frac{1}{2}$  square miles, and it drains directly an area of over 13 square miles, but since it receives the overflow from Loch Scarmclate its total drainage area is about  $20\frac{1}{4}$  square miles. The maximum depth observed was 12 feet, and no fewer than thirty-six soundings were taken at this depth in the south-eastern half of the loch. The volume of water is estimated at 341 million cubic feet, and the mean depth at  $8\frac{1}{3}$  feet. The loch was surveyed on October 8 and 9, 1902, when the elevation of the lake-surface was found to be 54·9 feet above the sea; when levelled by the officers of the Ordnance Survey on December 28, 1869, the elevation was 55·4 feet above sea-level. According to the miller at Watten, the wind sometimes perceptibly affected the level of the water, and after an easterly wind had been blowing strongly for some time it was impossible for him to work the mill, the water being driven before the wind and piled up at the north-west end. The water might rise 2 feet above, and fall 1 foot below, the level on the date of the survey.

Loch Watten may be described as a large, shallow, flat-bottomed basin, the deeper portion lying towards the south-eastern end, the water shoaling more gradually on proceeding towards the north-western end. The great majority of the soundings were taken in depths exceeding 5 feet, and more than one half of the lake-floor is covered by more than 10 feet of water. The mean depth of the entire basin is 70 per cent. of the maximum depth. The temperature of the surface water at 10 a.m. on October 8, 1902, was 49°·9 Fahr., and at 10 a.m. on October 9, the surface temperature was 49°·6, while a reading at 12 feet gave 49°·5.

*Loch Hempriggs* (see Plate III.).—Loch Hempriggs lies about 2 miles to the south-west of the town of Wick, and within a mile of the shores of the North Sea, though the outflowing stream pursues a long and devious course in a northerly direction before joining the Wick water on its way to the sea. The loch is irregularly subcircular in outline, and the maximum diameter from north to south and from east to west is in each case about three-quarters of a mile. The superficial area is about

217 acres, or one-third of a square mile, and the drainage area is nearly  $9\frac{1}{2}$  square miles. The maximum depth of 8 feet was recorded at six soundings in the northern half of the loch. The volume of water is estimated at 49 million cubic feet, and the mean depth at  $5\frac{1}{4}$  feet. The loch was surveyed on October 10, 1902, when the elevation of the lake-surface was found by levelling from bench-mark to be 153.7 feet above the sea; when visited by the Ordnance Survey officers on February 18, 1870, the elevation was 155.5 feet above sea-level. The height of the water is regulated by a sluice, and the cracked peaty soil at the margin, with boulders covered by a luxuriant growth of *Fontinalis*, indicated a very recent fall of about 2 feet from a former long-maintained level.

Like the other lochs in this locality, Loch Hempriggs is a shallow, flat-bottomed basin, over two-thirds of the lake-floor being covered by more than 5 feet of water, and the mean depth of the entire loch is about 65 per cent. of the maximum depth. The temperature of the surface water on the date of the survey was  $48^{\circ}.9$  Fahr., while readings at depths of 3 feet and 7 feet gave in each case  $48^{\circ}.5$ .

## LOCHS WESTER, HEILEN, AND ST. JOHN'S.

THESE three lochs apparently drain into the sea by separate streams. An inspection of the Ordnance Survey maps on the 6-inch and 1-inch scales would lead one to suppose that the outflow from Loch Heilen was carried into the Loch of Wester by the Burn of Reaster and the Burn of Lyth, but Mr. Garrett, who assisted in the survey, states that Loch Heilen drains out to the north, so that the draining stream is the Burn of Inkstack, which in its northward course passes close to St. John's Loch.

*Loch of Wester* (see Plate IV.).—The Loch of Wester lies little more than half a mile from the sea at Sinclair's Bay, Moray Firth, and only 6 feet above sea-level. The water of Wester carrying the outflow from the loch is about a mile in length, and when the tide is out there is no perceptible current in the river. Ordinary spring tides flow as far as Bridge of Wester, less than a quarter of a mile from the loch, while high spring tides are said to carry seaweed right up to the head of the loch, and to make the water salt for a time; a recent tidal drift-mark was observed 2 feet above the level of the water on the date of the survey. The loch contains sea-trout and loch-trout, but the fishing is preserved. The trend of the loch is north-west and south-east, and the length 1 mile, while the superficial area is about 110 acres, and the drainage area comparatively large, about  $29\frac{1}{2}$  square miles. The loch is extremely shallow, the maximum depth of 3 feet occurring in various places throughout the loch; the river between the loch and Bridge of Wester was found to be deeper than anything observed in the loch. The Loch of Wester was surveyed on October 11, 1902, when the temperature of the surface water was  $44^{\circ}3$  Fahr.; a reading at 3 feet gave  $44^{\circ}1$ .

*Loch Heilen* (see Plate V.).—Loch Heilen (or Loch of Hailan) is a small shallow loch lying in cultivated land, surrounded by reeds, about 2 miles to the east of Dunnet Bay on the north coast of Scotland, and about 8 miles from Thurso. Duck and other wild fowl are very abundant. The loch trends in an east and west direction, and is somewhat crescent-shaped in outline. The length is over  $1\frac{1}{2}$  miles, and the maximum breadth nearly half a mile, the superficial area being about 191 acres, or nearly one-third of a square mile. Several soundings in 5 feet of water (the maximum depth observed) were taken in the central part of the loch.

The volume of water is estimated at 21 million cubic feet, and the mean depth at one-half the maximum depth. The loch was surveyed on October 11, 1902, when the elevation of the lake-surface was found to be 112·8 feet above the sea, which is almost identical with the elevation determined by the officers of the Ordnance Survey on December 12, 1870, viz. 112·9 feet above sea-level. The surface temperature on the date of the survey was 46°·0 Fahr.

*St. John's Loch* (see Plate V.).—*St. John's Loch* lies a little over half a mile to the north-east of Dunnet Bay, into which its overflow is carried by the Burn of Dunnet. It is a small shallow loch; the western end is stony, and here many shells of lamellibranchs and gasteropods were found on the shore, having been thrown up by the wind. The loch is subcircular in outline, with a maximum diameter from east to west of less than a mile, the maximum breadth from north to south exceeding half a mile, its waters covering an area of about 195 acres, or nearly one-third of a square mile. The maximum depth of 7 feet was observed in the south-eastern part of the loch. The volume of water is estimated at 38 million cubic feet, and the mean depth at 4½ feet. The loch was surveyed on October 10, 1902, when the elevation of the lake-surface was found to be 71·3 feet above the sea; when levelled by the officers of the Ordnance Survey on February 4, 1871, the elevation was 72·1 feet above sea-level. The highest drift-mark observed was a foot above the level of the water on the date of the survey, and it was stated that the water might fall to the extent of 1½ feet.

*St. John's Loch* is a shallow flat-bottomed basin, the deep water occupying the eastern half of the loch, the deepest cast in 7 feet having been taken about 100 yards from the southern shore and less than 400 yards from the eastern end. The area of the lake-floor covered by more than 5 feet of water is about 114 acres, or 58 per cent. of the total area. The temperature of the surface water on the date of the survey was 46°·4 Fahr.

## LOCHS OF THE THURSO BASIN.

TOWARDS the headwaters of the river Thurso there are several small lochs, the most important being Loch More, which was the only one sounded by the Lake Survey. This loch, which must not be confounded with the larger Loch More in Sutherlandshire, is famous for its salmon and trout fishing; the large area of country draining into it is a striking characteristic.

*Loch More* (see Plate VI.).—Loch More lies about 13 miles to the south of Thurso, the overflow from the loch being carried by the river Thurso, after a long and devious course, into Thurso bay. The loch is irregularly subcircular in outline, with a maximum diameter in a north and south direction of less than a mile, the mean breadth being one-third of a mile. The superficial area is about 177 acres, or a quarter of a square mile, and the area draining into it is about  $67\frac{1}{2}$  square miles—an area 240 times greater than that of the loch. The maximum depth of 7 feet was observed near the eastern shore, off the mouth of the outflowing river. The volume of water is estimated at 32 million cubic feet, and the mean depth at 4 feet. The loch was surveyed on October 9, 1902, when the elevation of the lake-surface above the sea was found by levelling from bench-mark to be 381·4 feet; when levelled by the officers of the Ordnance Survey in July, 1870, the elevation was 381·0 feet above sea-level.

Like most of the Caithness lochs, Loch More is a shallow, flat-bottomed basin. Most of the soundings were taken in depths of 5 and 6 feet; the deepest cast in 7 feet was taken about 100 yards from the eastern shore where the river Thurso flows out, while along the southern and northern shores the bottom is being silted up by the deposition of material laid down by the Strathmore water and the Sleach water. The area of the lake-floor covered by less than 5 feet of water is about 92 acres, or 52 per cent. of the total area of the loch. On the date of the survey, temperature observations gave  $46^{\circ}\cdot 0$  Fahr. at the surface and at a depth of 3 feet, while a reading at 6 feet gave  $45^{\circ}\cdot 8$ .

## LOCHS OF THE FORSS BASIN.

THE Lake Survey staff sounded the two principal lochs within this basin, viz. Lochs Calder and Shurrery. The few smaller lochs—of which the most important are Loch Olginney flowing into Loch Calder, and Loch Chaluim flowing into Loch Shurrery—could not be surveyed for lack of boats. The headwaters of the basin take their rise on the flanks of Beinn nam Bad Mhor and Cnoc an Fhuarain Bhain, flowing by the Cnocglass or Torran water into Loch Shurrery, from which issues the Forss water, which on its way to the sea is joined by the Alltan Ghuinne, bearing the overflow from Loch Calder. Like most of the Caithness lochs, Loch Shurrery is shallow, while Loch Calder is important both on account of its depth, and because it is the source of the water-supply to the town of Thurso. The fishing in both lochs is good, though preserved; salmon and trout being got in Loch Shurrery, and trout and char in Loch Calder.

*Loch Shurrery* (see Plate VII.).—Loch Shurrery lies about 8 miles from Thurso and 7 miles from Reay, on the north coast of Caithness. The loch trends in a north and south direction, and is  $1\frac{1}{4}$  miles in length, the maximum width being less than half a mile. Its waters cover an area of about 228 acres, or over one-third of a square mile, and it drains an area of 29 square miles. The maximum depth of 7 feet was observed in two places—near the middle of the loch towards the eastern shore, and near the foot of the loch towards the western shore. The volume of water is estimated at 43 million cubic feet, and the mean depth at  $4\frac{1}{3}$  feet. The loch was surveyed on October 6, 1902, when the elevation of the lake-surface was found to be 321.45 feet above the sea; when levelled by the Ordnance Survey officers on June 4, 1870, the elevation was 321.1 feet above sea-level. Loch Shurrery is a shallow, flat-bottomed basin, the majority of the soundings having been taken in depths of 5 and 6 feet, while three soundings were taken at the maximum depth of 7 feet—two near the centre and one near the northern end, as already indicated. The area of the lake-floor covered by more than 5 feet of water is about 121 acres, or 53 per cent. of the total area of the loch. The temperature of the surface water towards the southern end was 50°0 Fahr., while towards the northern end readings at the surface and at a depth of 3 feet gave 49°5, and a reading at 5 feet gave 49°2.

*Loch Calder* (see Plate VII.).—Loch Calder lies about 5 miles to the south-west of Thurso. It is a large loch, distinguished from the other Caithness lochs visited by the Lake Survey by its great depth. At the time of the survey green algæ abounded in the water, and gulls and other birds were very numerous. The loch trends in a north-west and south-east direction, and is  $2\frac{1}{3}$  miles in length. The southern portion is narrow and shallow, while the northern portion is much wider and deeper, the maximum breadth being very nearly 1 mile, and the mean breadth of the entire loch exceeding half a mile. The superficial area is about 844 acres, or  $1\frac{1}{3}$  square miles, and the drainage area nearly 10 square miles. The maximum depth of 85 feet was observed towards the northern end and towards the eastern shore. The volume of water is estimated at 767 millions of cubic feet, and the mean depth at nearly 21 feet. The loch was surveyed on October 6, 1902, but the elevation of the lake-surface above the sea could not be determined; when levelled by the officers of the Ordnance Survey on May 28, 1870, the elevation was found to be 205·2 feet above sea-level. It was stated that the water might rise 2 feet above, and fall about  $1\frac{1}{2}$  feet below, the level on the date of the survey; but the level is affected by a sluice at Achavarn, which is used both by South Calder mill and by the Thurso waterworks.

Loch Calder is irregular in outline, and rather peculiar in conformation. In the wide portion of the loch, off the western shore, there is an island situated on a large bank surrounded by deeper water, and the narrow southern portion is so shallow that one must proceed three-quarters of a mile from the southern end before meeting with depths exceeding 11 feet. The deep basin is contained in the eastern half of the wide northern portion of the loch, the deepest sounding in 85 feet having been taken about half a mile from the northern shore and a quarter of a mile from the eastern shore. Here there is a basin about a mile in length, and exceeding 30 feet in depth, the 50-foot basin being nearly three-quarters of a mile in length, and distant about a quarter of a mile from the northern shore. The loch, as a whole, is comparatively shallow, since 72 per cent. of the lake-floor is covered by less than 25 feet of water, as will be seen from the following table, giving the approximate areas between the consecutive contour-lines, and the percentages to the total area of the loch:—

Feet.				Acres.		Per cent.
0 to 25	...	...	...	606	...	71·8
25 „ 50	...	...	...	170	...	20·1
50 „ 75	...	...	...	55	...	6·6
over 75	...	...	...	13	...	1·5
				844		100·0

*Temperature Observations.*—The temperature of the surface water at 9.30 a.m. on the date of the survey was 51°·1 Fahr., while the following

## SUMMARY TABLE.

Giving Details concerning the Lochs in the Wick, Wester, Heilen, Dunnet, Thurso, and Forss Basins.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.		
				Max.	Mean.		Max. Feet.	Mean. Feet.	Mean per cent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.	
Scarmclate	89.5	65	0.84	0.56	0.35	41.7	5	2.50	50.0	887	1774	21	0.30	6.96	23.5	
Watten	54.9	161	3.00	0.73	0.48	16.2	12	8.42	70.2	1320	1880	341	1.45	20.26	14.0	
Hempriggs	153.7	36	0.77	0.76	0.44	57.1	8	5.22	65.3	508	779	49	0.34	9.39	27.6	
Wester	6.0	57	1.00	0.30	0.17	17.0	3	1.50	50.0	1760	3520	7	0.17	29.59	174.1	
Heilen	112.8	61	1.60	0.42	0.19	11.9	5	2.50	50.0	1690	3380	21	0.30	1.52	5.1	
St. John's	71.3	73	0.82	0.56	0.37	45.2	7	4.50	64.3	618	962	38	0.30	1.55	5.1	
More	381.4	35	0.86	0.58	0.32	37.2	7	4.18	59.7	649	1086	32	0.28	67.40	240.7	
Shurrery	321.45	45	1.28	0.45	0.28	21.9	7	4.37	62.4	965	1547	43	0.36	28.89	80.3	
Calder	205.2	148	2.32	0.96	0.57	24.6	85	20.87	24.6	144	587	767	1.32	9.65	7.3	
	[May 28, 1870]	681										1319	4.82	163.25*		34.9

\* The drainage area of Loch Watten includes that of Loch Scarmclate.

series taken in the deepest part of the loch at 3 p.m. showed that the water was practically uniform in temperature from surface to bottom :—

Surface ...	...	...	...	...	...	51°·4 Fahr.
10 feet ...	...	...	...	...	...	51°·4 "
20 " ...	...	...	...	...	...	51°·5 "
30 " ...	...	...	...	...	...	51°·5 "
50 " ...	...	...	...	...	...	51°·5 "
80 " ...	...	...	...	...	...	51°·2 "

In the nine lochs included in the foregoing table 681 soundings were taken, and the aggregate area of the water-surface is almost 5 square miles, so that the average number of soundings per square mile of surface is 141. The aggregate volume of water contained in the lochs is estimated at about 1319 millions of cubic feet. The area drained by these lochs is 168½ square miles, or nearly thirty-five times the area of the lochs.

## LOCHS OF THE LAXFORD BASIN.

WITHIN this basin (see Index Map, Fig. 2) five lochs were sounded by the staff of the Lake Survey, viz., Lochs More, na h-Ealaidh, Stack, na Claise Feàrna, and nam Breac. The most important of these are Lochs More and Stack, which drain by the river Laxford into the head of Loch Laxford—a sea-loch on the west coast of Sutherland. Loch na h-Ealaidh is directly continuous with Loch More and at the same level, while Lochs na Claise Feàrna and nam Breac drain by independent streams falling into Loch Laxford on its southern shore. The area draining into these lochs is about 44 square miles. Lochs More and Stack are situated in a wild, mountainous district, many of the surrounding peaks exceeding 2000 feet in height, and are famed for their fishing, which is preserved; Loch More contains splendid trout, while Loch Stack contains also sea-trout, *Salmo ferox*, salmon, and char.

*Loch More* (see Plate.VIII.).—Loch More (see Fig. 29) lies about 6 miles from Laxford Bridge, and about 10 miles from Scourie, and approaches to within 2 miles of the head of Loch Merkland, in the Shin basin. The loch trends in a north-west and south-east direction, and exceeds 4 miles in length; the width of the loch is extremely uniform, so that the mean breadth of the entire loch is very little less than the maximum breadth, which is under half a mile. The superficial area is about 940 acres, or nearly  $1\frac{1}{2}$  square miles, and the area draining into the loch is only about 12 square miles. The maximum depth of 316 feet was observed approximately near the centre of the loch. The volume of water contained in the loch is estimated at nearly 5000 millions of cubic feet, and the mean depth at 126 feet. The loch was surveyed on September 2 to 6, 1902; the elevation of the lake-surface above the sea on commencing the survey was determined by levelling from bench-mark as being 127·65 feet, but between September 4 and 5 the water rose about 3 inches. When levelled by the officers of the Ordnance Survey on July 1, 1856, the elevation was 127·3 feet above sea-level.

Loch More is quite simple in conformation, the bottom sloping down on all sides towards the deepest part of the loch without any pronounced irregularity. There is a small basin exceeding 300 feet in depth in the middle of the loch, based on a single sounding in 316 feet. The 200-foot

basin is nearly  $2\frac{1}{2}$  miles in length, distant about three-quarters of a mile from the two ends of the loch, while the 100-foot basin is over 3 miles, and the 50-foot basin  $3\frac{1}{2}$  miles, in length. The two lines of soundings at the north-west end of the loch show slight irregularities of the bottom, so that the 50-foot and 100-foot contour-lines become somewhat sinuous in character. A line of soundings taken about a mile from the south-east end shows a

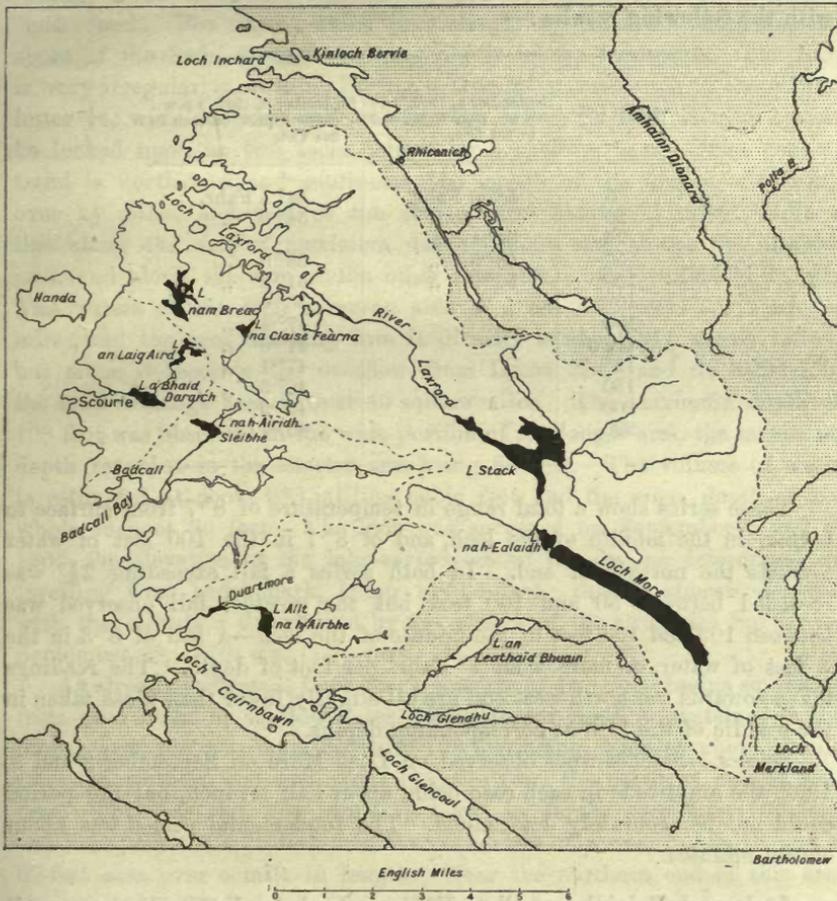


FIG. 2.—INDEX MAP OF THE LAXFORD, SCOURIE, BADCALL, AND DUARTMORE BASINS.

very slight undulation in deep water, a sounding in 220 feet having on one side 225 feet and on the other 234 feet. The areas between the consecutive contour-lines, and the percentages to the total area, are as follows:—

Feet.	...	...	...	Acres.	...	Per cent.
0 to 100	...	...	...	408	...	43.6
100 „ 200	...	...	...	254	...	27.1
200 „ 300	...	...	...	232	...	24.8
over 300	...	...	...	43	...	4.5
				<hr/> 937		<hr/> 100.0

This table shows that the average slope of the bottom is regular, the areas decreasing with increase of depth, and that the loch partakes of a flat-bottomed character, as evidenced by the comparatively large area of the lake-floor covered by more than 200 feet of water.

*Temperature Observations.*—Two series of temperatures were taken in Loch More, one towards the north-west end at 5.15 p.m. on September 5, and the other in the deepest part of the loch at 2 p.m. on September 6, with the following results:—

Depth in feet.	I.	II.
	September 5, 1902, 5.15 p.m., near N.W. end in 101 feet.	September 6, 1902, 2 p.m., deepest part of loch in 294 feet.
0	54°·4 Fahr.	54°·4 Fahr.
20	—	54°·2 "
25	53°·4 "	—
50	53°·5 "	53°·9 "
100	50°·9 "	51°·2 "
103		50°·6 "
106		47°·3 "
112·5		47°·3 "
125		47°·1 "
150		46°·3 "
200		45°·9 "
290		45°·7 "

These series show a total range in temperature of 8°·7 from surface to bottom in the middle of the loch, and of 3°·1 in the 100 feet of water towards the north-west end. In both series a fall exceeding 2½° was recorded between 50 and 100 feet, but the greatest fall observed was between 103 and 106 feet in the middle of the loch—a fall of 3°·3 in the 3 feet of water, or more than 1° Fahr. per foot of depth. The readings taken towards the north-west end are all slightly lower than those taken in the middle of the loch at corresponding depths.

*Seiches.*—Seiches were observed on Loch More on September 2 and 5, 1902, the amplitude in each case being about half an inch, but the period could not be accurately determined. The fundamental period was about eleven minutes.

*Loch na h-Ealaidh* (see Plate VIII.).—Loch na h-Ealaidh is a small shallow basin at the north-west end of Loch More, the narrows between them being crossed by stepping-stones, and having a depth of 1 foot on the date of the survey. The loch is irregularly subcircular in outline, with a maximum diameter of less than half a mile, its waters covering an area of about 64 acres. The maximum depth of 8 feet was observed towards the north-west end, where the river an Earachd flows out, and the great majority of the soundings were taken in depths exceeding 5 feet. The volume of water is estimated at 13 million cubic feet, and the mean depth at 4½ feet. The loch was surveyed on September 6, 1902, the

elevation being the same as that of Loch More. The basin is flat-bottomed in character, more than half the lake-floor (or 54 per cent.) being covered by over 5 feet of water.

*Loch Stack* (see Plate IX.).—Loch Stack lies about a mile to the north-west of Loch More, the overflow from Loch More being carried through Loch na h-Ealaidh, and by the short stream an Earachd, into Loch Stack. Ben Stack, which rises steeply up from the south-western shore of the loch, forms a striking object in the landscape. The loch is very irregular in outline, having a fanciful resemblance to the capital letter H, with one arm longer than the other; in fact, it may almost be looked upon as two lochs joined by a shallow neck. The general trend is north-west and south-east, the length of the longer arm being over  $2\frac{1}{2}$  miles, and that of the shorter arm nearly  $1\frac{1}{2}$  miles, while a line along the axis of maximum depth of one arm across the shallow neck and along the axis of the other arm would be  $3\frac{1}{4}$  miles in length. The waters of the loch cover an area of about 632 acres (or 1 square mile), and the area draining into it directly is about  $27\frac{1}{2}$  square miles; but since it receives the overflow from Lochs More and na h-Ealaidh, the total drainage area is over 40 square miles. The maximum depth of 108 feet was observed in the wide portion of the longer arm, the maximum depth recorded in the shorter arm being 85 feet. The volume of water is estimated at about 988 million cubic feet, and the mean depth of the whole loch at 36 feet. The loch was surveyed on September 6 and 8, 1902, the elevation of the lake-surface above the sea, as determined by levelling from bench-mark, being 117.65 feet; this is almost identical with the elevation determined by the officers of the Ordnance Survey on September 23, 1870, viz. 117.5 feet.

As already indicated, Loch Stack consists of two deep basins separated from each other by shallow water. The deeper basin is contained in the longer arm, the maximum depth of 108 feet being recorded about a mile from the southern end, and about  $1\frac{1}{2}$  miles from the northern end, of that arm. This was the only sounding taken in depths exceeding 100 feet, and here there is a 75-foot area three-quarters of a mile in length, and a 50-foot area over a mile in length. Near the northern end of this arm there is a small, isolated 50-foot area, based on soundings in 50 and 63 feet, separated from the main 50-foot area by a shoaling of the water at the narrow constriction in the outline of the loch, about half a mile from the northern end, where the depth is less than 30 feet. The shallower basin in the shorter arm of the loch is regular in conformation, the 50-foot area being about three-quarters of a mile in length, and enclosing a 75-foot area a quarter of a mile in length, based on soundings in 77, 81, and 85 feet. The last-mentioned sounding was recorded about a quarter of a mile from the eastern shore. In the shallow neck joining the two arms of the loch, the deepest sounding recorded was in 16 feet. In one or two

places a steep off-shore slope is indicated by the soundings, as, for instance, off the western shore of the longer arm towards the southern end, where a sounding in 55 feet was taken about 40 feet from shore, and a little farther north off the same shore, where a sounding in 24 feet was taken about 30 feet from shore; again, off the western shore of the shorter arm, towards the northern end, a sounding in 57 feet was taken about 60 feet from shore. The approximate areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows :—

Feet.	Acres.	Per cent.
0 to 25	265	42
25 „ 50	183	29
50 „ 75	146	23
75 „ 100	33	5
Over 100	5	1
	632	100

These figures show that the deep water is not of great extent, more than 70 per cent. of the lake-floor being covered by less than 50 feet of water, and more than 40 per cent. by less than 25 feet of water.

*Temperature Observations.*—The following serial temperatures were taken in the deepest part of the loch, at 4 p.m., on September 6, 1902 :—

Surface	56°·1	Fahr.
25 feet	55°·6	„
50 „	55°·3	„
100 „	54°·7	„

These observations show a range of only 1°·4 throughout the 100 feet of water.

*Seiche.*—A seiche was observed at the west end of the loch, having an amplitude of three-sixteenths of an inch, but the period could not be determined.

*Loch na Claise Feàrna* (see Plate X).—Loch na Claise Feàrna is a little irregular loch lying about half a mile from the southern shore of Loch Laxford, into which its outflow is carried by the Allt na Claise Feàrna. It is about midway between Laxford Bridge and Scourie, the road skirting its eastern shore. In outline it is subtriangular, with the apex pointing in a north-east direction, and covers an area of about 34 acres, while the area draining into it is nearly 2½ square miles. The maximum depth of 38 feet was observed near the middle of the loch, between the large central island and the northern shore. The volume of water is estimated at 20 million cubic feet, and the mean depth at 13¼ feet. The loch was surveyed on September 10, 1902, when the elevation of the lake-surface was found to be 135·0 feet above the sea. The western and southern parts of the loch are shallow, the deeper portion (exceeding 20 feet in depth) lying to the north and east of the large central island, and covering an area of about 6 acres, or 17 per cent. of the total area of the loch.

*Temperature Observations.*—The following serial temperatures, taken at 2 p.m. on the date of the survey in the deepest part of the loch, show a range of only  $1^{\circ}\cdot 2$  Fahr. throughout the body of water:—

Surface ...	...	...	...	...	...	57 $^{\circ}$ ·8 Fahr.
10 feet ...	...	...	...	...	...	57 $^{\circ}$ ·2 „
20 „ ...	...	...	...	...	...	57 $^{\circ}$ ·0 „
30 „ ...	...	...	...	...	...	56 $^{\circ}$ ·6 „

*Loch nam Breac* (see Plate X.).—Loch nam Breac lies about a mile to the north-west of Loch na Claise Fearna, near the southern shore of Loch Laxford, into which its overflow is carried by the Allt a' Mhuilinn. It is most irregular in outline, with arms projecting in various directions, and with one large and many smaller islands. From north to south it exceeds a mile in length, with a maximum breadth of half a mile, the superficial area being about 142 acres, or nearly a quarter of a square mile. The maximum depth of 71 feet was recorded in the southern wide portion of the loch. The volume of water is estimated at 172 million cubic feet, and the mean depth at 28 feet. The loch was surveyed on September 9, 1902, but the elevation of the lake-surface above the sea could not be determined.

Loch nam Breac is extremely irregular in conformation, which is not surprising, considering that the numerous islands and projecting promontories give rise to many constrictions in the outline. The bottom sinks in two places below the 50-foot level: (1) in the most southerly expansion of the loch, where there is a basin a quarter of a mile in length, enclosing the maximum depth of the loch (71 feet), three soundings having been recorded at that depth near the centre of the expansion; and (2) to the south-west of the largest island, where there is a smaller basin having a maximum depth of 66 feet. These two 50-foot basins cover an area of about 24 acres, or 17 per cent. of the total area of the loch. Besides these two deep basins, there are six isolated small areas in which the depth exceeds 25 feet, based in some cases on single soundings, the largest and deepest lying to the north-east of the largest island, and having a maximum depth of 44 feet. The area of the lake-floor covered by less than 25 feet of water is about 76 acres, or 54 per cent. of the total area.

*Temperature Observations.*—A series of temperatures taken at 6 p.m. on the date of the survey, in the deepest part of the loch, gave the following results:—

Surface ...	...	...	...	...	...	57 $^{\circ}$ ·1 Fahr.
25 feet ...	...	...	...	...	...	57 $^{\circ}$ ·0 „
40 „ ...	...	...	...	...	...	56 $^{\circ}$ ·5 „
45 „ ...	...	...	...	...	...	56 $^{\circ}$ ·0 „
48 „ ...	...	...	...	...	...	52 $^{\circ}$ ·0 „
50 „ ...	...	...	...	...	...	52 $^{\circ}$ ·0 „
60 „ ...	...	...	...	...	...	51 $^{\circ}$ ·0 „

This series shows a range of  $6^{\circ}\cdot 1$ , the position of the “sprungschicht” being well marked, viz. between 45 and 48 feet, where a fall in temperature amounting to  $4^{\circ}$  was recorded—a fall exceeding  $1^{\circ}$  per foot of depth.

## LOCHS OF THE SCOURIE BASIN.

THE two principal lochs within this basin (Lochs an Laig Aird and a' Bhaid Daraich) were sounded by the Lake Survey, and were found to form a complete contrast both in outline and conformation. Loch an Laig Aird is most irregular in these respects, while Loch a' Bhaid Daraich is quite simple. The overflow from Loch an Laig Aird is carried by the Allt Loch an Laig Aird into Loch a' Bhaid Daraich, which flows by the short stream Allt a' Mhuilinn into Scourie bay on the west coast of Sutherland.

*Loch an Laig Aird* (see Plate XI).—Loch an Laig Aird is situated about a mile to the north-east of Scourie, and half a mile to the south of Loch nam Breac. The waters of the loch almost entirely encircle a large promontory of land, the connecting isthmus being only about 100 feet across, and cover an area of about 67 acres. The loch is on the whole shallow, the area of the bottom covered by less than 20 feet of water being about 51 acres, or 76 per cent. of the total area. The deepest part of the loch is in the arm stretching south-westwards from the large promontory, where there is a long narrow basin exceeding 40 feet in depth, the deepest sounding in 42 feet having been taken close to the southern shore, about a quarter of a mile from the south-western extremity of the loch, and only about 40 feet from shore, so that the slope of the bottom at this place is very steep. A steep slope also occurs near the south-western extremity of the loch, where soundings in 13 and 14 feet were taken about 10 feet from shore. In the broad arm to the east of the large promontory the maximum depth observed was 31 feet, and a similar depth was found to the north-west of the large promontory. The loch was surveyed on September 9, 1902, but the elevation of the lake-surface above the sea could not be determined.

*Temperature Observations.*—A series of temperatures taken at 5 p.m. on the date of the survey, in the deepest part of the loch, gave the following results :—

Surface ...	...	...	...	...	...	57°·2 Fahr.
20 feet ...	...	...	...	...	...	56°·2 „
35 „ ...	...	...	...	...	...	56°·1 „

*Loch a' Bhaid Daraich* (see Plate XI).—Loch a' Bhaid Daraich is situated near the village of Scourie, and little more than a quarter of a

mile from the head of Scourie bay, but at an elevation of nearly 50 feet above the sea. The loch trends almost east and west, and is nearly a mile in length, with a maximum breadth of a third of a mile, its waters covering an area of about 111 acres, or one-sixth of a square mile. The maximum depth of 121 feet was observed approximately near the middle of the loch, but rather nearer the west than the east end. The volume of water is estimated at 270 million cubic feet, and the mean depth at  $55\frac{1}{2}$  feet. The loch was surveyed on September 8, 1902, when the elevation of the lake-surface was found to be 48·5 feet above the sea, so that the 50-foot contour-line on the map shows approximately the area of the bottom which falls below the sea-level.

Loch a' Bhaid Daraich forms a simple flat-bottomed basin, with no indication of any pronounced irregularity. The contour-lines coincide approximately with the outline of the loch, having here and there a slightly sinuous character, and there are in places steep off-shore slopes, as, for instance, off the northern shore towards the west end, where a sounding in 45 feet was taken about 40 feet from shore—a gradient exceeding 1 in 1. The following table gives the approximate areas between the consecutive contour-lines drawn in at equal intervals of 25 feet, and the percentages to the total area of the loch :—

Feet.				Acres.		Per cent.
0 to 25	...	...	...	26	...	23·3
25 ,, 50	...	...	...	29	...	26·2
50 ,, 75	...	...	...	19	...	17·6
75 ,, 100	...	...	...	22	...	19·5
Over 100	...	...	...	15	...	13·4
				—		—
				111		100·0

These figures show that Loch a' Bhaid Daraich departs from the usual rule of decreasing area with increasing depth, for in each of the zones between 25 and 50 feet, and again between 75 and 100 feet, the area is greater than in shallower water.

*Temperature Observations.*—A series of temperatures taken at 2 p.m. on the date of the survey, in the deepest part of the loch, gave the following results :—

Surface	...	...	...	...	...	57°·2 Fahr.
20 feet	...	...	...	...	...	57°·1 ,,
40 ,,	...	...	...	...	...	56°·1 ,,
42·5 ,,	...	...	...	...	...	54°·8 ,,
45 ,,	...	...	...	...	...	52°·0 ,,
50 ,,	...	...	...	...	...	50°·8 ,,
60 ,,	...	...	...	...	...	50°·0 ,,
100 ,,	...	...	...	...	...	48°·9 ,,
110 ,,	...	...	...	...	...	48°·6 ,,

These observations show a range of temperature throughout the body of water amounting to 8°·6, the greatest fall being observed between  $42\frac{1}{2}$  and 45 feet, viz. a fall of 2°·8 in the interval of  $2\frac{1}{2}$  feet of depth—a decrease exceeding 1° per foot.

## LOCHS OF THE BADCALL BASIN.

Of numerous small lochs draining into Badcall bay, Loch na h-Airidh Sléibhe was the only one which could be sounded at the time of the visit of the Lake Survey.

*Loch na h-Airidh Sléibhe* (see Plate XII).—Loch na h-Airidh Sléibhe lies little more than half a mile to the south-east of Loch a' Bhaid Daraich, the outflowing river running in a south-westerly direction into Badcall bay. The main body of the loch trends north-west and south-east, and is two-thirds of a mile in length, with a maximum breadth of one-third of a mile. Its waters cover an area of about 68 acres, while the area draining into it is about  $1\frac{1}{2}$  square miles. The maximum depth of 113 feet was observed about a quarter of a mile from the north-west end. The volume of water is estimated at 131 million cubic feet, and the mean depth at about  $44\frac{1}{2}$  feet. The loch was surveyed on September 10, 1902, but the elevation of the lake-surface above the sea could not be determined. The loch forms a simple basin, the bottom sloping down on all sides towards the deepest part, which lies towards the north-west end. The shallower contours coincide approximately with the outline of the loch, and in some places deep water approaches close to the shore, as, for instance, off the northern shore, in the vicinity of the deepest part, where a sounding in 43 feet was taken about 40 feet from shore, indicating a gradient exceeding 1 in 1. The approximate areas between the contour-lines, and the percentages to the total area of the loch, are given in the following table:—

Feet.				Acres.		Per cent.
0 to 25	...	...	...	24	...	36
25 „ 50	...	...	...	15	...	22
50 „ 75	...	...	...	15	...	22
75 „ 100	...	...	...	11	...	16
Over 100	...	...	...	3	...	4
				68		100

*Temperature Observations.*—The following series of temperatures was taken in the deepest part of the loch at 3.30 p.m. on the date of the survey:—

Surface ...	...	...	...	...	...	56°·4 Fahr.
10 feet ...	...	...	...	...	...	56°·4 "
25 "	...	...	...	...	...	56°·4 "
40 "	...	...	...	...	...	56°·4 "
45 "	...	...	...	...	...	58°·6 "
50 "	...	...	...	...	...	51°·1 "
100 "	...	...	...	...	...	49°·5 "

These observations show a total range throughout the body of water amounting to 6°·9, the superficial layers down to 40 feet being uniform in temperature, while between the depths of 40 and 50 feet a fall of 5°·3 was observed.

### LOCHS OF THE DUARTMORE BASIN.

WITHIN this basin two lochs were sounded by the Lake Survey, viz. Loch Allt na h-Airbhe and Loch Duartmore, which drain by a short stream into the small arm of the sea called Loch na Creige Ruaidhe. Between these two lochs lies Loch Eucail, which is overgrown with reeds and apparently shallow.

*Loch Allt na h-Airbhe* (see Plate XIII.).—Loch Allt na h-Airbhe (or Upper Loch Duartmore) is the largest in the basin, and trends in a north and south direction, being nearly two-thirds of a mile in length and one-third in maximum width. Its waters cover an area of about 83 acres, and an area of about  $8\frac{3}{4}$  square miles drains into it. The maximum depth of 60 feet was observed in the south-western part of the loch. The volume of water is estimated at 110 million cubic feet, and the mean depth at over 30 feet. The loch was surveyed on September 11, 1902, when the elevation of the lake-surface above the sea was determined, by levelling from benchmark, as being 119.5 feet.

Loch Allt na h-Airbhe is a comparatively deep loch with an uneven floor. The 25-foot contour-line follows approximately the shore-line, in some places approaching close to the shore, while the 50-foot basin is irregular, approaching the eastern shore in its northern portion, and widening out and approaching the western shore in its southern portion. In the central portion of the loch is an extensive shoaling, covered by less than 30 feet of water, surrounded on all sides by deeper water. The deepest sounding in 60 feet was recorded about 120 yards from the western shore and about 200 yards from the southern shore. The soundings indicate a steep off-shore slope in certain positions, as, for instance, off the western shore near the southern end, where a sounding in 35 feet was taken about 50 feet from shore; off the same shore, farther north, a sounding in 18 feet was taken about 20 feet from shore; while off the eastern shore, near the northern end, a sounding in 25 feet was taken about 20 feet from shore—the last-mentioned giving a gradient exceeding 1 in 1. The following table, giving the approximate areas between the contour-lines and the percentages to the total area of the loch, shows that a larger area of the lake-floor is covered by water between 25 and 50 feet in depth (equal to nearly one-half of the total area) than by water less than 25 feet in depth:—

Feet.			Acres.	Per cent.
0 to 25	...	...	32	39
25 ,, 50	...	...	40	48
Over 50	...	...	11	13
			—	—
			83	100

*Temperature Observations.*—A reading at the surface at the north end of the loch, on commencing the survey on September 11, 1902, gave 58°·6 Fahr., while a series taken at 3.30 p.m., in the deepest part of the loch, gave the following results :—

Surface	...	...	...	...	57°·2 Fahr.
10 feet	...	...	...	...	57°·0 „
25 „	...	...	...	...	56°·0 „
50 „	...	...	...	...	55°·5 „

These observations indicate a total range of temperature throughout the body of water amounting to 3°·1, no very decided fall being observed beneath the surface, but the difference of nearly 1½° between the two readings at the surface is noteworthy.

*Loch Duartmore* (see Plate XIII.).—Loch Duartmore is a small, irregular loch, trending almost east and west, and over a quarter of a mile in length. Its waters cover an area of about 13 acres, while, since it receives the overflow from Lochs Allt na h-Airbhe and Eucail, its drainage area is very large—about 11¼ square miles, or more than 550 times greater than the area of the loch. The maximum depth of 22 feet was observed near the east end of the loch. The volume of water is estimated at 3 million cubic feet, and the mean depth at nearly 6 feet. The loch was surveyed on September 11, 1902, when the elevation of the lake-surface was found to be 81·5 feet above the sea ; this was 4 feet lower than the level of Loch Eucail, and 38 feet lower than that of Loch Allt na h-Airbhe.

Loch Duartmore is on the whole very shallow, the area of the lake-floor covered by less than 10 feet of water being about 12 acres, or 92 per cent. of the total area. Only in two places were depths extending 10 feet recorded : (1) at the extreme eastern end, where soundings in 10 to 22 feet were taken, and (2) off the northern shore, near the middle of the loch, where soundings in 12 and 16 feet were taken, the last-mentioned only about 20 feet from the shore, indicating a steep slope in this position. Some of the bays are filled with reeds. Temperatures taken in the deep part at the east end, at 2 p.m. on the date of the survey, gave 55°·0 Fahr. at the surface and 54°·6 at a depth of 17 feet.

In the ten lochs included in the following table 994 soundings were taken ; the aggregate area of water surface is 3·35 square miles, so that the average number of soundings per square mile of surface is 296. The aggregate volume of water contained in the lochs is estimated at 6679 millions of cubic feet. The area drained by these lochs is over 59 square miles, or nearly 18 times the area of the lochs.

## SUMMARY TABLE.

Giving Details concerning the Locks in the *Laxford*, *Scourie*, *Budcall*, and *Duartmore Basins*.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. Feet.	Mean. Feet.	Mean per cent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
More ...	127.65	148	4.11	0.43	0.36	8.8	316	125.80	39.8	69	172	4928	1.46	12.05	8.2
na h-Ealaith ...	127.65	24	0.42	0.39	0.24	57.1	8	4.66	58.3	277	476	13	0.10	12.76	127.4
Stack ...	117.65	184	3.27	0.60	0.30	9.2	108	35.90	33.2	160	481	988	0.99	40.20	40.6
na Claise Fearnna ...	135.0	64	0.42	0.34	0.13	30.9	88	13.23	34.8	58	168	20	0.05	2.30	42.6
nam Breac ...	—	159	1.12	0.55	0.20	17.9	71	27.94	39.4	83	212	172	0.22	1.17	5.3
an Laig Aird ...	—	150	0.74	0.56	0.14	18.9	42	15.12	36.0	93	258	44	0.10	0.58	5.6
a' Bhaid Daraich ...	48.5	60	0.86	0.31	0.20	23.6	121	55.60	45.9	38	82	270	0.17	2.76	15.9
na h-Airidh Sléibhe ...	—	82	0.68	0.34	0.16	23.5	113	44.43	39.3	32	81	131	0.11	1.53	13.9
Allt na h-Airbhe ...	119.5	75	0.62	0.32	0.21	33.9	60	30.17	50.3	55	108	110	0.13	8.73	67.2
Duartmore ...	81.5	48	0.29	0.12	0.07	24.1	22	5.90	26.8	70	260	3	0.02	11.24	562.0
		994										6679	3.35	59.20*	17.7

\* The drainage area of Loch Stack includes those of Lochs More and na h-Ealaith; that of Loch a' Bhaid Daraich includes that of Loch an Laig Aird; and that of Loch Duartmore includes that of Loch Allt na h-Airbhe.

LOCHS OF THE BROOM BASIN.

THE area draining into Loch Broom on the west coast of Scotland is not an extensive one, the watershed between the eastern and western drainage systems approaching in this district very close to the west coast. The basin (see Index Map, Fig. 3) includes, besides numerous small lochs

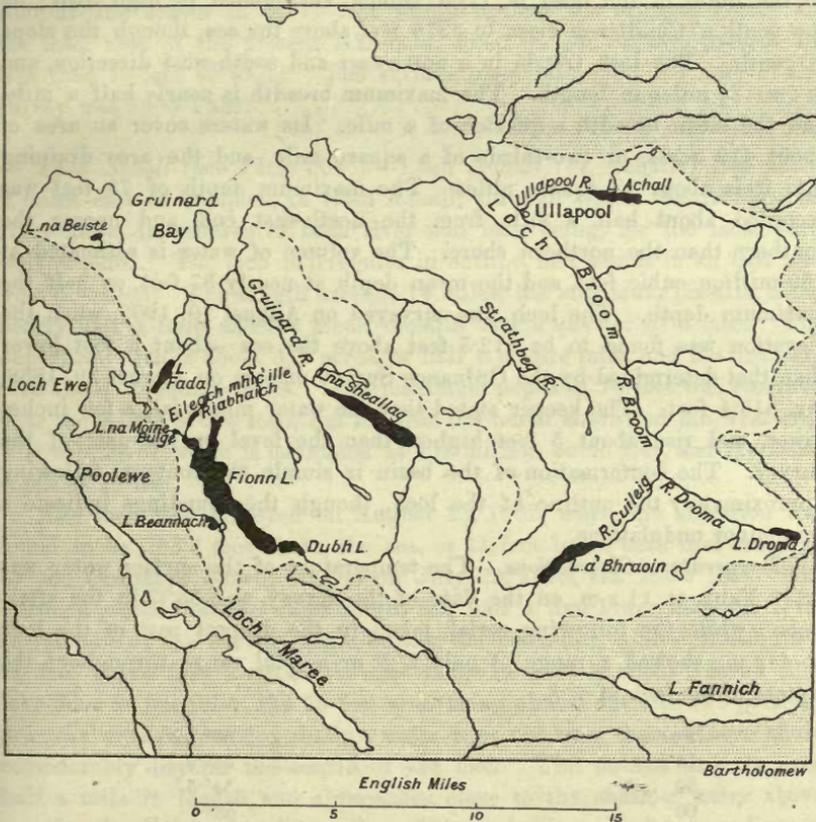


FIG. 3.—INDEX MAP OF THE BROOM AND GRUINARD BASINS.

which were not surveyed, three fair-sized lochs, to be dealt with here, viz. Lochs a' Bhraoin, Droma, and Achall, the two first mentioned draining by the river Broom into the head of Loch Broom, the last mentioned

draining by the Ullapool river into Loch Broom at Ullapool. The Broom basin is bordered on the south and east by the Conon and Shin basins belonging to the eastern drainage system, Loch Achall lying about 5 miles west of Loch an Daimh in the Shin basin, and Lochs Droma and a' Bhraoin about the same distance north of Loch Fannich in the Conon basin.

Besides the Broom and Ullapool rivers, the basin includes the river Kanaird, flowing into the wide part of Loch Broom, north of Ullapool, and the Strathbeg river, flowing into the head of Little Loch Broom, lying to the south-west of Loch Broom. The scenery of the district is very fine, and the lochs afford good fishing, though preserved. They all contain trout, and salmon also are got in Loch Achall. Some years ago Loch Droma was greatly enlarged, and the fishing vastly improved.

*Loch a' Bhraoin* (see Plate XIV.).—Loch a' Bhraoin lies about 7 miles to the south of the head of Loch Broom, surrounded by high hills; on the south a' Chailleach rises to 3276 feet above the sea, though the slope is gentle. The loch trends in a north-east and south-west direction, and is over  $2\frac{1}{2}$  miles in length. The maximum breadth is nearly half a mile, and the mean breadth a quarter of a mile. Its waters cover an area of about 419 acres, or two-thirds of a square mile, and the area draining into it is about 13 square miles. The maximum depth of 73 feet was recorded about half a mile from the north-east end, and nearer the southern than the northern shore. The volume of water is estimated at 669 million cubic feet, and the mean depth at nearly 37 feet, or half the maximum depth. The loch was surveyed on August 19, 1902, when the elevation was found to be 812.5 feet above the sea—about a foot lower than that determined by the Ordnance Survey officers on August 29, 1868, viz. 813.4 feet. The keeper stated that the water might fall a few inches lower, and rise about 5 feet higher, than the level on the date of the survey. The conformation of the basin is simple, the contours following approximately the outline of the loch, though the soundings indicate a few minor undulations.

*Temperature Observations.*—The temperature of the surface water was  $58^{\circ}0$  Fahr. at 11 a.m. on the date of the survey, and  $55^{\circ}7$  in the afternoon; while the following serial, taken in the deepest part of the loch at 4 p.m., showed a range of only  $2^{\circ}5$ , or a total range throughout the waters of the loch of  $4^{\circ}3$ .

Surface ...	...	...	...	...	...	...	...	56°2 Fahr.
15 feet ...	...	...	...	...	...	...	...	54°9 "
30 " ...	...	...	...	...	...	...	...	54°5 "
60 " ...	...	...	...	...	...	...	...	53°7 "

*Loch Droma* (see Plate XV.).—Loch Droma (or Druim) lies in the forest of Braemore, about 8 miles from the head of Loch Broom, and nearly 6 miles east of Loch a' Bhraoin; to the north lies Meall Leacachain (2028 feet), and to the south Beinn Liath Bheag (2173 feet). The loch

trends in an east and west direction, with a slight bend near the middle, so that the eastern portion dips south-east, and is  $1\frac{1}{4}$  miles in length, with a maximum breadth of a quarter of a mile. The superficial area is about 116 acres, and the drainage area about 3 square miles. The maximum depth of 16 feet was observed about 300 yards from the north-eastern shore, towards the east end of the loch. The volume is estimated at 32 million cubic feet, and the mean depth at  $6\frac{1}{4}$  feet.

The loch was surveyed on August 20, 1902, when the elevation was found to be 884.1 feet above the sea; the water could rise only about a foot higher. The loch is mostly artificial, only a small portion towards the east end having existed previous to the building of the embankment at what is now the west end of the loch. This agrees with the evidence of the levelling, for from observations it was determined that the water was 11 feet higher than it would be without the embankment, so that a contour-line drawn in at 11 feet would enclose the original loch. Of the total area of the present lake-floor, about 84 per cent. is covered by less than 10 feet of water. The surface temperature on the date of the survey was  $56^{\circ}5$  Fahr.

*Loch Achall* (see Plate XV.).—Loch Achall (or Achallt) lies about 2 miles east of Ullapool, in Glen Achall, through which the Rhidorroch river flows, the shores of both river and loch being, for the most part, well wooded. The loch is irregular in outline, and trends in an east and west direction. The length exceeds  $1\frac{3}{4}$  miles, the maximum breadth being nearly half a mile, and the mean breadth over a quarter of a mile. The superficial area is about 330 acres, or half a square mile, and the drainage area about 29 square miles. The maximum depth of 70 feet was recorded near the centre of the loch, but towards the north shore and the west end. The volume of water is estimated at 401 million cubic feet, and the mean depth at 28 feet.

The loch was surveyed on August 23, 1902, when the elevation was found to be 263.4 feet above the sea, or  $1\frac{1}{2}$  feet lower than that observed by the Ordnance Survey officers on July 23, 1870, viz. 264.9 feet. The boatman stated that the water might fall half a foot lower than the level on the date of the survey, while during the preceding winter it had risen  $4\frac{1}{2}$  feet above that level, so that the range in level is about 5 feet. The lake-floor is irregular, the 25-foot area being almost cut into two portions near the west end, where shallow water runs out from the northern shore considerably beyond the centre of the loch. The 50-foot area is over half a mile in length, and approaches close to the shallow water above mentioned, a distance of less than 250 yards separating a sounding in 55 feet from one in 18 feet.

The temperature of the surface-water on the date of the survey was  $56^{\circ}0$  Fahr.

## LOCHS OF THE GRUINARD BASIN.

WITHIN this basin eight lochs were sounded by the Lake Survey, viz. Lochs na Sheallag, Fionn, Dubh, Beannach, na Mòine Buige, Eileach Mhic'ille Riabhaich, Fada, and na Beiste. The drainage basin under consideration (see Index Map, Fig. 3) extends from the mouth of Gruinard bay (between Stattic Point on the east and Creag an Eilean on the west) to the heights of Beinn Tarsuinn, Mullach Coire Mhic Fhearchair, and Beinn Bheag, and includes numerous small lochs which could not be surveyed for lack of boats. As measured by the planimeter on the 1-inch Ordnance Survey maps the total area of this basin is about 117 square miles, of which considerably more than one-half, or over  $66\frac{1}{2}$  square miles, drain into the lochs under consideration, as will be seen in the summary table. Loch na Sheallag flows directly into Gruinard bay by the river Gruinard, as does Loch Fada by the Allt Bad an Luig, and Loch na Beiste by the Allt Udrigill, while the remaining lochs mentioned form a connected series, whose waters are carried into Gruinard bay by the Little Gruinard river, Loch Dubh adjoining the head of Loch Fionn, Lochan Beannach flowing into Loch Fionn about midway down the western shore, Loch na Mòine Buige flowing in at the head of Loch Fionn, while Loch Eileach Mhic'ille Riabhaich carries the outflow from Loch Fionn into the Little Gruinard river.

*Loch na Sheallag* (see Plate XVI).—Loch na Sheallag is situated about 9 miles to the north-east of Loch Maree, amid wild and magnificent scenery, the head of the loch lying between the heights of An Teallach (Bidein a' Ghlas Thuill—3483 feet, and Sgùrr Fìona—3474 feet) on the north-east, and of Beinn Dearg—2974 feet—on the south-west. It contains salmon, sea trout, river trout, and char, but the fishing is preserved. The loch trends in a south-east and north-west direction, and is  $3\frac{3}{4}$  miles in length. It is broadest towards the south-eastern (inflow) end, where the maximum width of over two-thirds of a mile occurs, narrowing gradually towards the outflow end. Its waters cover an area of about 876 acres, or over  $1\frac{1}{3}$  square miles, and it drains an area 27 times greater—an area of about 37 square miles. The maximum depth of 217 feet was observed in the wider part of the loch, about a mile from the south-east end. The volume of water is estimated at 3948 millions



This series shows a total range of temperature amounting to about  $7^{\circ}$ , the greatest fall observed being one of about  $3^{\circ}$  between 75 and 100 feet.

*Fionn Loch* (see Plate XVII.).—The Fionn Loch, a large irregular sheet of water, lies less than 3 miles to the north-east of Loch Maree. It is a good trout loch, and contains also *Salmo ferox*, but the fishing is strictly preserved. The lower portion does not lie in a well-marked glen, though round the upper end rise some precipitous and high mountains. There are many large islands, and almost everywhere around the shores, and in places at some considerable distance from shore, large rocks and boulders rise above the surface of the water. The head of the Fionn Loch is practically continuous with the Dubh Loch, which are separated from each other only by an artificial causeway built on a sandbank. When the water is high this causeway is flooded, though under ordinary circumstances the difference of level is about a foot. The matter was the subject of litigation in 1877, the Lord Ordinary deciding that the lochs were one, but the House of Lords reversed this decision. In this place the two lochs are treated separately.

The general trend of the Fionn Loch is from south-east to north-west, its total length being  $5\frac{3}{4}$  miles; it varies greatly in width, the maximum breadth being about  $1\frac{1}{2}$  miles, the mean breadth of the entire loch being nearly two-thirds of a mile. Its waters cover an area of about 2250 acres, or over  $3\frac{1}{2}$  square miles, and it drains directly an area of nearly 15 square miles, but since it receives the outflow from the Dubh Loch, Lochan Beannach, and Loch na Moine Buige, its total drainage area is about  $26\frac{1}{2}$  square miles. The maximum depth of 144 feet was observed in two places: (1) near the south-eastern end, and (2) in the central part of the loch opposite the entrance of the stream bearing the outflow from Lochan Beannach. The volume of water contained in the loch is estimated at 5667 millions of cubic feet, and the mean depth at  $57\frac{3}{4}$  feet.

The Fionn Loch was surveyed on August 4 to 8, 1902, but the elevation of the lake-surface could not be determined by levelling, owing to the inability of the surveyors to find bench-marks after prolonged search; when visited by the Ordnance Survey officers on September 2, 1870, the elevation was found to be 558.6 feet above the sea. The keeper stated that the water may rise 5 feet and fall about 2 feet from the level on the date of the survey. The bottom of the Fionn Loch is most irregular, and the contour-lines in most places extremely sinuous in character; the north-western end is filled with boulders, which often rise out of comparatively deep water in an astonishing manner. The main 50-foot basin is nearly 4 miles in length, approaching quite close to the south-eastern end, and extending between the islands called Eilean Fraoch and Eilean nan Corr-scriach. A second 50-foot basin runs in a north and south direction, along the centre of the large arm thrown out in a northerly direction towards the foot of the loch, extending to the west of Eilean nan

Corr-scriach, and is nearly 2 miles in length; the maximum depth in this basin, 97 feet, was observed near the southern end of the basin off Eilean nan Corr-scriach. A third small 50-foot basin occupies the extreme north-western end of the loch, and has a maximum depth of 78 feet observed near the north-eastern shore. Within the main 50-foot basin the bottom sinks in three places below the 100-foot line: (1) a subcircular basin, two-thirds of a mile in length, situated in the wide portion of the loch at the south-east end, the 100-foot contour-line approaching to within 300 yards of the shore; (2) an isolated sounding of 101 feet about three-quarters of a mile farther down the loch; and (3) about half a mile still farther down an irregular basin a mile and a half in length. As already indicated, the maximum depth of the loch (144 feet) was observed in both of the 100-foot basins numbered 1 and 3, in the former about 530 yards from the south-east end of the loch, and in the latter about 220 yards from the western shore of the loch at Rudha Dubh. An inspection of the map will show how irregular the lake-floor is in the shallower parts of the loch, and even in the deeper water several conspicuous undulations of the bottom may be observed. The areas between the consecutive contour-lines drawn in at equal intervals, and the percentages to the total area of the loch, are as follows:—

Feet.				Acres.		Per cent.
0 to 25	...	...	...	482	...	21·4
25 „ 50	...	...	...	581	...	25·8
50 „ 75	...	...	...	463	...	20·5
75 „ 100	...	...	...	440	...	19·6
Over 100	...	...	...	285	...	12·7
				2251		100·0

It will be noticed that the area between 25 and 50 feet is larger than that between the shore and the 25-foot contour, indicating an average slope steeper near shore than in depths beyond 25 feet.

The surface temperatures taken on August 4 and 5, 1902, showed a range from 54°·2 Fahr. to 55°·1. In winter the loch is covered all over with thick ice.

*Dubh Loch* (see Plate XVII.).—The Dubh Loch is situated in a corrie forming the natural head of the Fionn Loch, surrounded by high and steep hills. There is a bend in the outline of the loch, following the shape of the corrie, the narrower upper portion trending north-west and south-east, while the wider lower portion trends almost east and west. The loch is about 1½ miles in length, with a maximum breadth of two-fifths of a mile, the mean breadth being a quarter of a mile. Its waters cover an area of over 200 acres, or nearly one-third of a square mile, and the area draining into it is about 6¼ square miles. The maximum depth of 88 feet was observed near the centre of the loch, where the outline commences to widen out towards the west. The volume of water contained in the loch

is estimated at 374 million cubic feet, and the mean depth at over 42 feet, or nearly one-half of the maximum depth. The Dubh Loch was surveyed at the same time as the Fionn Loch, and the elevation of the lake-surface was, for the same reason, not determined by levelling.

The conformation of the Dubh Loch is quite a contrast to that of the adjoining Fionn Loch. Except for one or two irregularities of the lake-floor, Dubh Loch forms a simple basin, all the contour-lines, though showing occasional sinuosities, enclosing continuous areas. A bank covered by 2 feet of water occurs in the middle of the loch, about 300 yards from the south-east end, surrounded by depths exceeding 20 feet; farther down, a line of soundings running from south to north, towards the entrance of the Allt Bruthach an Easain, showed a rise of the bottom from 43 to 38 and 39 feet, sinking again to 51 feet; still farther down, another line of soundings running from south to north showed a remarkable rise of the bottom from 65 to 51 and 48 feet, sinking again to the deepest recorded sounding (88 feet), whence the soundings shoaled gradually towards the northern shore. The last-mentioned rise is the more striking, as it was observed in the deepest part of the loch, and in close proximity to the maximum depth. The soundings taken in the wide lower portion of the loch are quite regular, the irregularities above referred to occurring in the upper half of the loch. The areas between the consecutive contour-lines, and the percentages to the total area of the loch, are as follows:—

Feet.				Acres.		Per cent.
0 to 25	...	...	...	50	...	24·6
25 „ 50	...	...	...	78	...	38·2
50 „ 75	...	...	...	57	...	28·2
Over 75	...	...	...	18	...	9·0
				203		100·0

These figures indicate an average slope off-shore much steeper than in the deeper water, and an inspection of the map shows that the 25-foot contour follows approximately the shore line, approaching in some places very close to the shore, whereas the 50-foot contour runs, for the greater part of its course, at a considerable distance from shore, while the upper part of the loch is occupied by water less than 50 feet in depth.

*Lochan Beannach* (see Plate XVII.).—Lochan Beannach is a small irregular sheet of water lying off the central part of the western shore of the Fionn Loch, into which it flows by a stream less than a quarter of a mile in length. The loch consists of two distinct portions, and, as it was found impossible to get a boat through the passage, the smaller south-eastern portion was not surveyed, the soundings being limited to the larger western portion, which is of very peculiar form, almost encircling a large promontory of land projecting out into the loch from the western shore; the narrow neck of land connecting the promontory and the shore is less

than 50 yards across, and, if it were pierced through, the promontory would become a central island, entirely surrounded by the waters of the loch. Lochan Beannach is about two-thirds of a mile in length by one-third of a mile in maximum breadth, covering an area of about 80 acres, and draining an area of over  $4\frac{1}{2}$  square miles. The maximum depth of 27 feet was observed in the southern portion of the loch, comparatively close to the largest island. The volume of water is estimated at 22 million cubic feet, and the mean depth at  $6\frac{1}{2}$  feet. The floor of Lochan Beannach is irregular, with many islands and rocks rising above the surface of the water. The deepest sounding (27 feet), and a neighbouring one of 23 feet, were the only ones exceeding 20 feet in depth, while a sounding of 18 feet was taken in the northern part of the loch, and two of 14 feet off the north-eastern shore, the area covered by less than 10 feet of water being about 70 acres, or  $88\frac{1}{2}$  per cent. of the total area.

*Loch na Mòine Buige* (see Plate XVII.).—Loch na Mòine Buige is a small loch lying at the foot of the Fionn Loch, into which it drains by a short stream. It trends north-west and south-east, and is about three-quarters of a mile in length, with a maximum breadth of less than a quarter of a mile, covering an area of about 55 acres. The maximum depth of 60 feet was observed close to the shore near the south-eastern end, where the stream flows out of the loch. The volume of water is estimated at 59 million cubic feet, and the mean depth at over  $24\frac{1}{2}$  feet. The variation in the level of the water is slight, the highest drift-mark observed being only half a foot above the water on the date of the survey (August 8, 1902), when the loch was at its lowest level. Loch na Mòine Buige is comparatively deep, considering its dimensions, the 25-foot area extending nearly from end to end, and covering nearly one-half of the total area of the loch. The 50-foot area is very small, based on the single sounding of 60 feet close to the south-western shore, so that the slope of the bottom in that position must be steep. The area covered by less than 25 feet of water is about 29 acres, or 52 per cent. of the entire area.

*Loch Eileach Mhic 'ille Riabhaich* (see Plate XVII.).—This little loch is merely a deepening and widening of the river flowing out of the Fionn Loch, from which it is separated by two waterfalls; at its outflow is a third waterfall, separating it from another smaller expansion of the Little Gruinard river. It trends north-north-east and south-south-west, and is nearly three-quarters of a mile in length, with a maximum breadth of less than a quarter of a mile, covering an area of about 30 acres. It drains directly an area of about half a square mile, but, since it carries the outflow from the Fionn Loch, its total drainage area is over 27 square miles—an area nearly 550 times greater than that of the loch. The maximum depth of 33 feet was observed in the wide part near the foot of the loch, where there is a small circular area exceeding 25 feet in

depth. The volume of water is estimated at 19 million cubic feet, and the mean depth at over 14 feet. The area covered by less than 25 feet of water is about 27 acres, or 90 per cent. of the total area. The loch is not liable to any great change in level.

*Loch Fada* (see Plate XVII.).—Loch Fada lies about 2 miles to the north-north-west of the Fionn Loch, and a similar distance to the south-west of the head of Gruinard bay. It must not be confounded with Lochan Fada, situated to the south-east of the Fionn Loch and draining into the head of Loch Maree, which, though designated by the diminutive term "lochan," is a much larger sheet of water. This Lochan Fada has already been described when dealing with the lochs of the Ewe basin.\*

Loch Fada trends in a north-east and south-west direction, and is irregular in outline, with a length of  $1\frac{1}{2}$  miles, and a maximum breadth in the central portion of the loch of half a mile. Its waters cover an area of about 145 acres, or nearly one-quarter of a square mile, and it drains an area ten times greater, or over  $2\frac{1}{4}$  square miles. The maximum depth of 56 feet was observed near the centre of the wide central portion of the loch. The volume of water is estimated at 109 million cubic feet, and the mean depth at over 17 feet. Loch Fada was surveyed on July 31, 1902, but the elevation of the lake-surface could not be determined by levelling; when visited by the Ordnance Survey officers on August 10, 1870, the elevation was found to be 498·1 feet above the sea. Loch Fada is most irregular in conformation, with a few large islands, and with stones and boulders rising to the surface in many parts. The deepest water is found in the wide central portion, where there is a small 50-foot basin, based upon soundings of 51 and 56 feet, enclosed within an irregular 25-foot basin nearly half a mile in length by over a quarter of a mile in width. The main 10-foot basin is nearly a mile in length, approaching to within 250 yards from the north-east end. Outside the main 10-foot basin the bottom sinks in three places below that depth: (1) an isolated sounding of 13 feet in a large bay on the south-eastern shore towards the north-east end; (2) a sounding of 26 feet recorded about a quarter of a mile from the south-west end; and (3) an isolated sounding of 20 feet about 200 yards from the south-west end. Of the entire lake-floor about 45 per cent. is covered by less than 10 feet of water, and 25 per cent. by more than 25 feet of water. A series of temperatures taken at 5.30 p.m. on the date of the survey, in the deepest part of the loch, gave  $56^{\circ}\cdot 5$  Fahr. at the surface,  $55^{\circ}\cdot 5$  at 25 feet, and  $55^{\circ}\cdot 3$  at 50 feet.

*Loch na Beiste* (see Plate XVII.).—Loch na Beiste is a small sheet of water situated on the peninsula of Rudha Mòr, little more than half a mile from the western shore of Gruinard bay. The loch is reputed to be the abode of a great beast, and Mr. Banks, a former owner, attempted

\* See *Geographical Journal*, vol. 24, pp. 554-557, November, 1904.

## SUMMARY TABLE.

Giving Details concerning the Lochs in the Broom and Grunard Basins.

Loch.	Height above sea, feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.		
				Max.	Mean.		Max. Feet.	Mean. Feet.	Mean percent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.	
a' Bhraoin	812.3	83	2.66	0.40	0.25	9.4	73	86.60	50.2	192	383	669	0.66	13.03	19.7	
Droma	884.1	34	1.23	0.26	0.15	12.2	16	6.27	39.2	406	1036	32	0.18	3.00	16.7	
Achall	263.4	91	1.83	0.42	0.28	15.3	70	27.83	39.8	138	847	401	0.52	28.85	55.5	
na Sheallag	277.7	168	3.74	0.69	0.37	9.9	217	103.47	47.7	91	191	3,948	1.37	36.94	27.0	
Fionn	558.6	428	5.76	1.55	0.61	10.6	144	57.79	40.1	211	526	5,667	3.52	26.55	7.5	
	[Sept. 2, 1870]															
Dubh	—	74	1.23	0.40	0.26	21.1	88	42.38	48.1	74	153	374	0.32	6.24	19.5	
Beannach	—	46	0.63	0.35	0.19	30.2	27	6.45	23.9	123	516	22	0.12	4.65	38.8	
na Mòine Buige	—	51	0.76	0.21	0.11	14.9	60	24.62	41.0	67	163	59	0.09	0.78	8.7	
Eileach Mhic'ille Riabhach	—	25	0.70	0.22	0.07	10.0	38	14.13	42.8	112	262	19	0.05	27.12	542.2	
Fada	498.1	106	1.52	0.51	0.15	9.9	56	17.15	30.6	143	468	109	0.23	2.29	10.0	
	[Aug. 10, 1870]															
na Beiste	—	35	0.37	0.16	0.10	27.0	35	10.56	30.2	56	185	11	0.04	0.27	6.8	
		1141										11,311	7.10	111.50*	15.7	

\* The drainage area of Loch Eileach Mhic'ille Riabhach includes those of Lochs Fionn, Dubh, Beannach, and na Mòine Buige.

to pump out the water for the purpose of examining the beast, but he failed in drawing off the water. The most probable origin of the rumour about the beast lies in the fact that the moon at a certain time casts the shadow of two stones upon the water, the shadow resembling the outline of an animal. The loch is over one-third of a mile in length by one-sixth of a mile in maximum width, covering an area of about 23 acres, and comparatively deep, the maximum depth being 35 feet, and the mean depth  $10\frac{1}{2}$  feet. The soundings show no irregularities in the conformation of the lake-floor, the deep water being found towards the east end, while the south-western portion is shallow. Of the total area about 61 per cent. is covered by less than 10 feet of water, and 13 per cent. by more than 20 feet of water. The loch was surveyed on August 11, 1902, but the elevation above the sea could not be determined by levelling. The variation in the level of the water is said to be about a foot.

From the table on p. 47 it will be seen that in the eleven lochs under consideration 1141 soundings were taken, and that the aggregate area of the water-surface is over 7 square miles, so that the average number of soundings per square mile of surface is 161. The aggregate volume of water contained in the lochs is estimated at 11,311 millions of cubic feet. The area drained by these lochs is  $111\frac{1}{2}$  square miles, or  $15\frac{1}{2}$  times the area of the lochs.

## LOCHS OF THE GAIRLOCH BASIN.

EIGHT of the lochs within this basin (see Index Map, Fig. 4) were sounded by the Lake Survey, viz. Lochs an Eilein, na h-Oidche, Dubh, Bad an Sgalaig, a' Bhealaich, a' Ghobhainn, Braigh Horrisdale, and Bad a' Chròtha. An attempt was made to sound Loch Clair, but after taking one line of soundings in a north-easterly and south-westerly direction, on which a depth of 50 feet was attained, the work had to be abandoned on account of the leaking of the boat and the strong wind. Loch an Eilein drains by a stream entering Loch Gairloch at its north-eastern angle, while Lochs na h-Oidche, Dubh, and Bad an Sgalaig form a connected series draining by the river Kerry into the south-eastern angle of Loch Gairloch, and Lochs a' Bhealaich, a' Ghobhainn, Braigh Horrisdale, and Bad a' Chròtha form another connected series draining by a stream entering Loch Gairloch on its southern shore. Yellow trout occur in most of the lochs, and Loch Bad a' Chròtha contains also salmon and sea-trout, while Loch Bad an Sgalaig contains pike.

*Loch an Eilein* (see Plate XVIII.).—Loch an Eilein (or Badh a' Chream) is situated between Loch Ewe and Loch Gairloch, being distant from the former rather more than a mile, and from the latter over 2 miles. The loch is irregular in outline, with a maximum diameter in a north and south direction of two-thirds of a mile, while from east to west the greatest width is nearly half a mile, its waters covering an area of about 92 acres. The maximum depth of 34 feet was observed off the central portion of the south-western shore, where the outflowing stream leaves the loch. The volume of water is estimated at 58 million cubic feet, and the mean depth at nearly  $14\frac{1}{2}$  feet. The loch was surveyed on August 9, 1902, but the elevation of the lake-surface above the sea could not be determined.

The floor of Loch an Eilein is uneven; the 10-foot contour-line coincides approximately with the outline of the loch, but within this contour the bottom rises in the southern portion of the loch to form two small islands, and sinks in four places below the 20-foot level. The principal deep basin lies towards the middle of the south-western shore at the outflow, where soundings in 28, 30, and 34 feet were taken; a depth of 27 feet was found near the southern end, and a depth of 24 feet towards the northern end, while a sounding in 23 feet was recorded

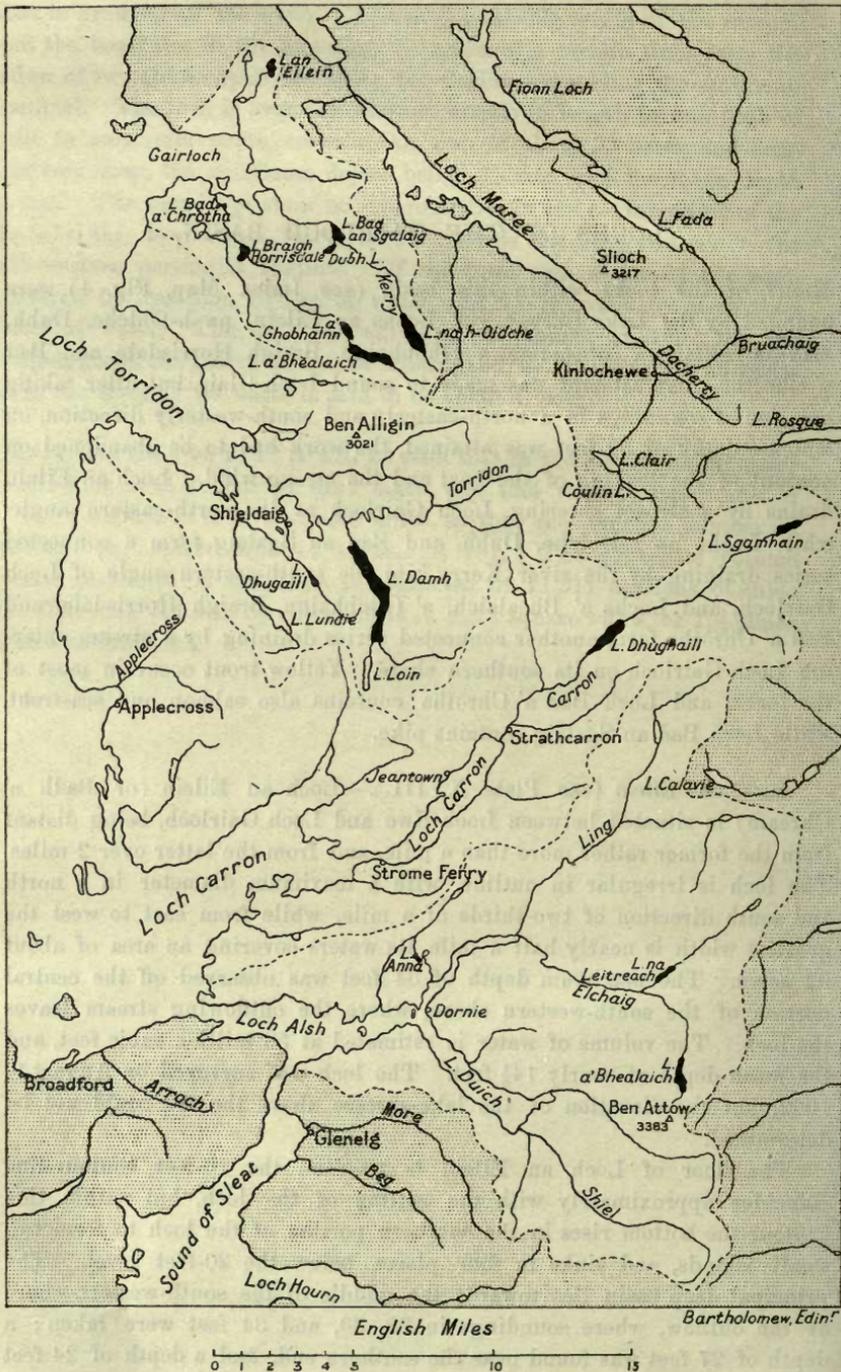


FIG. 4.—INDEX MAP OF THE GAIRLOCH, TORRIDON, CARRON, AND ALSH BASINS.

towards the central portion of the eastern shore. The area of the lake-floor covered by less than 10 feet of water is about 30 acres, and that covered by more than 20 feet of water is about 7 acres, so that about 60 per cent. of the bottom is covered by water between 10 and 20 feet in depth.

*Temperature Observations.*—The following temperatures taken in the position of the deepest sounding show little variation in the temperature of the water :—

Surface ...	...	...	...	...	...	56°·1 Fahr.
15 feet ...	...	...	...	...	...	56°·0 "
30 " ...	...	...	...	...	...	55°·5 "

*Loch na h-Oidche* (see Plate XIX.).—Loch na h-Oidche (or *nauigh*) lies about 6 miles to the south-east of Loch Gairloch, and about 3 miles from the shores of Loch Maree. The outflowing stream bifurcates about half a mile from the loch—one branch flowing into Loch Garbhaig, and thence into Loch Maree, while the other branch flows into Loch Bad an Sgalaig, and thence into Loch Gairloch, so that Loch na h-Oidche may be said to belong both to the Ewe basin and to the Gairloch basin. The district is mountainous, Beinn an Eòin rising from the eastern shore of the loch, and Bus-bheinn from the western shore, to heights exceeding 2800 feet, while to the south lie Beinn Dearg (2995 feet) and Beinn Alligin (3232 feet). The loch trends in a north-north-west and south-south-east direction, and is  $1\frac{3}{4}$  miles in length, with a maximum breadth of nearly half a mile. The superficial area is about 347 acres, or more than half a square mile, while the drainage area is about 3 square miles. The maximum depth of 121 feet was observed approximately near the centre of the loch. The volume of water contained in the loch is estimated at 816 millions of cubic feet, and the mean depth at 54 feet. The loch was surveyed on August 7, 1902, but the elevation above the sea could not be determined; judging from spot-levels on the Ordnance Survey maps the elevation may be about 1250 or 1260 feet above sea-level.

Loch na h-Oidche forms, on the whole, a simple basin, though with a slight undulation of the lake-floor in the deep water of the northern portion, which isolates a sounding in 100 feet from the main 100-foot basin. The cross-lines of soundings indicate a regularly sloping bottom from the eastern and western shores towards the centre; but, while the third line of soundings from the northern end attains a maximum depth of 100 feet, the fourth line of soundings farther to the south attains a maximum of only 89 feet. The 100-foot contour-line is thus interrupted by the undulation referred to, but the shallower contours all enclose continuous areas, and coincide approximately with the shore-line, the 75-foot basin being over a mile, and the 50-foot basin nearly  $1\frac{1}{4}$  miles in length. The flat-bottomed character of the loch is indicated by the figures in the following table, giving the approximate areas between the contour

lines drawn in at equal intervals, and the percentages to the total area, for it will be observed that the area between the 25-foot and 50-foot contours is smaller than in the deeper zones, while the area of the lake-floor covered by more than 100 feet of water is very considerable:—

Feet.	Acres.	Per cent.
0 to 25	107	30·9
25 „ 50	59	17·0
50 „ 75	70	20·1
75 „ 100	63	18·3
Over 100	48	13·7
	347	100·0

*Temperature Observations.*—A series of temperatures taken in the deepest part of the loch at 5 p.m. on the date of the survey gave the following results:—

Surface	...	...	...	...	...	51°·0	Fahr.
20 feet	...	...	...	...	...	51°·0	„
50 „	...	...	...	...	...	50°·5	„
80 „	...	...	...	...	...	47°·2	„
100 „	...	...	...	...	...	46°·8	„

These observations give a total range of temperature throughout the body of water of 4°·2, the “sprungschicht” occurring between 50 and 80 feet, where a fall of 3°·3 was recorded.

*Dubh Loch* (see Plate XVIII.).—*Dubh Loch* lies about 3 miles to the south-east of *Loch Gairloch*, and is almost continuous with *Loch Bad an Sgalaig*, the stream between them being about 300 yards in length, and the difference in level about 4 feet. The loch trends in a south-west and north-east direction, and is nearly a mile in length, varying considerably in width, the maximum breadth being one-third of a mile. Its waters cover an area of about 99 acres, and it drains an area of nearly  $2\frac{1}{2}$  square miles. The maximum depth of 68 feet was observed near the centre of the loch. The volume of water is estimated at 136 million cubic feet, and the mean depth at  $31\frac{3}{4}$  feet. The loch was surveyed on August 2, 1902, when the elevation of the lake-surface above the sea was ascertained to be 357·35 feet.

*Dubh Loch* forms a simple basin, the bottom sloping down on all sides towards the deepest part in the centre; the deeper water, however, is found nearer to the south-western than to the north-eastern end. The contour-lines follow approximately the trend of the shore-line, but approach closer to the north-western shore than to the opposite one, indicating a steeper slope in that direction. Thus, near the middle of the north-western shore a sounding in 36 feet was taken about 30 feet from shore, giving a gradient exceeding 1 in 1, and towards the south-west end another sounding in 36 feet was taken about 40 feet from shore. The 50-foot basin is half a mile, and the 25-foot basin three-quarters of a mile, in

length. The area of the lake-floor covered by less than 25 feet of water is about 39 acres, that covered by water between 25 and 50 feet in depth is about 37 acres, and that covered by more than 50 feet of water is about 23 acres.

*Temperature Observations.*—A series of temperatures taken in the deepest part of the loch at 1.30 p.m. on the date of the survey gave the following results :—

Surface ...	...	...	...	...	...	56°·0 Fahr.
5 feet ...	...	...	...	...	...	55°·9 "
10 "	...	...	...	...	...	55°·9 "
20 "	...	...	...	...	...	55°·8 "
50 "	...	...	...	...	...	55°·1 "
58 "	...	...	...	...	...	52°·2 "
65 "	...	...	...	...	...	51°·0 "

These observations give a total range of temperature of 5°·0, the upper layers of water being practically uniform in temperature, while between 50 and 65 feet there is a fall amounting to 4°·1.

*Loch Bad an Sgalaig* (see Plate XVIII.).—Loch Bad an Sgalaig (or Bad-na-Skallaig, or Batnaskalloch) is somewhat egg-shaped, though irregular, in outline (see Fig. 30), with a length from north to south exceeding two-thirds of a mile, and a maximum breadth from east to west of nearly half a mile. Its waters cover an area of about 137 acres, and it drains directly an area of over 7 square miles, but since it receives the overflow from Dubh Loch and Loch na h-Oidhe its total drainage area exceeds 12½ square miles. The maximum depth of 64 feet was observed approximately near the middle of the loch, though rather nearer the southern than the northern shore. The volume of water is estimated at 151 million cubic feet, and the mean depth at 24½ feet. The loch was surveyed on July 30, 1902, when the elevation of the lake-surface above the sea was determined by levelling from bench-mark as being 352·6 feet—almost identical with the elevation recorded by the Ordnance Survey officers on July 8, 1870, viz. 352·5 feet above sea-level. Between July 30 and August 2, 1902 (when Dubh Loch was sounded), the water in Loch Bad an Sgalaig rose to the extent of 9 inches.

Loch Bad an Sgalaig is simple in conformation; though the contour-lines are somewhat sinuous in character, the cross-lines of soundings indicate a bottom sloping gradually from the shores towards the deep water in the middle. In places the contour-lines approach close to each other or to the shore-line, as, for instance, off the central portion of the western shore, where a sounding in 20 feet was taken about 50 feet from shore, but on the whole the soundings give no indication of any very steep gradients. The following table gives the approximate areas between the contour-lines, and the percentages to the total area of the loch :—

Feet.	Acres.	Per cent.
0 to 25 ... ..	74 ...	54
25 ,, 50 ... ..	45 ...	33
Over 50 ... ..	18 ...	13
	137	100

*Temperature Observations.*—The following series of temperatures taken in the deepest part of the loch at 5 p.m. on the date of the survey shows (as in the case of Dubh Loch) a uniform temperature in the upper layers of water, with a maximum fall beyond the depth of 50 feet:—

Surface ... ..	55°·3 Fahr.
5 feet ... ..	55°·3 ,,
10 ,, ... ..	55°·3 ,,
20 ,, ... ..	55°·3 ,,
30 ,, ... ..	54°·9 ,,
50 ,, ... ..	54°·0 ,,
60 ,, ... ..	51°·8 ,,

Here the total range is only 3°·5, and the fall of temperature between 50 and 60 feet 2°·2; while in Dubh Loch the range was larger, the surface temperature being higher and the bottom temperature lower, and the fall of temperature greater, than in Loch Bad an Sgalaig.

*Loch a' Bhealaich* (see Plate XIX.).—Loch a' Bhealaich (or Vallich) lies less than a mile to the south-west of Loch na h-Oidche, and is almost continuous with Loch a' Ghobhainn, the stream flowing from Loch a' Bhealaich into Loch a' Ghobhainn being only about 200 yards in length. Loch a' Bhealaich trends in a west-north-west and east-south-east direction, and is  $1\frac{3}{4}$  miles in length, varying considerably in width, the maximum width being less than half a mile, while the mean breadth of the entire loch is a quarter of a mile. Its waters cover an area of about 279 acres, or nearly half a square mile, and it receives the drainage from an area of 5 square miles. The maximum depth of 92 feet was observed near the middle of the wide eastern portion, about a quarter of a mile from the east end of the loch and towards the northern shore. The volume of water is estimated at 398 millions of cubic feet, and the mean depth at  $32\frac{3}{4}$  feet. The loch was surveyed on August 8, 1902, but the elevation of the lake-surface above the sea could not be determined.

Loch a' Bhealaich is complex in conformation, including three deep basins exceeding 50 feet in depth, separated by shallower water, the shoalings coinciding with constrictions in the outline. The largest and deepest basin is contained in the wide eastern portion of the loch, where there is a 50-foot area nearly half a mile in length, by a quarter of a mile in maximum width. Separated from this eastern basin by a short interval, in which a maximum depth of 40 feet was observed, is a small central 50-foot area, based on soundings in 51, 55, and 55 feet, a quarter of a mile in length. This central area is separated by a longer interval, in which a

maximum depth of 44 feet was observed, from the small western 50-foot area, based on soundings in 51 and 58 feet, distant about 200 yards from the western end of the loch. The 25-foot contour encloses a continuous area from end to end, coinciding approximately with the shore-line. Off the southern shore, about half a mile from the western end, were some sunken rocks and stones covered by 1 to 2 feet of water. The following table gives the approximate areas between the contour-lines, and the percentages to the total area of the loch:—

Feet.			Acres.		Per cent.
0 to 25	...	...	121	...	43
25 ,, 50	...	...	104	...	38
50 ,, 75	...	...	37	...	13
Over 75	...	...	17	...	6
			279		100

The surface temperature on commencing the survey at 12.30 p.m. on August 8, 1902, was 54°·0 Fahr.

*Loch a' Ghobhainn* (see Plate XIX.).—*Loch a' Ghobhainn* (or *Gouen*) lies immediately to the north-west of *Loch a' Bhealaich*, and about 2 miles to the west of *Loch na h-Oidche*. The outflow is carried into *Loch Gaineamhach*, lying about a mile to the west-north-west, which was not surveyed because there was no boat on it. *Loch a' Ghobhainn* is irregularly elliptical in outline, and trends in a north-west and south-east direction, being about three-quarters of a mile in length and one-third of a mile in maximum breadth. Its waters cover an area of about 98 acres, and it drains directly an area of over a square mile, but since it receives the superfluent waters from *Loch a' Bhealaich* its total drainage area exceeds 6 square miles. The maximum depth of 28 feet was observed approximately in the middle of the loch. The volume of water is estimated at 54 million cubic feet, and the mean depth at 12½ feet. The loch was surveyed on the same day as *Loch a' Bhealaich*, August 8, 1902, but the elevation of the lake-surface above the sea could not be determined; judging from spot-levels and contour-lines on the Ordnance Survey maps the elevation of both these lochs must be just above the 1000 feet level.

Although the 10-foot and 20-foot contours enclose continuous areas, the floor of *Loch a' Ghobhainn* is rather irregular, especially in the south-eastern half of the loch, as evidenced by the sinuous character of the contours. The deeper water occurs in the north-western portion of the loch, and approaches close to the north-west end, a sounding in 27 feet having been taken within 100 yards from that end. Near the middle of the loch in the vicinity of the deepest sounding a rise of the bottom, covered by 15 feet of water and with deeper water on both sides, was observed, and similar irregularities occur towards the south-east, where a sounding in 6 feet was taken in a central position, and one in 9 feet near the south-western shore, surrounded by deeper water. Near the south-east



This series shows a total range of  $1^{\circ}9$  from surface to bottom, the upper layers of water being nearly uniform in temperature, while between 20 and 50 feet the fall was  $1^{\circ}6$ .

*Loch Bad a' Chròtha* (see Plate XVIII).—Loch Bad a' Chròtha (or Badachro) is a shallow expansion of the river, much overgrown with weeds, lying within half a mile of the southern shore of Loch Gairloch. It is irregular in outline and conformation, covering an area of about 44 acres, and draining directly an area of about 7 square miles; but since it receives the overflow from Lochs a' Bhealaich, a' Ghobhainn, and Braigh Horrisdale, its total drainage area exceeds 21 square miles—an area three hundred times greater than that of the loch. The maximum depth of 23 feet was observed in the north-eastern part of the loch. The volume of water is estimated at 12 million cubic feet, and the mean depth at 6 feet. The loch was surveyed on August 6, 1902, but the elevation of the lake-surface above the sea could not be determined. The area of the lake-floor covered by less than 10 feet of water is about 40 acres, or 90 per cent. of the total area; in five places soundings in depths exceeding 10 feet were recorded, one of them exceeding 20 feet, *i.e.* the deepest sounding in 23 feet. The temperature of the surface water on the date of the survey was  $58^{\circ}4$  Fahr.

## LOCHS OF THE TORRIDON BASIN.

ONLY two lochs within the Torridon basin were sounded by the Lake Survey, viz. Loch Damh, which drains into Upper Loch Torridon, and Loch Dhugaill, which drains into Loch Shildaig, a branch of Loch Torridon. Loch Lundie, which also drains into Loch Shildaig, and other smaller lochs, could not be surveyed for lack of facilities. The district abounds in deer forests and lofty mountains, and the scenery is of a true Highland character. Loch Damh contains salmon, sea-trout, and *salmo ferox*, as well as trout, while Loch Dhugaill contains salmon, sea-trout, and yellow trout; but the fishings are preserved.

*Loch Dhugaill* (see Plate XX.).—Loch Dhugaill (or Dougall) lies at the foot of Glen Shildaig (see Fig. 31), about a mile from the head of Loch Shildaig, the precipitous slopes of Ben Shildaig rising on the east. The loch trends in a north-west and south-east direction, and is narrowly triangular in outline, with the apex to the north-west. The length exceeds half a mile, and the maximum breadth at the south-east end is about a quarter of a mile. The superficial area is about 38 acres, and the drainage area over 4 square miles. The maximum depth of 108 feet was observed in the middle of the loch towards the south-east end. The volume of water is estimated at 63 million cubic feet, and the mean depth at  $38\frac{1}{4}$  feet. The loch was surveyed on August 22, 1902, but the elevation could not be determined; on July 1, 1869, the Ordnance Survey officers found the elevation to be 84·3 feet above the sea. The conformation of the basin is simple, the deeper water lying at the wide upper end of the loch. About 74 per cent. of the lake-floor is covered by less than 50 feet of water, while about 7 per cent. is covered by more than 100 feet of water. Temperatures taken in the deepest part of the loch gave 57°·0 Fahr. at the surface and 45°·7 at 100 feet, showing a range of 11°·3.

*Loch Damh* (see Plate XX.).—Loch Damh lies about a mile from the southern shore of Upper Loch Torridon, into which it drains by the river Balgay, Beinn Damph (2958 feet) rising from the eastern shore of the loch (see Fig. 32). The two little lochs, an Lòin and Coultric, at the head of Loch Damh, were not surveyed, but were seen to be largely filled with weeds, and are apparently shallow. Loch Damh trends nearly north and south, and is somewhat V-shaped in outline, with the limbs of the V

very much depressed. It is nearly 4 miles in length, with a maximum breadth of three-quarters of a mile, and a mean breadth of one-third of a mile. Its waters cover an area of about 851 acres, or  $1\frac{1}{3}$  square miles, and it drains an area of 41 square miles. The maximum depth of 206 feet was observed at the widest part of the loch, at the junction of the two limbs of the V. The volume of water is estimated at 2183 millions of cubic feet, and the mean depth at 59 feet. The loch was surveyed on August 21 and 22, 1902, when the elevation was found to be 129.0 feet above the sea, nearly identical with that determined by the Ordnance Survey officers on July 29, 1870, viz. 129.2 feet. The range in level is 4 to 5 feet, the water being lower than usual for the season at the time of the survey, and might rise 3 or 4 feet higher, and fall a foot lower.

Loch Damh is complex in conformation, there being three 25-foot basins separated from each other by shallower water. The northern basin is unimportant, with a maximum depth of 34 feet. The southern basin is of simple form, over three-quarters of a mile in length, and encloses a 100-foot basin over half a mile in length, having a maximum depth of 135 feet. The central basin is the largest and deepest, being  $2\frac{1}{2}$  miles in length, and enclosing towards its southern end a small 200-foot basin, elliptical in form, and nearly a quarter of a mile in length. At the northern end of this central basin the 50-foot contour is irregular, shallow water extending towards the middle of the loch, and approaching very close to a small area slightly exceeding 100 feet in depth. Here a sounding in 42 feet was recorded less than 30 yards from one in 115 feet, giving a gradient of nearly 1 in 1. The shore-slopes to the east of the 200-foot basin are fairly steep, a sounding in 84 feet having been taken about 40 yards from shore, and one in 134 feet about 90 yards from shore.

*Temperature Observations.*—Serial temperatures were taken in the deepest part of the loch on August 21, and in the southern basin on August 22, with the following results:—

Depth.	Central basin.	Southern basin.
	5.30 p.m., Aug. 21, 1902. 204 feet.	10.45 a.m., Aug. 22, 1902. 127 feet.
	° Fabr.	° Fabr.
Surface ...	56.5	56.8
10 feet ...	56.5	—
30 " ...	—	56.2
50 " ...	56.0	55.1
100 " ...	48.5	48.1
120 " ...	—	48.0
150 " ...	43.1	—
180 " ...	42.2	—
200 " ...	42.2	—

These observations show a range of  $14^{\circ}.6$  Fahr., the superficial layers of water down to 50 feet being nearly uniform in temperature, while between 50 and 100 feet there was a fall of  $7^{\circ}$  and  $7\frac{1}{2}^{\circ}$ . In the deepest part of the loch there was a further fall of  $5\frac{1}{2}^{\circ}$  between 100 and 150 feet.

## LOCHS OF THE CARRON BASIN.

THERE are two Carron rivers in Ross-shire, one flowing into the Dornoch firth on the east coast, the other into Loch Carron on the west coast. The latter is the one under consideration; it rises at the head of Glen Carron, and in its course passes through Lochs Sgamhain and Dhùghaill, which are here to be described. The scenery is grand and mountainous, and the fishing in the lochs, which is preserved, includes salmon, sea-trout, *salmo ferax*, and char.

*Loch Sgamhain* (see Plate XXI).—Loch Sgamhain (or Scaven) lies near the head of Glen Carron, with Beinn na Feusaige (2000 feet) rising on the north, and Moruisg (3026 feet) on the south, and distant only about  $2\frac{1}{2}$  miles from Loch Gown in the Conon basin, belonging to the eastern drainage system. The loch trends in a north-east and south-west direction, and exceeds a mile in length by one-third of a mile in maximum breadth. Its waters cover an area of about 141 acres, and it drains an area of  $7\frac{1}{2}$  square miles. The maximum depth of 72 feet was observed near the centre of the loch. The volume of water is estimated at 165 million cubic feet, and the mean depth at nearly 27 feet. The loch was surveyed on August 8, 1902, when the elevation was found to be 491.6 feet above the sea, as compared with 490.9 feet observed by the Ordnance Survey officers on August 12, 1870.

The shores of the loch are comparatively simple, but near the west end a considerable promontory known as Cnoc nan Sguad projects into the loch from the northern shore. There are two small islands in the centre of the loch, opposite Cnoc nan Sguad; between the islands and the promontory a depth of 32 feet was recorded, but between the islands and the southern shore the depth does not exceed 12 feet. The 25-foot basin extends nearly from end to end of the loch, but is very narrow in its western portion. The wide eastern portion encloses the 50-foot basin, which occupies a central position, and is about one-third of a mile in length, approaching close to the promontory of Cnoc nan Sguad on its eastern side. The area of the lake-floor covered by less than 25 feet of water is about 75 acres, or 53 per cent. of the total area.

*Loch Dhùghaill* (see Plate XXII).—Loch Dhùghaill (or Doule) lies about 4 miles from the head of Loch Carron, and about 6 miles south-west of Loch Sgamhain. It is surrounded by lofty mountains, Fuar Tholl

(2968 feet) rising to the north-west, and Creag a' Chaoruinn Eagan (2260 feet) to the south. On its south side the shore of the loch rises steeply to the ridge of Creag an Eilein, the highest part of which (1137 feet) is about a quarter of a mile distant. The loch trends north-east and south-west, and is 2 miles in length, with a maximum breadth of less than half a mile near the north-east end, whence it tapers off towards the south-west, the lower end for half a mile being merely a series of small expansions of the river Carron. Its waters cover an area of about 283 acres, and it drains directly an area of  $31\frac{1}{2}$  square miles, but since it receives the overflow from Loch Sgamhain the total drainage area is 39 square miles. The maximum depth of 179 feet was observed opposite the highest part of Creag an Eilein, less than half a mile from the north-east end. The volume of water is estimated at 823 million cubic feet, and the mean depth at nearly 67 feet. The loch was surveyed on August 6 and 7, 1902, when the elevation was found to be 93.1 feet above the sea.

The main body of the loch is simple in conformation, the contour-lines following approximately the shore-line, but there are two 100-foot basins, the main basin being over three-quarters of a mile in length, and approaching very close to the north-east end, soundings in 108 and 111 feet having been taken about 120 yards from shore; the smaller basin is based on a single sounding in 105 feet, and is separated from the main basin by a slight shoaling, covered by 97 feet of water, north of Eilean Mòr. There are two small basins over 25 feet in depth in the river-expansions at the south-western end of the loch, the larger having a maximum depth of 32 feet, the smaller based on a sounding in 28 feet.

*Temperature Observations.*—A series of temperatures taken in the deepest part of the loch at 4.30 p.m. on August 7, 1902, gave the following results:—

Surface ... ..	54°.5 Fahr.
25 feet ... ..	54°.5 "
50 " ... ..	54°.0 "
60 " ... ..	53°.5 "
70 " ... ..	50°.0 "
75 " ... ..	49°.3 "
100 " ... ..	47°.5 "
165 " ... ..	47°.0 "

These observations show a range from surface to bottom of  $7\frac{1}{2}^{\circ}$ , a fall of  $3\frac{1}{2}^{\circ}$  being recorded between 60 and 70 feet, while the decrease in temperature both above and below the "sprungschicht" is gradual.

From the following table it will be seen that in the twelve lochs under consideration nearly 1100 soundings were taken, and that the aggregate area of the water surface is nearly 4 square miles, so that the average number of soundings per square mile is 281. The aggregate volume of water contained in the lochs is estimated at 4921 millions of cubic feet. The area drained by these lochs is nearly  $98\frac{1}{2}$  square miles, or 25 times the area of the lochs.

## SUMMARY TABLE.

Giving Details concerning the Locks in the Gairloch, Torridon, and Carron Basins.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. Feet.	Mean Feet.	Mean per cent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
an Eilein	—	47	0·66	0·48	0·21	31·8	34	14·89	42·3	102	242	58	0·14	0·66	4·7
na h-Oidche	[about 1250]	92	1·78	0·44	0·31	17·9	121	53·95	44·6	75	169	816	0·54	2·91	15·4
Dubh	357·35	64	0·92	0·34	0·16	17·4	68	31·74	46·7	71	153	136	0·15	2·87	15·8
Bad an Sgalaig	352·6	92	0·69	0·46	0·32	46·4	64	25·26	39·5	57	144	151	0·22	12·66	57·3
a' Bhealach	—	95	1·78	0·38	0·25	14·0	92	32·74	35·6	102	287	398	0·44	5·04	11·5
a' Ghobhainn	—	50	0·73	0·36	0·21	28·8	28	12·59	46·6	143	306	54	0·15	6·09	40·6
Braigh Horriisdale	302·3	72	0·82	0·32	0·17	20·7	51	18·10	35·5	85	239	62	0·14	14·11	100·8
Bad a' Chrótha	—	29	0·63	0·23	0·11	17·5	23	6·08	26·4	145	547	12	0·07	21·13	301·9
Dhugaill	84·3	16	0·56	0·23	0·11	18·7	108	38·27	35·4	27	77	63	0·06	4·15	69·2
Damh	129·0	218	3·93	0·80	0·34	8·6	206	58·91	28·6	101	352	2183	1·33	20·99	15·8
Sgamhain	491·6	129	1·12	0·33	0·20	17·9	72	26·77	37·2	82	221	165	0·22	7·51	34·1
Dhùghaill	98·1	194	2·02	0·40	0·24	11·9	179	66·65	37·2	60	160	823	0·44	38·93	88·5
		1098										4921	3·90	98·46*	25·2

\* The drainage area of Loch Bad an Sgalaig includes those of Lochs na h-Oidche and Dubh; that of Loch Bad a' Chrótha includes those of Lochs a' Bhealach, a' Ghobhainn, and Braigh Horriisdale; that of Loch Dhùghaill includes that of Loch Sgamhain.

## LOCHS OF THE ALSH BASIN.

THE area draining into Loch Alsh and its two branches—Loch Duich and Loch Long—is an extensive one, but only three small lochs within the basin were sounded by the Lake Survey. The two more important ones, Loch na Leitreach and Loch a' Bhealaich, drain by the River Elchaig into the head of Loch Long; while the third and smallest one, Loch Anna, drains into the Allt Gleann Udalain, which flows into Loch Alsh on its northern shore. The large area draining into Loch Duich is almost entirely devoid of lakes. The scenery of the district is grand and mountainous, many of the peaks exceeding 3000, and some of them exceeding 3500, feet in height.

*Loch na Leitreach* (see Plate XXIII).—Loch na Leitreach lies about six miles east of the head of Loch Long, and about the same distance north-east of the head of Loch Duich. It trends in a south-west and north-east direction, and is widest towards the north-eastern end, narrowing gradually towards the outflow at the south-western end. It exceeds a mile in length, with a maximum breadth of one-fifth of a mile, the superficial area being about 84 acres. The area draining into it is about 12 square miles, including Loch Muirichinn (not surveyed) lying at the head of the glen at a high elevation. The maximum depth of 88 feet was observed near the middle of the loch. The volume of water is estimated<sup>a</sup> at 147 million cubic feet, and the mean depth at over 40 feet. The formation of the main basin is simple, the deeper water occupying the wide upper portion of the loch, a depth of 65 feet having been recorded close to the upper end, and the maximum depth of 88 feet about half a mile down the loch. Near the south-west end a depth of 31 feet was found, separated from the main basin by depths of 14 and 15 feet.

The loch was surveyed on October 10, 1904, when the elevation was supposed to be about 275.3 feet above the sea, that is to say, the water just covered the position indicated on the 6-inch Ordnance Survey map for a bench-mark placed at that altitude on the south side of the road at the north angle of the loch. The temperature of the water was practically uniform, the reading at the surface being 46°.2 Fahr., and at a depth of 80 feet 46°.0.

*Loch a' Bhealaich* (see Plate XXIV).—Loch a' Bhealaich lies about 4½ miles east of the head of Loch Duich, and 3½ miles south of Loch na

Leitreach. The loch trends nearly north and south, and is irregular in outline, two-thirds of a mile in length, and over a quarter of a mile in maximum breadth, the superficial area being about 78 acres, while the area draining into it is nearly 2 square miles. The maximum depth of 44 feet was found towards the lower (northern) end, in the vicinity of the two islands situated in the lower half of the loch. The volume of water is estimated at 56 million cubic feet, and the mean depth at  $16\frac{1}{2}$  feet. The loch was surveyed on October 25, 1904, when the elevation was found to be 1242.6 feet above the sea, as compared with 1242.3 feet determined by the officers of the Ordnance Survey on August 6, 1867. Serial observations taken in the deepest part of the loch showed that the temperature of the water was practically uniform, the reading at the surface being  $46^{\circ}.4$  Fahr., and at 25 feet and at the bottom  $46^{\circ}.2$ .

*Loch Anna* (see Plate XXIII).—Loch Anna lies about  $1\frac{1}{2}$  miles from the northern shore of Loch Alsh at Ardelve. It trends in a north-west and south-east direction, and is one-third of a mile in length, the superficial area being about 24 acres, and the drainage area about half a square mile. The volume is estimated at 13 million cubic feet, and the mean depth at nearly 13 feet. The wide northern portion contains the deepest basin, the maximum depth of 27 feet being found close to the north-eastern angle of the loch, while at the upper end there is a small basin based on soundings in 20 and 21 feet. The loch was surveyed on October 24, 1904, the elevation being estimated from spot-levels at about 1040 feet above the sea. The temperature of the water was found to be uniform, readings at the surface and at a depth of 20 feet giving  $44^{\circ}.6$  Fahr. in each case.

## LOCHS OF THE ALINE BASIN.

THE area draining into Loch Aline, a branch of the Sound of Mull, includes three lochs which were sounded by the Lake Survey, viz. Lochs Doire nam Mart, Arienas, and Teàrnait (see Index Map, Fig. 5). Loch



FIG. 5.—INDEX MAP OF THE ALINE BASIN AND THE ISLAND OF LISMORE.

Doire nam Mart lies little more than a mile to the south of the head of Loch Teacuis, a branch of Loch Sunart, but drains in the opposite direction by a short stream into the larger Loch Arienas, the overflow from which is carried by the river Aline into the head of Loch Aline. Loch Teàrnait lies to the east of the head of Loch Aline, into which it drains by

an independent stream, the Rannoch river. The fishings in these lochs are strictly preserved.

*Loch Doire nam Mart* (see Plate XXV.).—Loch Doire nam Mart (or Durinemart, or Durinemast) lies about  $3\frac{1}{2}$  miles north-west of Loch Aline. It trends in a north-west and south-east direction, and is nearly two-thirds of a mile in length, the maximum breadth exceeding a quarter of a mile. Its waters cover an area of about 72 acres, and the area draining into it exceeds 2 square miles. The maximum depth of 48 feet occupies a central position, but rather nearer the northern than the southern end. The volume of water is estimated at 67 million cubic feet, and the mean depth at over 21 feet. The loch was surveyed on August 18, 1904, when the elevation was found to be 37·2 feet above the sea; the Ordnance Survey officers found the elevation to be 36·6 feet above sea-level on March 16, 1867. The loch is simple in conformation, about 57 per cent. of the lake-floor being covered by less than 20 feet of water.

*Loch Arienas* (see Plate XXV.).—Loch Arienas (or Ari-Innes) lies about 2 miles north of Loch Aline, and trends in a west-north-west and east-south-east direction, being widest in the central part, and narrowing towards both ends. It is nearly 2 miles in length, with a maximum breadth of three-quarters of a mile, the mean breadth being about one-third of a mile. The shore-line is regular on the northern side, except for the projecting delta at the mouth of the Arienas burn, the southern shore being more irregular. The loch covers an area of about 420 acres, or two-thirds of a square mile, and the area draining into it exceeds 8 square miles, including that draining into Loch Doire nam Mart. The maximum depth of 116 feet was found almost in the centre of the loch. The volume of water is estimated at 1035 millions of cubic feet, and the mean depth at  $56\frac{1}{2}$  feet. The loch was surveyed on August 18 and 19, 1904, when the elevation was 31·3 feet above the sea; on March 4, 1867, the Ordnance Survey officers found the elevation to be 36·0 feet above sea-level, or nearly 5 feet higher than in 1904. Thus in March, 1867, Loch Doire nam Mart was only half a foot higher than Loch Arienas, whereas in August, 1904, it was about 6 feet higher.

Loch Arienas forms a simple basin, the contour-lines coinciding approximately with the outline, but approaching closer to the northern shore, where the slope is steepest. The following table, giving the areas between the contour-lines, indicates the flat-bottomed character of the basin:—

Feet.				Acres.		Per cent.
0 to 25	...	...	...	110	...	26·1
25 ,, 50	...	...	...	85	...	20·2
50 ,, 75	...	...	...	78	...	18·6
75 ,, 100	...	...	...	77	...	18·5
Over 100	...	...	...	70	...	16·6
				420	...	100·0



## LOCHS OF THE LEVEN BASIN.

THE area draining by the river Leven into Loch Leven, a branch of Loch Linnhe, is an extensive one, and includes four lochs which were sounded by the Lake Survey, viz. Loch a' Bhailidh, Lochan na Sàlach Uidhre, Lochan Inbhir, and Loch Éilde Mòr (see Index Map, Fig. 6). These four lochs receive the drainage from nearly 60 square miles of mountainous

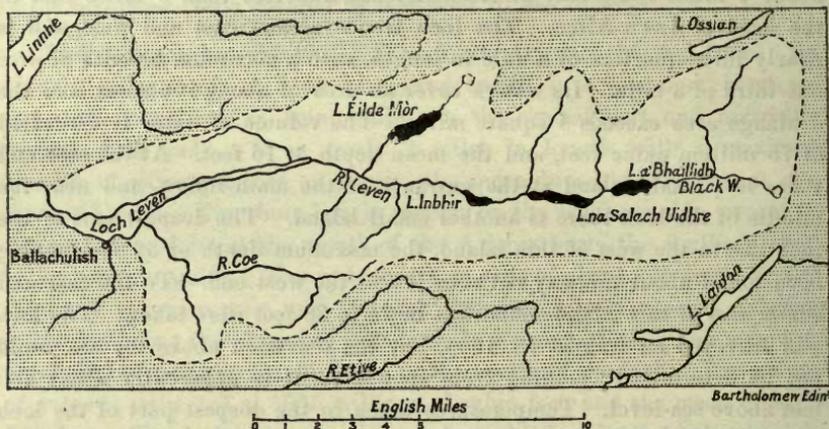


FIG. 6.—INDEX MAP OF THE LEVEN BASIN.

country, some of the peaks approaching 3000 feet in height, while Binnein Mòr, to the north-east of Loch Éilde Mòr, attains an elevation of 3700 feet above the sea. Loch Éilde Mòr is situated in Inverness-shire, draining by the Allt na h-Eilde into the river Leven, while the other three lochs lie on the boundary-line between Inverness-shire and Argyllshire, and may be looked upon as merely a series of expansions of the river Leven. The fishings in the lochs are preserved.

*Loch a' Bhailidh* (see Plate XXVI).—Loch a' Bhailidh (or Vallie) lies about 5 miles from Rannoch station on the West Highland Railway, and equi-distant from Loch Laidon in the Tay basin, and Loch Ossian in the Lochy basin. It is irregular in form, trending nearly east and west, and exceeding a mile in length, with a maximum breadth of about half a mile, the mean breadth being over a quarter of a mile. The loch is comparatively

shallow, the maximum depth being 20 feet, and the mean depth  $7\frac{1}{2}$  feet. The superficial area is about 184 acres, of which 74 per cent. is covered by less than 10 feet of water. The volume of water is estimated at 61 million cubic feet, and the drainage area extends to 30 square miles. The elevation above the sea could not be determined, but the Ordnance Survey maps give it as 1024 feet, though the date is not indicated.

There are three basins in which the depth exceeds 10 feet: one at the east end enclosing the maximum depth of the loch (20 feet), one in the central part of the loch having a maximum depth of 12 feet, and one at the west end having a maximum depth of 16 feet, taken close to a promontory projecting from the northern shore.

*Temperature Observations.*—Serial temperatures taken in the deepest part of the loch on May 19, 1903, gave the following results:—

Surface ... ..	53°·0 Fahr.
10 feet ... ..	50°·0 „
15 „ ... ..	46°·2 „
20 „ ... ..	46°·0 „

The range of temperature from surface to bottom was 7°, the greatest fall being one of 3°·8 between the depths of 10 and 15 feet.

*Lochan na Sùlach Uidhre* (see Plate XXVI.).—This loch lies to the west of Loch a' Bhaillidh, and is most irregular in outline, consisting of several divisions varying in size, connected by short channels. The two easternmost divisions could not be surveyed, being cut off from the main loch by a narrow channel, with a fall of about 5 feet. There is also a slight fall of 6 inches to a foot in the channel leading into the westernmost division of the loch, though the Ordnance Survey maps give the same level (1022 feet above the sea) for the entire loch west of the falls. On the whole, the loch is shallow, with many islands and boulders. The length of the portion surveyed is nearly 2 miles from east to west, and the maximum breadth over one-third of a mile. The area is about 245 acres, of which 86 per cent. is covered by less than 10 feet of water. In nine places soundings deeper than 10 feet were taken, mostly restricted areas varying from 10 to 12 feet in depth, and only in three places were depths of 20 feet and over recorded: (1) in the narrower portion between the two peninsulas called Rudha Dubh-mòr and Rudha Dubh-beag at the east end, where a sounding in 20 feet was taken; (2) to the west of Rudha Dubh-beag, where soundings in 22 and 26 feet were taken; and (3) in the westernmost division, where soundings in 23, 25, and 29 feet (the maximum depth recorded) were taken. The volume of water is estimated at 70 million cubic feet, and the mean depth at  $6\frac{1}{2}$  feet. The area draining directly into the loch is nearly 9 square miles, but as it receives the overflow from Loch a' Bhaillidh, the total drainage area is about  $38\frac{1}{2}$  square miles.

*Temperature Observations.*—Serial temperatures taken on May 19, 1903,

at the position of the deepest sounding, showed a range from surface to bottom of  $4^{\circ}$  Fahr., as follows:—

Surface ... ..	50°·0 Fahr.
10 feet ... ..	48°·0 „
20 „ ... ..	47°·5 „
28 „ ... ..	46°·0 „

*Lochan Inbhir* (see Plate XXVI.).—Lochan Inbhir lies about a mile to the west of Lochan na Sàlach Uidhre, and is also irregular in outline, with many islands and boulders. The length is about  $1\frac{1}{4}$  miles, and the maximum breadth one-third of a mile. The superficial area is about 145 acres, of which 81 per cent. is covered by less than 10 feet of water. Soundings in depths of 10 feet and over were taken in four places: (1) near the east end, where casts in 12 and 16 feet were made; (2) farther to the north-west and close to the northern shore, where an isolated sounding in 10 feet was taken; (3) in the central portion of the loch, where soundings in 11, 13, and 14 feet were taken; and (4) in the western portion of the loch, where there is a large deep basin, one-third of a mile in length, having a maximum depth of 50 feet, occupying a central position within the basin. The volume of water is estimated at 50 million cubic feet, and the mean depth at 8 feet. On the Ordnance Survey maps the elevation is given as 992 feet above the sea, which makes it 30 feet lower than the western division of Lochan na Sàlach Uidhre; a drift-mark was observed at the east end 7 feet above the level of the water. The drainage basin of Lochan Inbhir is a very large one, including the drainage areas of the two lochs further east, and amounting to  $52\frac{1}{2}$  square miles, or about 230 times greater than the area of the loch.

*Temperature Observations.*—Serial temperatures taken in the deepest part of the loch on May 20, 1903, gave the following results:—

Surface ... ..	49°·0 Fahr.
10 feet ... ..	49°·0 „
20 „ ... ..	46°·0 „
25 „ ... ..	45°·7 „
50 „ ... ..	45°·0 „

The range of temperature from surface to bottom was  $4^{\circ}$ , there being a fall of  $3^{\circ}$  between 10 and 20 feet, while the readings at the surface and at 10 feet were identical.

*Loch Éilde Mòr* (see Plate XXVII.).—Loch Éilde Mòr (or Eilt-More) is the largest loch within the basin, and is situated about 6 miles south-east from Ben Nevis, high mountains towering on both sides of the loch, culminating in Binnein Mòr (3700 feet) and Sgor na h-Eilde (3279 feet) on the north-west, and Glas Bheinn (2587 feet) on the east. Unlike the other lochs in the basin, Loch Éilde Mòr is regular in conformation, and comparatively deep, trending north-east and south-west, and about 2 miles in length, with a maximum breadth of a quarter of a mile. Its waters

## SUMMARY TABLE.

Giving Details concerning the Lochs in the Aish, Aline, and Leven Basins.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.		Drainage area.	
				Max.	Mean.		Max. Feet.	Mean. Feet.	Mean percent. of max.	Max.	Mean.		Total in square miles.	Ratio to area of loch.		
na Leitreach	[275 approx.]	39	1.14	0.20	0.12	10.1	88	40.39	45.8	86	149	147	0.18	11.90	91.6	
a' Bhealaich	1242.6	38	0.66	0.29	0.18	27.9	44	16.53	37.6	79	211	56	0.12	1.77	14.8	
Anna...	[1040 approx.]	38	0.35	0.19	0.10	28.6	27	12.74	47.2	68	145	13	0.04	0.44	11.0	
Doire nam Mart	37.2	26	0.62	0.29	0.18	29.4	48	21.93	44.4	68	153	67	0.11	2.31	12.5	
Arienas	31.3	82	1.85	0.75	0.35	19.2	116	56.60	48.8	84	173	1035	0.66	8.25	24.4	
Tearnait	[460 approx.]	43	0.70	0.38	0.24	33.8	39	16.16	41.4	95	229	75	0.17	4.16	13.2	
a' Bhaillidh	[1024 approx.]	89	1.04	0.48	0.28	26.6	20	7.60	38.0	275	723	61	0.29	29.91	18.2	
na Salach Uidhre	[1022 approx.]	92	1.90	0.86	0.20	10.6	29	6.54	23.4	358	1533	70	0.38	38.52	101.4	
Inbhir	[992 approx.]	57	1.30	0.32	0.19	15.8	50	7.85	18.7	151	807	50	0.23	52.57	228.6	
Eilde Mòr	[1110 approx.]	66	1.98	0.28	0.19	9.5	100	47.01	47.0	105	222	493	0.38	6.16	16.2	
		570										2067	2.51	85.25*	38.9	

\* The drainage area of Loch Arienas includes that of Loch Doire nam Mart; that of Lochan Inbhir includes those of Loch a' Bhaillidh and Lochan na Salach Uidhre.

cover an area of about 240 acres, and the area draining into it exceeds 6 square miles, including Loch Eilde Beag, lying a quarter of a mile to the north-east, which was not surveyed. The maximum depth of 100 feet was observed near the south-west end, about 150 yards from the north-western shore. The volume of water is estimated at 493 millions of cubic feet, and the mean depth at 47 feet. The loch was surveyed on May 13, 1903, the elevation being approximately 1110 feet above the sea.

The contour-lines of depth coincide approximately with the outline of the loch, but approach nearer to the north-western shore, off which the slope is steepest. Near the north-east end there is a slight shoaling covered by 70 feet of water, separating a sounding in 75 feet from the main deep basin. The following table, giving the areas between the contour-lines, and the percentages to the total area, indicates the general regularity and somewhat flat-bottomed character of the basin:—

Feet.				Acres.		Per cent.
0 to 25	...	...	...	65	...	27.1
25 „ 50	...	...	...	64	...	26.6
50 „ 75	...	...	...	66	...	27.5
Over 75	...	...	...	45	...	18.8
				240		100.0

The temperature of the surface water on the date of the survey was 47°·0 Fahr., but serials could not be attempted on account of a heavy gale.

From the table on p. 71 it will be seen that in the ten lochs under consideration 570 soundings were taken, and that the aggregate area of the water-surface is about  $2\frac{1}{2}$  square miles, so that the average number of soundings per square mile of surface is 228. The aggregate volume of water contained in the lochs is estimated at 2067 millions of cubic feet. The area drained by these lochs is  $85\frac{1}{4}$  square miles, or 34 times the area of the lochs.

## LOCHS OF THE OBAN BASIN.

THE only loch to be dealt with here is the little Loch Gleann a' Bhearraidh, lying about 2 miles to the south-south-west of Oban, from which the town draws its water-supply. It is a good trout loch, but the fishing is preserved.

*Loch Gleann a' Bhearraidh* (see Plate XXVIII.).—Loch Gleann a' Bhearraidh (or na Gleann na Bheathrach) is a long narrow loch, trending south-west and north-east, and about two-thirds of a mile in length, by one-eighth of a mile in maximum breadth, covering an area of about 29 acres, and draining an area of about half a square mile. The loch is cut into two portions by the narrows near the upper (south-west) end, where the road crosses the loch over a bridge. The upper portion beyond the bridge is shallow, the greatest depth being 9 feet; but the north-eastern portion is almost entirely covered by more than 10 feet of water, and there is a deep basin with a maximum depth of 48 feet near the lower end. The volume of water is estimated at 16 million cubic feet, and the mean depth at 13 feet. The basin is simple, and of the whole area 89 per cent. is covered by less than 20 feet of water, while 4 per cent. exceeds 40 feet in depth. When the loch was surveyed on May 28, 1903, the elevation above the sea could not be determined, but the water was standing up to the edge of the overflow passage at the weir.

## LOCHS OF THE FEOCHAN BASIN.

WITHIN the area draining into Loch Feochan, a branch of the Firth of Lorne, three lochs were sounded by the Lake Survey, viz. Lochs Nell, Scamadale, and na Sreinge (see Index Map, Fig. 7). Loch Nell drains by

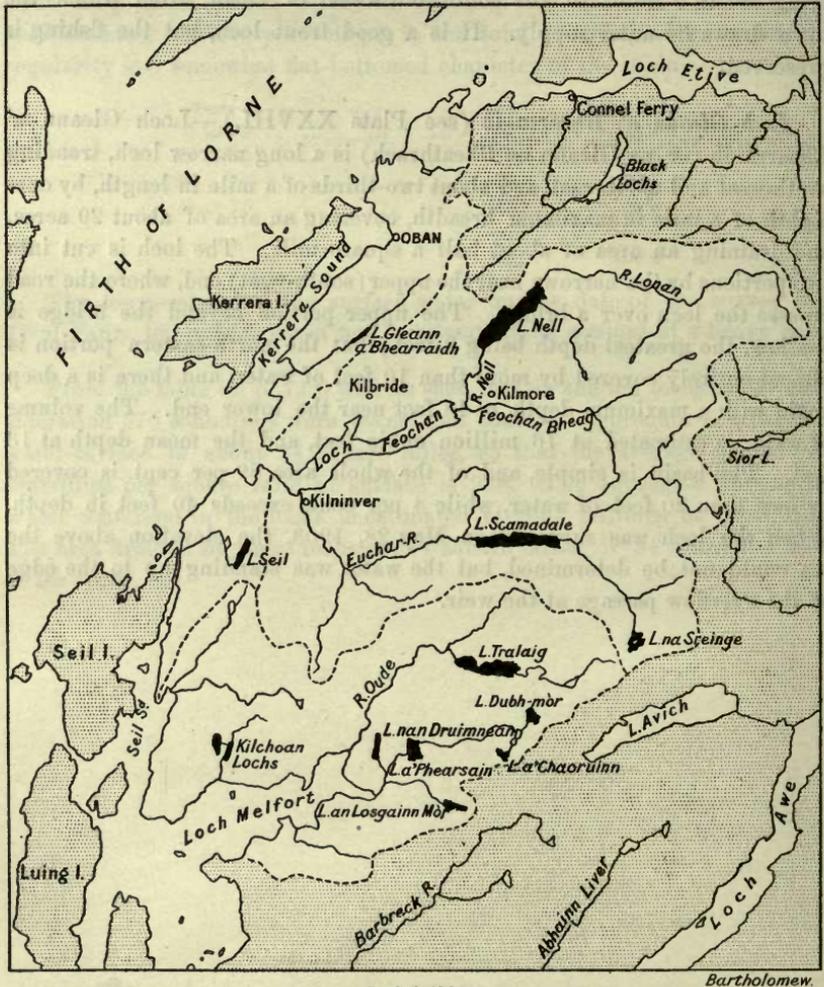


FIG. 7.—INDEX MAP OF THE OBAN, FEOCHAN, SEIL, AND MELFORT BASINS.

the river Nell into the head of Loch Feochan, while the other two drain by the river Euchar, entering on the southern side of the sea-loch at Kilninver. Lochs Nell and Scamadale are important lochs, both exceeding 100 feet in depth, and the fishing in all the lochs is good, Loch na Sreinge being referred to as one of the best fishing lochs in Lorn, though strictly preserved, while Loch Scamadale contains salmon, sea-trout, and yellow trout.

*Loch Nell* (see Plate XXIX.).—Loch Nell is situated about 2 miles south-east of Oban, and  $1\frac{1}{2}$  miles north-east of the head of Loch Feochan. It may at one time have formed part of the sea-loch, being separated from it by low, flat, alluvial ground. It is somewhat irregular in outline, with a constriction near the middle, and trends in a north-east and south-west direction, being nearly 2 miles in length, by over one-third of a mile in maximum breadth. Its waters cover an area of about 321 acres, or half a square mile, and the drainage area extends to about 14 square miles. The north-eastern half of the loch is comparatively shallow, *i.e.* less than 50 feet in depth, but the south-western portion is deep, the maximum depth of 115 feet having been recorded little more than half a mile from the lower end. The volume of water is estimated at 515 million cubic feet, and the mean depth at 37 feet. The loch was surveyed on May 27, 1903, when the elevation was found to be 49·2 feet above the sea.

The river Lonan has laid down a considerable delta at the head of the loch, as has also the Allt Cabrachan on the south-eastern shore, near the upper extremity. The conformation of the basin is simple, the 25-foot area being over a mile in length, and distant about half a mile from the head of the loch, while the 50-foot area is three-quarters of a mile, and the 100-foot area nearly half a mile, in length. Of the entire lake-floor about 56 per cent. is covered by less than 25 feet of water.

*Temperature Observations.*—Serial temperatures taken in the deepest part of the loch gave the following results:—

Surface ... ..	61°·4 Fahr.
5 feet ... ..	54°·9 "
10 " ... ..	52°·7 "
25 " ... ..	49°·9 "
50 " ... ..	49°·2 "
100 " ... ..	48°·2 "

The range of temperature from surface to bottom amounted to 13°·2, there being a fall of no less than 6°·5 between the surface and a depth of 5 feet—a fall equal to 1°·3 per foot of depth.

*Loch na Sreinge* (see Plate XXVIII.).—Loch na Sreinge (or String) is situated about  $2\frac{1}{2}$  miles to the south-east of Loch Scamadale, into which it drains by the Allt Braglenmore, and about a mile north of Loch Avich in the Etive basin. It is sub-triangular in outline, with the apex pointing in a south-west direction, and a large island occupies a central position in

the loch. It is half a mile in length, with a maximum breadth of one-third of a mile. The superficial area is about 56 acres, of which 63 per cent. is covered by less than 20 feet of water, and the drainage area is about 1 square mile. The maximum depth of 43 feet was observed off the central part of the western shore. The volume of water is estimated at 43 million cubic feet, and the mean depth at  $17\frac{1}{2}$  feet. The loch was surveyed on May 27, 1903, when the elevation was found to be 777.6 feet above the sea. The surface temperature was  $63^{\circ}0$  Fahr.

*Loch Scamadale* (see Plate XXIX.).—Loch Scamadale lies about  $2\frac{1}{2}$  miles from the head of Loch Feochan, and about 6 miles south-east from Oban. The loch trends east and west, and is over  $1\frac{1}{2}$  miles in length, the maximum breadth being about one-third of a mile, and the mean breadth less than a quarter of a mile. The superficial area exceeds one-third of a square mile, or about 226 acres, while the total area draining into it is nearly  $13\frac{1}{2}$  square miles, including that draining into Loch na Sreinge. The maximum depth of 145 feet was recorded near the centre of the loch, the mean depth being estimated at nearly 70 feet, and the volume of water at 685 millions of cubic feet. The loch was surveyed on June 1, 1903, when the elevation was found to be 221.0 feet above the sea, or 4 inches lower than that observed by the officers of the Ordnance Survey on July 25, 1864, viz. 221.3 feet.

The conformation of the basin is simple, the slope along the southern shore being much steeper than along the northern shore. The contour-lines are deflected southward off the alluvial cone at the mouth of the Eas Ruadh, on the northern shore, apparently as the result of the deposition of material brought down by that stream. The approximate areas between the contour-lines drawn in at intervals of 50 feet, and the percentages to the total area, are as follows:—

Feet.	Acres.	Per cent.
0 to 50	79	35.1
50 „ 100	89	39.4
Over 100	58	25.5
	226	100.0

This table shows the somewhat flat-bottomed character of the basin, the zone covered by water between 50 and 100 feet in depth being larger than the shore-zone covered by less than 50 feet of water.

*Temperature Observations.*—Serial temperatures, taken in the deepest part of the loch, gave the following results:—

Surface	...	...	...	...	...	...	55 <sup>o</sup> .0 Fahr.
20 feet	...	...	...	...	...	...	52 <sup>o</sup> .1 „
35 „	...	...	...	...	...	...	47 <sup>o</sup> .8 „
70 „	...	...	...	...	...	...	46 <sup>o</sup> .4 „
140 „	...	...	...	...	...	...	46 <sup>o</sup> .2 „

The range of temperature from surface to bottom amounted to  $8^{\circ}8$ , there being a fall of  $2^{\circ}9$  between the surface and a depth of 20 feet, and a further fall of  $4^{\circ}3$  between the depths of 20 and 35 feet.

## LOCHS OF THE SEIL BASIN.

Loch Seil is the only loch draining into Seil sound which was sounded by the Lake Survey.

*Loch Seil* (see Plate XXX.) lies little more than a mile south-west from Kilninver, to the south of the entrance to Loch Feochan. It trends north-north-east and south-south-west, and is two-thirds of a mile in length, the maximum breadth being about one-sixth of a mile, and the superficial area about 50 acres, while the area draining into it is about three-quarters of a square mile. The loch is comparatively deep, the maximum depth being 91 feet, and the mean depth 37 feet, the volume of water being estimated at 79 million cubic feet. The basin is simple, the sides sloping towards the centre, where the deepest water was found. The loch was surveyed on June 3, 1903, when the elevation was found to be 55·1 feet above the sea; the Ordnance Survey officers determined the elevation on July 25, 1898, as being 54·8 feet above sea-level.

*Temperature Observations.*—Serial temperatures taken in the deepest part of the loch gave the following results:—

Surface ...	...	...	...	...	...	59°·0 Fahr.
10 feet ...	...	...	...	...	...	58°·8 "
15 "	...	...	...	...	...	54°·1 "
20 "	...	...	...	...	...	52°·1 "
40 "	...	...	...	...	...	50°·2 "
80 "	...	...	...	...	...	48°·0 "

The range from surface to bottom was 11°, the greatest fall being one of 4°·7 between the depths of 10 and 15 feet—a fall nearly equal to 1° per foot of depth.

### LOCHS OF THE MELFORT BASIN.

THE area draining into Loch Melfort includes a complex series of lochs, eight of which were sounded by the Lake Survey, viz. Lochs Tralaig, Dubh-mòr, a' Chaoruinn, a' Phearsain, nan Druimnean, an Losgainn Mòr, and Kilchoan (upper and lower). Loch Tralaig, the most important one in the basin, drains by the river Oude into Fearnach bay, the north-eastern offshoot at the head of Loch Melfort, while Lochs Dubh-mòr, a' Chaoruinn, a' Phearsain, nan Druimnean, and an Losgainn Mòr drain into Loch na Cille, the south-eastern offshoot at the head of Loch Melfort; the two Kilchoan lochs drain into Kilchoan bay on the northern shore of Loch Melfort near its mouth. These lochs are fairly deep, all but one exceeding 40 feet, and two of them exceeding 100 feet, in depth. The scenery of the district is very fine, and the trout fishing in the lochs is good, some of them having been stocked with Loch Leven trout.

*Loch Tralaig* (see Plate XXXI).—Loch Tralaig is situated about 3 miles north-east of Kilmelfort, and little more than 2 miles north-west of Loch Avich in the Etive basin. It trends almost east and west, and exceeds a mile in length, with a maximum breadth of one-third of a mile. The loch covers an area of about 149 acres, or nearly a quarter of a square mile, and receives the drainage from an area of about  $4\frac{1}{2}$  square miles. The principal inflow is at the eastern end, while several minor streams enter on the southern side; the river Oude flows out at the west end. The volume of water is estimated at 267 millions of cubic feet, and the mean depth at 41 feet. The conformation is rather complex, the loch being divided into two basins, the larger and deeper one in the eastern portion of the loch, separated by a narrow channel from the smaller and shallower one at the west end. The maximum depth of 117 feet was observed in the centre of the eastern basin, while the deepest sounding taken in the western basin was 53 feet, the depth on the intervening barrier being 13 to 23 feet. Within the eastern basin there is in deep water a slight shoaling covered by 74 feet, with deeper water both to the west and to the east. The following table gives the approximate areas between the contour-lines, and the percentages to the total area:—

Feet.	Acres.	Per cent.
0 to 25 ... ..	57 ...	38·5
25 ,, 50 ... ..	39 ...	26·3
50 ,, 75 ... ..	33 ...	22·1
75 ,, 100 ... ..	12 ...	8·1
Over 100 ... ..	8 ...	5·0
	149	100·0

The loch was surveyed on June 6, 1903, when the elevation was found to be 420·0 feet above the sea; when visited by the Ordnance Survey officers on August 31, 1864, the elevation was 422·9 feet above sea-level.

*Temperature Observations.*—Serial temperatures were taken in the deepest part of the loch with the following results :—

Surface ... ..	60°·0 Fahr.
10 feet ... ..	59°·8 ,,
20 ,, ... ..	55°·7 ,,
45 ,, ... ..	47°·8 ,,
90 ,, ... ..	47°·0 ,,

These observations show a range of 13° from surface to bottom, there being a fall of about 4° between 10 and 20 feet, and a further fall of about 8° between 20 and 45 feet.

*Loch Dubh-mòr* (see Plate XXXI).—Loch Dubh-mòr is a small but comparatively very deep loch situated less than a mile to the south-east of Loch Tralaig, and little more than a mile to the north-west of Loch Avich. The outline is sub-circular, though the shore-line is somewhat irregular, the maximum diameter being about one-third of a mile. The superficial area is about 30 acres, of which 54 per cent. is covered by less than 50 feet of water, and 9 per cent. by more than 100 feet of water. Near the north-eastern shore is a small deep area enclosing the maximum depth of 114 feet, the shore-slope being steepest in this locality. The volume of water is estimated at 66 million cubic feet, and the mean depth at 51 feet. The elevation could not be determined by levelling, but is apparently about 900 feet above the sea.

*Temperature Observations.*—Serial temperatures taken on June 5, 1903, in the deepest part of the loch gave the following results :—

Surface ... ..	57°·4 Fahr.
10 feet ... ..	57°·0 ,,
15 ,, ... ..	54°·6 ,,
20 ,, ... ..	49°·2 ,,
25 ,, ... ..	47°·8 ,,
50 ,, ... ..	46°·0 ,,
100 ,, ... ..	44°·7 ,,

These readings are all lower than those taken at similar depths in the larger Loch Tralaig on the following day, the difference at the depth of 20 feet, for instance, being as much as 6°·5. The range shown by these observations is 12°·7, the most rapid fall being recorded between

15 and 20 feet—a fall of  $5^{\circ}4$  in the 5 feet of water, or more than  $1^{\circ}$  per foot of depth.

*Loch a' Chaoruinn* (see Plate XXXI.) is a small shallow loch, lying over half a mile to the south-west of Loch Dubh-mòr; weeds are abundant, and the bottom is covered by a peaty mud. The loch is irregular in outline, trending east and west, and one-third of a mile in length, with a maximum breadth across the middle of one-seventh of a mile. The area is about 18 acres, of which 60 per cent. is covered by less than 10 feet of water. The eastern portion is shallow, the deeper water lying in the western half, two soundings at the maximum depth of 20 feet being recorded, one in a central position, and the other near the west end. The volume is estimated at 7 million cubic feet, and the mean depth at  $9\frac{1}{2}$  feet. The elevation could not be determined, but is apparently about 860 feet above the sea. On June 5, 1903, the surface temperature was  $59^{\circ}2$  Fahr.

*Loch a' Phearsain* (see Plate XXXI.).—Loch a' Phearsain (variously spelt Phearsan, Pearsan, or Fearsan, or Parson's Loch) is situated close to Kilmelfort, at the head of Loch Melfort, and is nearly rectangular in outline, with a slight curve in the eastern shore-line, which causes a narrowing near the middle, where a shallow ridge crosses the loch. It trends almost north and south, and is nearly half a mile in length, with a maximum breadth of a quarter of a mile. The central ridge divides the loch into two basins, the maximum depth of 53 feet being found in the southern basin towards the eastern shore, the maximum depth in the northern basin being 41 feet. The superficial area is about 61 acres, of which about 36 per cent. is covered by less than 10 feet of water, while 10 per cent. is covered by more than 40 feet of water, the mean depth being  $19\frac{1}{2}$  feet. The loch lies in a rock-basin, and contains about 52 million cubic feet of water, the area draining into it being about  $3\frac{1}{2}$  square miles. The loch was surveyed on May 30, 1903, when the elevation was found to be 226.0 feet above the sea. The temperature of the surface water was  $60^{\circ}2$  Fahr.

*Loch nan Druimnean* (see Plate XXXI.).—Loch nan Druimnean (or Drimnin) is situated near the head of Loch Melfort, less than half a mile to the west of Loch a' Phearsain. It is a narrow loch, trending nearly north and south, and exceeding half a mile in length, its waters covering an area of about  $37\frac{1}{2}$  acres. The maximum depth of 59 feet was observed near the middle of the loch. The volume of water is estimated at 26 million cubic feet, and the mean depth at  $15\frac{1}{2}$  feet. The loch was surveyed on May 30, 1903, when the elevation was 169.3 feet above the sea; when visited by the Ordnance Survey officers on October 5, 1864, the elevation was 170.1 feet above sea-level. A shallow ridge crosses the loch towards the northern end, dividing it into two deep basins, the smaller basin at the north end having a maximum depth of 30 feet, while the

larger and deeper basin occupies the wide southern portion of the loch; the slope off the eastern shore is in places very steep. The surface temperature was 63°·0 Fahr.

*Loch an Losgaim Mòr* (see Plate XXXI.) is an irregular loch situated about a mile south-east of Loch a' Phearsain, trending nearly east and west, and exceeding half a mile in length. The loch lies in a rock-basin, and covers an area of about 33 acres, the volume being estimated at 27 million cubic feet. It was surveyed on May 29, 1903, when the elevation was 508·4 feet above the sea, which differs little from the elevation determined by the Ordnance Survey on October 4, 1864, viz. 508·6 feet. A prominent peninsula projecting from the southern shore cuts the loch into two unequal basins, the smaller to the east of the peninsula having a maximum depth of 29 feet, the larger occupying the wide portion of the loch to the west of the peninsula, and having a maximum depth of 51 feet. Of the entire lake-floor, about 68 per cent. is covered by less than 25 feet of water.

*Temperature Observations.*—Serial temperatures taken in the deepest part gave the following results:—

Surface ...	...	...	...	...	...	60°·4 Fahr.
10 feet ...	...	...	...	...	...	58°·0 „
20 „ ...	...	...	...	...	...	54°·8 „
40 „ ...	...	...	...	...	...	49°·5 „

These observations show a range of about 11° from surface to bottom, the fall of temperature being tolerably uniform.

*Kilchoan Lochs* (see Plate XXX.)—Two small lochs trending in a north and south direction, and situated in close proximity about half a mile from the northern shore of Loch Melfort, are known as the Kilchoan Lochs. Both lie in rocky basins, and are separated by a ridge of rock, the difference in level being about 42 feet.

*Upper Kilchoan Loch* is the larger and deeper of the two, and is about one-third of a mile in length, covering an area of about 23 acres. The maximum depth of 70 feet was found rather nearer the northern than the southern end. The volume of water is estimated at 29 million cubic feet, and the mean depth at 29½ feet. The basin is simple, and the contour-lines coincide approximately with the outline of the loch, about half the lake-floor being covered by less than 25 feet of water. The loch was surveyed on June 2, 1903, the elevation being approximately 378 feet above the sea.

*Lower Kilchoan Loch* is rather longer than the upper one, while the breadth is nearly uniform throughout, and equal to about one-twelfth of a mile, or 150 yards. It is fairly deep, the maximum depth being 45 feet, and the mean depth 20 feet, the volume of water being estimated at 16 million cubic feet. The superficial area is about 18 acres, of which

## SUMMARY TABLE.

Giving Details concerning the Lochs in the Oban, Feochan, Seil, and Melfort Basins.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Max. breadth per cent. of length.	Depth.		Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. Feet.	Mean Feet.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
Gleann a' Bhearraidh	—	73	0·64	0·12	0·07	11·1	48	12·79	26·6	70	264	0·05	0·50	10·0
Nell ...	49·2	93	1·68	0·38	0·30	17·8	115	36·80	32·0	77	241	0·50	13·80	27·6
na Sreinge ...	777·6	74	0·50	0·30	0·17	34·9	43	17·50	40·8	61	151	0·09	0·92	10·2
Scamadale ...	221·0	88	1·54	0·32	0·23	14·9	145	69·58	48·0	56	117	0·35	13·35	38·1
Seil ...	55·1	82	0·68	0·16	0·11	16·8	91	36·70	40·4	39	98	0·08	0·77	9·6
Traibig ...	420·0	73	1·16	0·32	0·20	17·3	117	41·08	35·1	52	149	0·23	4·42	19·2
Dubh-mòr ...	[about 900]	65	0·30	0·28	0·17	56·7	114	50·98	44·7	14	31	0·05	0·32	6·4
a' Chaoruinn ...	[about 860]	47	0·32	0·14	0·09	27·9	20	9·37	46·8	85	180	0·08	0·20	6·7
a' Phearsain ...	226·0	64	0·46	0·24	0·21	45·2	53	19·44	36·7	46	125	0·10	3·51	35·1
nan Drumnean ...	169·3	48	0·52	0·16	0·11	21·7	59	15·61	26·5	47	176	0·06	0·57	9·5
an Losgainn Mòr ...	508·4	58	0·52	0·18	0·10	19·0	57	18·65	32·7	48	147	0·05	0·57	11·4
Kilchoan (Upper) ...	[378 app.]	52	0·32	0·16	0·11	34·5	70	29·54	42·2	24	57	0·04	0·14	3·5
" (Lower) ...	[336 app.]	38	0·36	0·08	0·08	21·6	45	20·30	45·1	42	94	0·03	0·54	18·0
		855									1828	1·66	34·03*	20·5

\* The drainage area of Loch Scamadale includes that of Loch na Sreinge; that of Loch a' Phearsain includes those of Lochs Dubh-mòr and a' Chaoruinn; that of Lower Kilchoan Loch includes that of Upper Kilchoan Loch.



## THE LOCHS OF BUTE.

THE principal lochs on the island of Bute (see Index Map, Fig. 8) are situated close together in the southern half of the island, close to the county town of Rothesay. They are all narrow and elongate, with their axes running parallel from south-south-west to north-north-east. Owing to lack of boats only Loch Fad and the Kirk Dam were surveyed. Loch Ascog, a mile in length, and half a mile east of Loch Fad, is used as the water supply of Rothesay.

*Loch Fad* (see Plate XXXII).—Loch Fad lies immediately south of the town of Rothesay, from which it is about a mile distant. It lies between dense woods on the west and cultivated land on the east. The greater part of the west shore is formed by a range of low crags, but the north end is gravelly. The east shore is also gravelly in the northern part, but from the rocky wooded knoll of Bardarroch wood southward rock is exposed at many places.

The length is nearly 2 miles, and the greatest breadth, at the south end, a quarter of a mile. It is a simple basin of very uniform contour and of very moderate depth, with steep sides, nearly flat bottom, and the central depth varying but little from end to end. The loch is greatly narrowed in the middle, but is not reduced in depth there. The maximum depth of 38 feet is a little south of the narrows. There is a terrace laid down by the Barnauld burn. The mean depth is 17 feet, the area rather more than a quarter of a square mile, or about 176 acres, and the volume 232 millions of cubic feet.

The drainage area exceeds 2 square miles. The only important in-flowing stream is the Barnauld burn. The outflow is by the channel, in length merely the width of the road, leading to the Kirk Dam. When surveyed on August 21, 1906, the surface was 34·5 feet above sea-level, nearly identical with the elevation determined by the Ordnance Survey on June 10, 1896, viz. 34·3 feet.

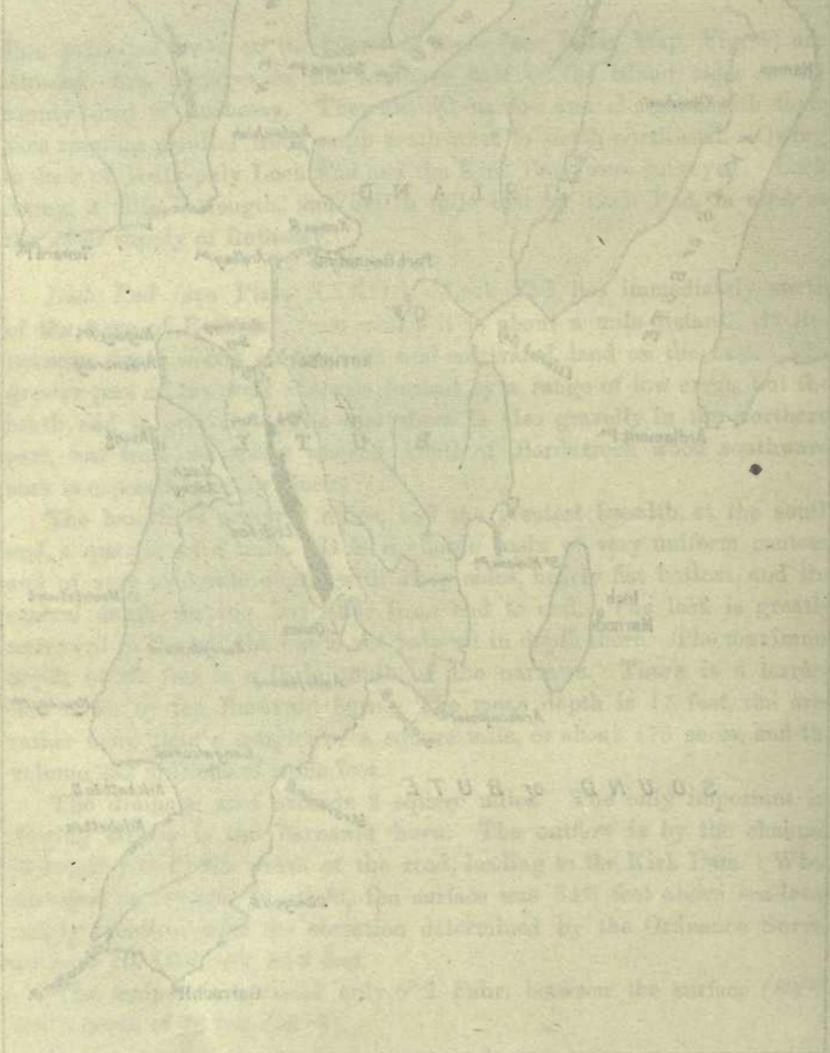
The temperature varied only 0°·2 Fahr. between the surface (60°·5) and a depth of 26 feet (60°·3).

*Kirk Dam* (see Plate XXXII).—The Kirk Dam is the northern portion of Loch Fad, and lies close to the town of Rothesay. It is separated from Loch Fad by an embankment, but communicates freely



It is three-quarters of a mile long, narrow in the middle, and expanded towards each end to one-sixth of a mile. The bottom is absolutely flat, as indicated by the invariable soundings, the maximum and the mean depth alike 5 feet. The area is about 54 acres, and the volume 12 millions of cubic feet. It is dammed at the north end, and communicates with the sea by a mill lade. The drainage area, including Loch Fad, is fully 3 square miles.

The temperature was  $62^{\circ}0$  Fahr. throughout, nearly  $2^{\circ}$  higher than Loch Fad.



## LOCHS OF THE EACHAIG BASIN.

THE only loch within this basin (see Index Map, Fig. 9) is Loch Eck, which drains by the river Eachaig into the Holy loch, an arm of the Clyde estuary, and is one of the best-known in the western Highlands, the coach-road from Dunoon to Strachur running along its eastern shore, and carrying numerous tourists during the season. The head of the loch is distant about 4 miles from the shores of Loch Fyne at Strachur, while the foot of the loch is distant about 3 miles from the head of the Holy loch. The scenery of the district is very fine, most of the hills on both sides of the loch exceeding 1000 feet, and some of them exceeding 2000 feet, in height, culminating in Beinn Bheula (2527 feet) at the north end of the loch, and Beinn Mhor (2433 feet) to the west of the lower portion of the loch. The fishing in the loch includes salmon and sea-trout, as well as loch-trout.

*Loch Eck* (see Plate XXXIII).—Loch Eck partakes of the elongate character of many Highland lochs, trending nearly north and south on the whole, but with a curve in the outline towards the upper end, which causes the extreme northern portion to trend in a north-west direction. It is 6 miles in length, with a maximum breadth of over one-third of a mile, the mean breadth being about a quarter of a mile. The superficial area is about  $1\frac{3}{4}$  square miles, while the area draining into the loch is nearly 40 square miles. The shore-line is sinuous, while numerous streams have cut their way into the sides of the mountains, and empty themselves into the loch on both sides. The principal inflowing stream is the river Cur, which enters at the upper end, draining with its tributaries the mountain-slopes at the head of the basin. The loch is fairly deep, the maximum depth observed being 139 feet, while the mean depth exceeds 50 feet, the volume of water being estimated at 2381 millions of cubic feet. The 25-foot contour is continuous from end to end of the loch, but the 50-foot basin is divided into two portions by a slight shoaling just south of the narrows at Coirantee, the deepest sounding on the shoaling being 46 feet. The 75-foot contour is cut up into four portions: the largest and deepest is nearly 2 miles in length, and is distant little more than half a mile from the upper extremity; the others are of small extent, one close to the northern end, based on a sounding in 79 feet; a second about  $1\frac{1}{4}$  miles from the southern end, based on soundings in 75 and 81 feet; and a third



about half a mile from the southern end, based on soundings in 82 and 83 feet. Within the largest 75-foot basin, and about  $1\frac{1}{2}$  miles from the northern end, is the 100-foot basin, about half a mile in length, enclosing the maximum depth of the loch. The areas between the contour-lines at intervals of 50 feet, and the percentages to the total area, are as follows:—

Feet.				Acres.		Per cent.
0 to 50	...	...	...	571	...	52·3
50 „ 100	...	...	...	485	...	44·6
Over 100	...	...	...	34	...	3·1
				1090		100·0

Loch Eck was surveyed on June 20–22, 1903, when the elevation was found to be 66·6 feet above the sea, which agrees closely with the elevation determined by the Ordnance Survey officers on June 9, 1863, viz. 66·8 feet.

*Temperature Observations.*—Two serial temperatures were taken on June 22, 1903, one at 2.30 p.m., in the deepest part of the loch, in 135 feet of water, and the other at noon, about a quarter of a mile to the south, in 74 feet of water, with the following results:—

	Deepest basin, 135 feet.	South of deepest basin, 74 feet.
Surface ... ..	60°·0	58°·4
20 feet ... ..	58°·9	57°·5
27½ „ ... ..	54°·9	—
35 „ ... ..	52°·0	56°·3
42½ „ ... ..	—	51°·5
50 „ ... ..	50°·0	50°·2
70 „ ... ..	—	48°·3
100 „ ... ..	47°·8	—
130 „ ... ..	46°·5	—

The series in the deepest basin shows a range from surface to bottom of 13°·5, the greatest fall being one of 4° between 20 and 27½ feet. The shallower series shows a range of 10°·1 in the 70 feet of water, the greatest fall being one of 4°·8 between 35 and 42½ feet. The “sprungschicht” was thus observed nearer the surface in the deepest basin, the temperature at a depth of 35 feet being 4°·3 lower than at the same depth in the shallower water to the south, while at 50 feet the temperature was practically the same in both series. A strong south-east wind was blowing at the time these observations were taken, which might explain the higher readings at the surface and at 20 feet in the more northerly position.

From the following table it will be seen that in the three lochs under consideration 372 soundings were taken, and that the aggregate area of the water-surface is just over 2 square miles, so that the average number of soundings per square mile of surface is 180. The aggregate volume of water contained in the lochs is estimated at 2525 millions of cubic feet. The area drained by these lochs is nearly 43 square miles, or 21 times the area of the lochs.

## SUMMARY TABLE.

Giving Details concerning the Lochs in Bute and the Eachaig Bas in.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.		Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
			Max.	Mean.	Max.	Mean.		Max. Feet.	Mean Feet.	Mean per cent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
Fad ...	84.5	53	1.60	0.24	0.17	10.6	38	17.13	46.8	498	0.28	2.25	8.0			
Kirk Dam ...	34.5	26	0.80	0.18	0.10	12.5	5	5	—	84	0.09	3.24	36.0			
Eck ...	66.6	293	6.02	0.38	0.28	4.7	139	50.16	36.1	229	1.70	39.40	23.2			
		372									2.07	42.64*	20.6			

\* The drainage area of Kirk Dam includes that of Loch Fad.

## LOCHS OF THE DOON BASIN.

THE river Doon, rising among the highest mountains of the south of Scotland, drains a considerable mountain mass in the counties of Ayr and Kirkcudbright. The elevated southern portion of the valley of the Doon includes a number of lochs of moderate size, and Loch Doon, the greatest lake of the south of Scotland. There are some small lochs in the lowland part of the valley. Six of the lochs in the basin were surveyed. Lochs Regar and Macaterick, the largest in the basin after Loch Doon, Loch Enoch, a beautiful loch lying at a great elevation on the east side of the Merrick, and a number of smaller lochs, could not be surveyed. The superficial areas of the six lochs surveyed added together give a total area of 2.6 square miles; their combined volumes amount to 1648 millions of cubic feet, and together they drain nearly 60 square miles of country.

After leaving the mountains near Dalmellington, the river Doon flows for some 15 miles through fertile lowlands, and enters the Firth of Clyde 2 miles to the south of the town of Ayr (see Index Map, Fig. 10).

*Loch Doon* (see Plate XXXIV).—This large and beautiful loch is situated on the borders of the counties of Ayr and Kirkcudbright, about 15 miles south-east of the town of Ayr. It lies amid hills, which increase in height towards the head of the loch till an elevation of 2000 feet is reached on the east side; while to the south the Galloway highlands rise, peak above peak, culminating in the Merrick (2764 feet) and Corserine (2668 feet). The hills of the upper part of the glen are rugged and dark; the lower end is wooded. Here the river, immediately on issuing from the loch, rushes as a torrent through Ness Glen, a glen of unrivalled beauty. There is much smooth, polished rock exposed on the shores, and in the form of whale-backed islands.

The valley occupied by the loch runs north and south, but the axis of the loch is strongly curved. In form, Loch Doon is narrow and elongate, like the majority of the highland lochs. It measures 5 miles in length, in a straight line between the ends, nearly 6 miles following the central line. The greatest breadth, at the Ford of Moak, about 2 miles from the lower end, is over  $1\frac{1}{2}$  miles, and the mean breadth is one-third of a mile. The maximum depth,  $1\frac{1}{2}$  miles from the head of the loch, is 100 feet, and the mean depth 27 feet. The superficial area is 2 square miles, and the volume of water 1517 millions of cubic feet. The area drained amounts



nearly in the broadest part. It is of small extent (a quarter of a mile long), and has a greatest depth of 58 feet. At the date of the survey (July 10 and 11, 1903) the surface was 673·3 feet above sea-level. This was considerably higher than when surveyed by the Ordnance Survey (though the elevation is not given on the 6-inch maps), and the outline of the loch, especially in the southern portion, was greatly altered in consequence.

A series of temperatures taken near the deepest part of the loch showed a range of 4°·6 Fahr., as shown in the following table:—

Surface ...	...	...	...	...	...	59°·6 Fahr.
10 feet ...	...	...	...	...	...	58°·9 "
25 " ...	...	...	...	...	...	58°·0 "
50 " ...	...	...	...	...	...	56°·8 "
80 " ...	...	...	...	...	...	55°·0 "

*Derclach Loch* (see Plate XXXV.).—A very small, narrow, and shallow loch, lying close to the west of Loch Finlas. It is a little over half a mile long, one-eighth of a mile broad, and 12 feet deep. The bottom at the deeper part is flat, and 10 feet deep over a considerable area. The maximum of 12 feet is close to the west end; the eastern part is very narrow, irregular, and from 1 to 6 feet deep. The mean depth is 7½ feet, the area 38 acres, and the volume 12 millions of cubic feet. The area drained is scarcely a square mile. No important stream enters, and the burn flowing east to Loch Finlas is only about 100 yards long. The shores are of peat and gravel, with rock exposed at several points. The surface was 837·15 feet above sea-level on July 13, 1903. The temperature was 58°·4 Fahr. throughout.

*Loch Finlas* (see Plate XXXV.).—A small, narrow, dumb-bell-shaped loch, with a straight axis running north-west to south-east, lying among moorland, 1½ miles to the west of Loch Doon. The hills on the north rise to a little over 1000 feet (200 feet above the loch); on the south they are higher, Craiglee attaining a height of 1716 feet. The loch is 1½ miles long and one-third of a mile broad in the north-western expansion. The channel connecting the ends of the loch is three-quarters of a mile long, for the most part less than 100 yards broad, and varies in depth from 6 to 18 feet in the centre. The north-western expansion is the deeper. The bottom is irregular, with the maximum depth of 40 feet in the centre, but other soundings up to 34 feet close inshore. The south-eastern expansion is much shallower, and nearly flat-bottomed, with a depth of about 10 feet, and a little depression of 26 feet at the end of the strait. The mean depth is nearly 10 feet, the area about 138 acres, and the volume of water 58 millions of cubic feet. The area drained is nearly 5 square miles. The natural outflow is by the Garpel burn, issuing from the east end of the loch; but the water is now utilized as the water supply for the town of Ayr. The surface was 829·65 feet above sea-level on July 13, 1903.

Temperatures taken in the deepest part showed a range of less than 2° Fahr. :—

Surface ... ..	58°·2 Fahr.
10 feet ... ..	58°·2 „
20 „ ... ..	58°·0 „
25 „ ... ..	57°·7 „
30 „ ... ..	57°·0 „
40 „ ... ..	56°·3 „

*Loch Muck* (see Plate XXXVI.).—A small loch, shaped like the letter L, lying about a mile east of Loch Doon, with which it is connected by the Muck burn, entering the head of the bay called the Ford of Moak. It is barely half a mile long and one-fifth of a mile broad at the southern end. There is a slight constriction in the middle, where the depth is only 7 feet. North of this is a slight depression, with a depth of 10 feet; to the south is a deeper basin, with the maximum depth of 22 feet. The mean depth is 7 feet, the area about 28 acres, and the volume 9 millions of cubic feet. The area drained is about  $1\frac{1}{2}$  square miles. The Polnaskie burn enters just where the Muck burn flows out southwards. The surface was 992·4 feet above the sea on July 20, 1903.

Temperatures in the deepest part gave—

Surface ... ..	58°·2 Fahr.
5 feet ... ..	57°·4 „
10 „ ... ..	56°·4 „
20 „ ... ..	56°·3 „

*Bogton Loch* (see Plate XXXVI.).—This is simply a shallow, weedy expansion of the river Doon, 2 miles north-west of the outflow from Loch Doon. It is two-thirds of a mile long, a quarter of a mile broad, and 4 feet in greatest depth. The bottom is flat, and nearly everywhere covered by 3 feet of water. The mean depth is 2 feet, the area 60 acres, and the volume 5 millions of cubic feet. The area drained, including Loch Doon, etc., amounts to 60 square miles. The surface was 522·6 feet above sea-level on July 13, 1903, or more than 150 feet lower than Loch Doon, showing the very rapid fall in the intervening 2 miles.

The surface temperature at the north-west end was 56°·6 Fahr., at the south end 57°·5.

*Martnaham Loch* (see Plate XXXVI.).—A narrow loch, lying 5 miles south-east of the town of Ayr. The shores are partly wooded, partly smooth fields. Nearly midway between the ends the ruins of Martnaham Castle stand on an island, connected with the south shore by a causeway. The shores of the western basin are fringed with reeds. The axis of the loch runs north-east to south-west. The length is  $1\frac{1}{4}$  miles, and the greatest breadth, in the middle of the loch, where a deep bay runs to the north-west, is a quarter of a mile.

There are three small basins, the western one being the deepest, with

the maximum of 29 feet, the central one 22 feet, and the eastern one 16 feet. In the channel at the castle the depth is only 5 feet. The mean depth is nearly 10 feet, the area about 113 acres, and the volume 47 millions of cubic feet. The drainage area measures  $3\frac{3}{4}$  square miles. The Sandhill burn flows in at the north-east corner of the loch. The outflow, at the south-west corner, has been dammed up by a bank of stones in order to supply a mill lade; but there is no sluice, and the overflow is divided between the two streams. The surface was 268·8 feet above sea-level on November 6, 1906.

The temperature at the surface was  $45^{\circ}\cdot 5$  Fahr., and at 25 feet  $45^{\circ}\cdot 3$ .

*Loch Linn* (see Plate XXXVII).—A very small loch lying at an elevation of 1300 ft above the sea, near the source of the river Givran. Flung rocky and heather-clad hills surround the loch, rising more steeply on the north side. The promontories round the loch are of red granite, and there is a broad rocky flat table to the south. The loch is about 1 mile long and the greatest breadth one-seventh of a mile. The loch is shallow and the bottom nearly flat with a greatest depth of 7 feet and a mean depth of 4 feet. The area is about 13 acres, and the volume 3 millions of cubic feet. The area drained is fully a square mile. The water of Givran flows northward from the west end of the loch. The surface temperature on November 1, 1906, was  $42^{\circ}\cdot 5$  Fahr.

*Loch Linn* (see Plate XXXVII).—A very small loch, immediately west of the first. It lies among rough moorland, and on the south rises a rugged and sparsely wooded hill. The loch is over one-third of a mile long and the greatest breadth one-seventh of a mile. It is flat-bottomed and shallow, the maximum depth 7 feet and the mean depth 4 feet. The area is about 20 acres, and the volume 5 millions of cubic feet. The drainage area at the west end is filled with reeds and floating plants. The water of Givran flows in at the west end, and out at the east, as a broad short stream flowing round numerous islands to Loch Linn. The height of

## LOCHS OF THE GIRVAN BASIN.

THE river Girvan, or water of Girvan, which has its entire course in the county of Ayr, originates in a tiny lochan, called Loch Girvan Eye, on the northern slope of Shalloch on Minnoch, a hill 2520 feet in height, near the county border. For some 10 miles from its source it runs from south-east to north-west, parallel to, and very near, the river Doon, passing through a number of small lochs, the chief of which is Loch Bradan, then at the village of Kirkmichael it turns at right angles and flows south-westward to the sea at Girvan. Three lochs near the source of the river were surveyed, Loch Bradan, of fair size, the other two (Loch Lure and Cornish Loch) very small. The three lochs have a combined area of nearly one-fifth of a square mile, a volume of 24 millions of cubic feet, and drainage area of  $5\frac{1}{2}$  square miles.

*Cornish Loch* (see Plate XXXVII).—A very small loch lying at an elevation of 1303·7 feet above the sea, near the source of the river Girvan. Rugged rocky and heather-clad hills surround the loch, rising more steeply on the north side. The promontories round the shore are of rock. On the south side, where two large streams enter, one of them the water of Girvan, there is a broad boggy flat, liable to floods. The length, from east to west, is a quarter of a mile, and the greatest breadth one-seventh of a mile. The loch is shallow and the bottom nearly flat, with a greatest depth of 7 feet, and a mean depth of 4 feet. The area is about 15 acres, and the volume 3 millions of cubic feet. The area drained is fully a square mile. The water of Girvan flows northward from the west end of the loch.

The surface temperature on November 1, 1906, was 42°·5 Fahr.

*Loch Lure* (see Plate XXXVII).—A very small loch, immediately west of Loch Bradan. It lies among rough moorland, and on the south rises a rugged and sparsely wooded hill. The length is over one-third of a mile, and the greatest breadth one-seventh of a mile. It is flat-bottomed and shallow, the maximum depth 7 feet and the mean depth 4 feet. A large area at the west end is filled with reeds and floating plants. The area is about 29 acres, and the volume 5 millions of cubic feet. The drainage area, including Cornish Loch, is nearly 4 square miles. The water of Girvan flows in at the west end, and out at the east, as a broad short stream flowing around numerous islands to Loch Bradan. The height of

the surface above sea-level could not be determined. It was at the time of the survey (November 2, 1906) 2 feet higher than Loch Bradan, which was estimated to be 990 feet above sea-level.

The surface temperature was  $43^{\circ}\cdot 0$  Fahr., or  $1\frac{1}{2}^{\circ}$  less than that of Loch Bradan on the previous day.

*Loch Bradan* (see Plate XXXVII).—A small loch, situated high up among the hills, 4 miles west of Loch Doon. The rough moorland surrounding the loch rises more steeply on the south. The shores are stony, with a few exposures of rock. The length is nearly one mile, and the maximum breadth, in the middle of the length, a quarter of a mile. The bottom is nearly flat, with a maximum depth of 8 feet, and a mean depth of  $4\frac{1}{2}$  feet. Many banks of stones and single boulders project above the surface. The area is about 82 acres, and the volume 16 millions of cubic feet. The drainage area is about  $5\frac{1}{2}$  square miles, and includes Lochs Cornish and Lure. The water of Girvan enters at the west end of the loch, and flows out northward from the north-east corner. Two other large burns enter on the south side, one of them coming from Loch Brechowie.

No bench-mark could be found near the loch. The level was estimated at about 990 feet above the sea on November 1, 1906.

The temperature was  $44^{\circ}\cdot 5$  Fahr. throughout.

## LOCHS OF THE STINCHAR BASIN.

THE river Stinchar, rising on Shalloch hill, about a mile west of the source of the Girvan, runs its whole course roughly parallel to that river, and entirely within the county of Ayr, entering the Firth of Clyde a few miles further south, at Ballantrae. There are only a few insignificant lochs in the basin. The largest, Loch Linfern, near the source of the river, could not be surveyed. The only loch surveyed, Drumlamford Loch, is near the Wigtownshire border, on a tributary of the Stinchar, the Duisk burn.

*Drumlamford Loch* (see Plate XXXVII).—A small round loch in southern Ayrshire, 4 miles south-east of Barrhill station, amid moor and partly cultivated land. Shore of peat and stones. It measures a quarter of a mile in greatest diameter. A large island, on which are some trees, divides the loch into two parts, the connecting channels being mere ditches. The larger eastern portion has a depth of 26 feet, the very small western portion a depth of 23 feet. The mean depth is 11 feet, the area about 28 acres, and the volume of water 13 millions of cubic feet. The outflow is by a ditch, leading by the Lavery burn and the Duisk burn into the river Stinchar. The water is raised by a windmill, and supplies Drumlamford house.

The surface level is estimated at rather less than 450 feet above the sea.

## LOCHS OF THE RYAN BASIN.

THE area draining into Loch Ryan (see Index Map, Fig. 11) includes only two lochs that were sounded by the Lake Survey: the Black Loch and the White Loch of Inch, both considerable sheets of water, situated in the grounds of Lochinch Castle; their overflow is carried by the Messan burn,

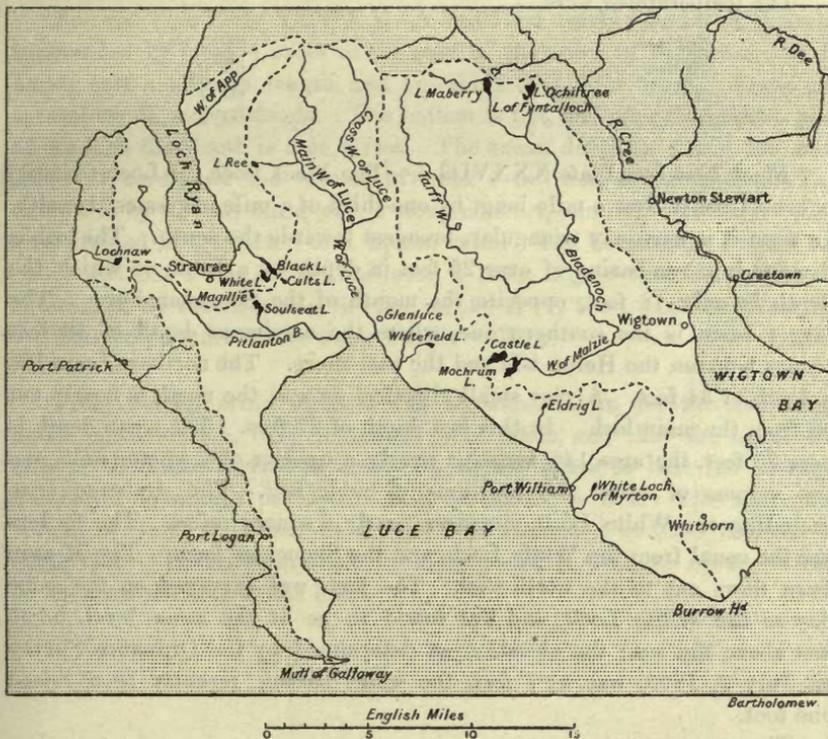


FIG. 11.—INDEX MAP OF THE RYAN, GALDENOCH, LUCE, AND BLADENOCH BASINS.

a stream about 2 miles long, into Loch Ryan, 2 miles north-east of the town of Stranraer. They are both at the same level, being connected by a broad canal. Their axes run parallel to one another, from south-east to north-west. Their combined areas amount to half a square mile, their volumes to 241 millions of cubic feet, and they drain an area of 6 square miles.



## LOCHS OF THE GALDENOCH BASIN.

A VERY small basin on the west coast of Wigtownshire, having only one small, shallow, and apparently artificial, loch (Lochnaw), within the grounds of Lochnaw Castle. The Galdenoch has a course of about three miles in length, flowing from Lochnaw westward to the North Channel.

*Lochnaw* (see Plate XXXIX).—A small and nearly round loch, entirely surrounded by trees, 4 miles to the west of the town of Stranraer. It is barely half a mile in length, and one-third of a mile broad. There are several small, stony islands. The bottom is flat, and over the greater part of the loch the depth is 5 or 6 feet. The mean depth is 4 feet, the area about 47 acres, and the volume of water 9 millions of cubic feet. The outflow is by a small burn, with a stony channel, running westward. The area drained is a quarter of a square mile. The surface, on August 22, 1903, was 255·3 feet above sea-level, a little higher than the elevation determined by the Ordnance Survey, on April 11, 1893, viz. 255·1 feet.

The temperature of the water was 61°·0 Fahr.

From the following table it will be seen that in the thirteen lochs under consideration, 1028 soundings were taken, and that the aggregate area of the water-surface is nearly  $3\frac{1}{2}$  square miles, so that the average number of soundings per square mile of surface is 302. The aggregate volume of water contained in the lochs is estimated at 1935 millions of cubic feet. The area drained by these lochs is over 75 square miles, or 22 times the area of the lochs.

SUMMARY TABLE.  
*Giving Details concerning the Lochs in the Doon, Girvan, Stinchar, Ryan, and Galdenoch Basins.*

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.	Max. Feet.	Mean Feet.	Mean per cent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
Doon...	673-8	483	5.64	1.34	0.36	100	26.71	26.7	298	1115	1517	2.04	50.41	24.7
Derelach	837.15	31	0.58	0.14	0.10	12	7.42	61.8	255	418	12	0.06	0.72	12.0
Finlas	829.65	108	1.46	0.30	0.15	40	9.69	24.2	193	795	58	0.22	3.95	18.0
Muck	942.4	33	0.42	0.18	0.10	22	7.12	32.3	101	312	9	0.04	1.43	35.8
Bogton	522.6	51	0.66	0.28	0.14	4	2.00	50.0	871	1742	5	0.09	59.81	664.6
Martnaham	268.8	54	1.26	0.25	0.14	29	9.61	33.1	256	682	47	0.18	9.72	20.8
Cornish	1303.7	12	0.26	0.14	0.09	7	3.80	54.6	196	359	3	0.02	1.16	58.0
Lure...	[992 appr.]	19	0.40	0.15	0.11	7	3.90	56.1	302	537	5	0.05	3.69	73.8
Bradan	[990 appr.]	36	0.90	0.22	0.14	8	4.40	55.3	594	1075	16	0.13	5.56	42.8
Drumlamford	[nearly 450]	42	0.28	0.26	0.16	26	10.82	41.6	57	137	13	0.04	0.13	3.2
White	53.95	52	0.88	0.42	0.26	38	14.09	37.1	122	329	92	0.23	1.15	5.0
Black	53.95	67	1.36	0.36	0.17	50	23.37	46.7	144	307	149	0.23	5.65	24.6
Lochnaw	255.3	40	0.44	0.31	0.17	6	4.32	71.9	387	538	9	0.07	0.29	4.1
		1028									1985	3.40	75.16*	22.1

\* The drainage area of Bogton Loch includes those of Lochs Doon, Derelach, Finlas, and Muck; that of Loch Bradan includes those of Lochs Cornish and Lure; and that of Black Loch includes that of White Loch.

## LOCHS OF THE LUCE BASIN.

THE area draining into Luce bay, on the south coast of Scotland, includes seven lochs which were sounded by the Lake Survey, viz. Lochs Magillie, Soulseat, Cults, Ree, Whitefield, Eldrig, and White Loch of Myrton. The three first-mentioned lochs drain by the Pitlanton burn into the head of Luce bay near Glenluce, while Loch Ree lies farther to the north, near the eastern shore of Loch Ryan, and drains by the Penwherran burn into the water of Luce, the three last-mentioned lochs draining, each by an independent stream, into Luce bay on its eastern side.

*Loch Magillie* (see Plate XXXIX.).—A very small oblong loch, situated 150 yards to the north of Soulseat Loch. It is surrounded by fields, and has stony shores. It is nearly a quarter of a mile long and one-tenth of a mile broad. The greater part of the bottom is covered by 7 feet of water, or less, deepening slightly towards the east shore, close to which is the maximum depth of 14 feet. The mean depth is over 5 feet, the area about 12 acres, and the volume 3 millions of cubic feet. The drainage area is about one-third of a square mile. There is no apparent outflow, but the water is supposed to percolate through the gravel to Loch Soulseat. When surveyed on August 21, 1903, the surface was  $4\frac{1}{2}$  feet above Loch Soulseat, or 43·7 feet above sea-level. The temperature at the surface was  $61^{\circ}\cdot 2$  Fabr., and at 10 feet  $61^{\circ}\cdot 0$ .

*Loch Soulseat* (see Plate XXXIX.).—Soulseat Loch lies half a mile south-west of Castle Kennedy station on the Portpatrick and Wigtownshire railway. It is surrounded by fields, and in form is irregular, being divided into two portions by a wooded promontory, on which are the ruins of Soulseat abbey. The length is over half a mile, and the greatest breadth over a quarter of a mile. The constriction at the promontory is 16 feet deep, the basin on the north has the maximum depth of 42 feet near the north shore, while the southern basin is shallower, with a depth of 30 feet near the east shore. The mean depth is over 15 feet, the area 71 acres, and the volume 47 millions of cubic feet. The drainage area, including Loch Magillie, is  $1\frac{1}{4}$  square miles. The Soulseat burn flows south about 2 miles into the Pitlanton burn. The surface, on August 20, 1903, was 39·1 feet above sea-level, nearly identical with the elevation determined by the Ordnance Survey on June 8, 1893, viz. 39·0 feet. The

temperature at the surface, was  $61^{\circ}8$  Fahr., at 10 feet  $61^{\circ}5$ , at 20 feet  $61^{\circ}2$ , and at 30 feet  $60^{\circ}0$ .

*Cults Loch* (see Plate XXXIX.).—A small, nearly round loch, lying among fields about a mile north-east of Castle Kennedy station. There is a boggy stretch to the north-east of the loch, but no outflow could be found. The greater part of the loch is shallow, and there is a crannog a little west of the centre. East of the crannog is a small basin, in which there is a maximum depth of 28 feet. The length is a quarter of a mile, from south-east to north-west, and the breadth one-sixth of a mile. The mean depth is over 9 feet, the area 17 acres, and the volume 7 millions of cubic feet. The drainage area is one-eighth of a square mile. The loch is supposed to drain into the Chleury burn, which joins the Pitlanton burn near its mouth. The surface, on August 20, 1903, was 65·4 feet above sea-level, rather higher than the elevation determined by the Ordnance Survey on August 2, 1893, viz. 65·1 feet. The temperature at the surface was  $61^{\circ}3$ , at 10 feet  $60^{\circ}6$ , at 20 feet  $60^{\circ}0$ , and at 25 feet  $58^{\circ}7$ .

*Loch Ree* (see Plate CXXI.).—A small and nearly square loch in the basin of the Luce, lying at an elevation of 639·6 feet, among the hills on the east side of Loch Ryan, from which it is about 3 miles distant. The length, measured diagonally from north-west to south-east, is one-third of a mile, and the greatest breadth a quarter of a mile. The basin is simple, deeper towards the south side and east end, the slope of the bottom from north and west very gradual. The maximum depth is 44 feet, and the mean depth 15 feet. The area of the surface is about 27 acres, and the volume of water 18 millions of cubic feet. The drainage is entirely local, from boggy moorland, the area drained extending to half a square mile. A very small burn flows out eastward, and by the Penwherran burn joins the main water of Luce, which enters the sea in Luce bay at Glenluce. The temperature of the water on August 21, 1903, was uniformly  $57^{\circ}5$  Fahr. from the surface to a depth of 40 feet.

*Whitefield Loch* (see Plate XXXIX.).—A small loch, with densely wooded shores, about 3 miles south-east of the village of Glenluce. It is half a mile long, and a quarter of a mile in greatest breadth. It is a simple basin, with flattish bottom, interrupted by a number of small islands. The maximum depth, 14 feet, is in the centre. The mean depth is 8 feet, the area 47 acres, and the volume 16 millions of cubic feet. The drainage area is fully half a square mile. No large stream enters the loch. The outflow is by a small stream flowing out from the west end. The surface on October 17, 1906, was 192·7 feet above sea-level, or a foot higher than the elevation determined by the Ordnance Survey on April 12, 1893, viz. 191·7 feet. The temperature was  $49^{\circ}0$  Fahr. throughout.

*Eldrig Loch* (see Plate XXXIX.).—A small loch in Wigtownshire, 8 miles south-west of the town of Wigtown. It is surrounded by pasture and

moorland, rising little higher than the loch. There are many boulders along the west shore, and no rock was seen except at two spots on the east side. The south end is weedy, and there the Old Mill burn goes out through a boggy flat. Of the two crannogs the southern is covered, and the northern is just seen above the surface. The length is half a mile, and the greatest breadth one-sixth of a mile. The bottom is nearly flat, and the maximum depth of 10 feet is in the centre of the loch. The mean depth is nearly 6 feet, the area 44 acres, and the volume 11 millions of cubic feet. The drainage area is about 2 square miles. The surface on October 16, 1906, was 239·1 feet above sea-level, much higher than the elevation found by the Ordnance Survey on May 25, 1893, viz. 234·5 feet. The temperature was 50°·0 Fahr. throughout.

*White Loch of Myrton* (see Plate XXXIX.).—A small loch, within the woods of Monreith park, 1 mile east of the village of Port William in Wigtownshire. The shore where seen is stony. The south end and west side are fringed with dense beds of reeds. The length is a little over half a mile, and the greatest breadth nearly a quarter of a mile. It is a simple basin, and relatively deep. The maximum depth of 40 feet is near the west shore and the north end. The mean depth is nearly 14 feet, the area 51 acres, and the volume 30 millions of cubic feet. The drainage area is three-quarters of a square mile. The Barsalloch burn flows out from the south end, and is controlled by a sluice. On the date of the survey, October 15, 1906, the surface was 98·7 feet above sea-level, or a foot higher than the elevation determined by the Ordnance Survey on May 28, 1894, viz. 97·6 feet. The temperature at the surface was 53°·0 Fahr., and at 36 feet it was 52°·7, or only 0°·3 lower.

## LOCHS OF THE BLADENOCH BASIN.

WITHIN the area drained by the river Bladenoch five lochs were sounded by the Lake Survey, viz. Lochs Maberry, Fyntalloch, Ochiltree, Castle, and Mochrum. The three first-mentioned lochs lie towards the headwaters of the basin on the borders of Ayrshire and Wigtownshire, the boundary-line crossing Loch Maberry, while the two last-mentioned lochs are situated near the eastern shore of Luce bay. The river Bladenoch rises in Loch Maberry, and after a course of some 3 miles is joined by the Beoch Burn, bearing the overflow from Lochs Fyntalloch and Ochiltree, while the Water of Malzie, bearing the outflow from Castle and Mochrum Lochs, falls into the Bladenoch about 4 miles before entering Wigtown bay, at the town of Wigtown. Except the Loch of Fyntalloch, the lochs are of fair size, three of them exceeding a mile in length, but they are mostly very shallow, only Loch Ochiltree exceeding 15 feet in depth.

*Loch Maberry* (see Plate XL).—Loch Maberry lies about 10 miles north-west of Newton Stewart, and trends nearly north and south. It is considerably over a mile in length, with a maximum breadth of nearly half a mile, the mean breadth being a quarter of a mile. The southern portion of the loch for a quarter of a mile is narrow, but the main body is nearly uniform in width. The superficial area is about 175 acres, or over a quarter of a square mile, of which 67 per cent. is covered by less than 10 feet of water. The western and southern portions of the loch are shallow, the deepest part running along the eastern shore, where the maximum depth of 14 feet was recorded. The volume of water is estimated at 56 million cubic feet, and the mean depth at over 7 feet, while the drainage area extends to  $7\frac{1}{2}$  square miles. The loch was surveyed on August 17, 1903, when the elevation was found to be 388·7 feet above the sea; when visited by the officers of the Ordnance Survey on July 20, 1893, the elevation was 387·2 feet above sea-level. The temperature of the surface water was 60°·0 Fahr., and at a depth of 10 feet 59°·0.

*Loch of Fyntalloch* (see Plate XL).—The Loch of Fyntalloch stands close to, and at the same level as, Loch Ochiltree, into which it drains by a stream only some 50 yards long. The length from north-west to

south-east is over a third of a mile, the maximum breadth being nearly a quarter of a mile, and the superficial area 26 acres, of which 67 per cent. is covered by less than 10 feet of water. The deeper water occupies a central position, the maximum depth of 15 feet being found towards the north-eastern shore. The volume of water is estimated at 8 million cubic feet, and the mean depth at  $7\frac{1}{2}$  feet, the area drained being about three-quarters of a square mile. The temperature at the surface and at a depth of 12 feet was identical on August 17, 1903, viz.  $57^{\circ}8$  Fahr.

*Loch Ochiltree* (see Plate XL.).—Loch Ochiltree lies a mile and a half to the east of Loch Maberry, and is nearly a mile in length from north to south, the maximum breadth across the centre being over half a mile, and the mean breadth a quarter of a mile. The superficial area is about 156 acres, of which 74 per cent. is covered by less than 10 feet of water. At the northern end is a small deep basin, where the maximum depth of 34 feet was recorded. The volume of water is estimated at 52 million cubic feet, and the mean depth at nearly 8 feet. Besides Loch Fyntaloch, the little Black Loch lying to the north drains into Loch Ochiltree, the total drainage area exceeding 2 square miles. The loch was surveyed on August 17, 1903, when the elevation was 341.1 feet above the sea, as compared with 341.5 feet determined by the Ordnance Survey on December 14, 1893.

*Temperature Observations.*—Serial temperatures in the deepest part of the loch gave the following results:—

Surface ... ..	58 <sup>o</sup> .5 Fahr.
10 feet ... ..	58 <sup>o</sup> .0 „
20 „ ... ..	57 <sup>o</sup> .4 „
30 „ ... ..	57 <sup>o</sup> .4 „

The range of temperature from surface to bottom was only  $1^{\circ}1$ , and this occurred between the surface and a depth of 20 feet, the readings at 20 and 30 feet being identical.

*Castle Loch* (see Plate XLI.).—The Castle Loch lies to the west of the Mochrum Loch, the nearest point about half a mile distant. It is slightly smaller than Mochrum Loch, and of less irregular form, roughly triangular, with the apex to the south-west. The surrounding moor is very rough, with much rock showing, except on the north, where smooth rounded hills rise, covered with grass or bracken. It measures nearly  $1\frac{1}{4}$  miles in length, from south-west to north-east, and half a mile in greatest breadth. The bottom is nearly flat, and the maximum depth is 11 feet. The mean depth is  $6\frac{1}{2}$  feet, the area about 228 acres, or one-third of a square mile, and the volume 65 millions of cubic feet, a very little less than that of Mochrum Loch. The loch is fed by a few small burns. The outflow is by a large burn flowing eastward through a marshy stretch into Mochrum Loch. No rock was seen in the stream, but there was rock exposed near the outflow. There is rock at Castle island, and several other small islands. Besides

the many islands there are numerous large boulders projecting above the surface of the loch. The surface on October 25, 1906, was 264·6 feet above sea-level, and fully 16 feet higher than Mochrum Loch; the elevation found by the Ordnance Survey on April 15, 1893, was 264·2 feet above the sea. The temperature was 48°·0 Fahr. throughout.

*Mochrum Loch* (see Plate XLI).—The Mochrum Loch, the largest in the basin, is situated nearly midway between the towns of Wigtown and Glenluce. It is of very irregular form, with rocky shores and many rocky islets, the largest of which are covered with trees. Westward to Castle Loch stretches flat boggy moor, on the east is cultivated ground and woods. The length is 1½ miles, and the greatest breadth nearly one-third of a mile. The depth is very low (mean 7 feet, maximum 13 feet), the bottom in the open parts of the loch nearly flat or gently undulating. The area is about 230 acres, or one-third of a square mile, and the volume of water 68 millions of cubic feet. The drainage area, including Castle Loch, is about 4 square miles. The only considerable feeder is the burn coming from Castle Loch. The Water of Malzie issues from the east side of the loch, and flows some 5 or 6 miles in an easterly direction to join the river Bladenoch. On the date of the survey, October 24, 1906, the surface was 248·15 feet above sea-level; the elevation determined by the Ordnance Survey on March 27, 1893, was 247·7 feet above the sea.

The temperature was 48°·4 Fahr. at the surface, and 48°·0 at 10 feet.

## LOCHS OF THE CREE BASIN.

THE river Cree, one of the largest streams entering the Solway Firth on the Scottish side, drains an extensive mountainous region lying chiefly in the county of Kirkcudbright (see Index Map, Fig. 12). There are a good many lochs in the basin, but owing to lack of boats it was possible to survey only three of them. Loch Trool, the largest loch in the basin, lies in Glen Trool, between the mountains Merrick and Lamachan, Loch Dornal lies between Ayrshire and Wigtownshire, and Loch Kirriereoch is near the head of the Water of Minnoch, and close to the Ayrshire border in Kirkcudbrightshire. Lochs Moan, Neldricken, and Valley are considerable lochs, which could not be surveyed.

*Loch Dornal* (see Plate XLII).—Loch Dornal lies about 8 miles north-west from Newton-Stewart, among rough moorland. The shores are of stones and peat, with rock exposed at several places. There are many small islands and boulders throughout the loch, which is of very irregular form, shallow and flat-bottomed, 10 feet in maximum depth, and 5 feet in mean depth. The length is two-thirds of a mile, and the breadth one-third of a mile. The superficial area is about 110 acres, and the volume of water 26 millions of cubic feet. The drainage area is  $2\frac{1}{2}$  square miles. The only stream entering is the Corwar burn, and the outflow is by the Carrick burn, eastward to the river Cree.

The surface on August 17, 1903, was 386·2 feet above sea-level, or a foot higher than the elevation determined by the Ordnance Survey on July 12, 1893, viz. 385·2 feet. The temperature of the water was 59°·5 Fahr. throughout.

*Loch Kirriereoch* (see Plate XLII).—A very small and nearly square loch, lying on elevated moorland, nearly 700 feet above sea-level, and 12 miles north of Newton-Stewart. The shores are chiefly of gravel with boulders, while a deep bed of peat forms the east side. It measures a quarter of a mile long, by one-fifth of a mile broad, and is 15 feet in maximum depth. The mean depth is 7 feet, the area about 16 acres, and the volume of water 5 millions of cubic feet. The drainage area is small. Though the loch is close to the Water of Minnoch, the outflow is into the Kirriemore burn, which joins the Minnoch about a mile to the south. The temperature on August 15, 1903, was 56°·8 Fahr. throughout.



are rocky. The length, in a straight line joining the ends, is  $1\frac{1}{2}$  miles, the maximum breadth, near the upper end, a quarter of a mile. The eastern basin is largest and deepest, with steep sides and nearly flat centre, and the maximum depth of 55 feet. The middle basin is similar, but smaller, and has a depth of 48 feet. Between these basins the depth is only 22 feet. The western basin is separated from the middle basin by a strait, in which the depth is only 12 feet—the slope is less steep, and the maximum depth is 36 feet. Another constriction, with a depth of 10 feet, separates a small expansion at the west end of the loch, with a depth of 23 feet. The area of the loch is about 144 acres, or nearly a quarter of a square mile, the mean depth is over 18 feet, and the volume of water 116 millions of cubic feet. The drainage area is extensive, measuring  $14\frac{1}{2}$  square miles, and comprises the whole southern slope of the Merrick, the northern slope of the Lamachan, and a number of lochs to the north-east, which were not surveyed.

The principal streams feeding the loch are the Pulnabrick and Puchan burns on the north, and the Gairland and Glenhead burns, which unite and enter the head of the loch. The Water of Trool flows out to the south-west, and joins the Minnoch about 2 miles distant. There is a sluice at the outflow. The surface on August 14, 1903, was 246·35 feet above sea-level, or rather higher than the elevation determined by the Ordnance Survey on June 26, 1894, viz. 245·9 feet. The temperature varied over  $2^{\circ}$  from surface to bottom, thus :—

Surface ...	...	...	...	...	...	58°·3 Fahr.
10 feet ...	...	...	...	...	...	58°·2 "
20 "	...	...	...	...	...	57°·0 "
30 "	...	...	...	...	...	56°·8 "
40 "	...	...	...	...	...	56°·5 "
50 "	...	...	...	...	...	56°·0 "

From the following table it will be seen that in the fifteen lochs under consideration 594 soundings were taken, and that the aggregate area of the water surface is over 2 square miles, so that the average number of soundings per square mile of surface is 280. The aggregate volume of water contained in the lochs is estimated at 527 millions of cubic feet. The area drained by these lochs is nearly  $35\frac{1}{2}$  square miles, or  $16\frac{1}{2}$  times the area of the lochs.

## SUMMARY TABLE.

Giving Details concerning the Lochs in the Luce, Bladenoch, and Cree Basins.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. Feet.	Mean. Feet.	Mean percent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
Magillie	43·7	22	0·22	0·10	0·08	37·3	14	5·97	44·74	97	216	3	0·02	0·31	15·5
Soulseat	39·1	54	0·58	0·28	0·19	33·0	42	15·19	36·17	73	202	47	0·11	1·24	11·3
Cults ...	65·4	25	0·26	0·18	0·10	39·1	28	9·16	32·7	49	150	7	0·08	0·12	4·0
Ree ...	689·6	31	0·32	0·24	0·13	40·9	44	14·96	34·9	38	113	17	0·04	0·38	9·5
Whitefield	192·7	27	0·56	0·24	0·13	23·2	14	8·01	57·2	211	369	16	0·07	0·60	8·6
Eldrig ...	239·1	19	0·50	0·18	0·14	28·0	10	5·70	57·2	264	461	11	0·07	1·98	28·6
White Loch of Myrton	98·7	25	0·56	0·22	0·14	25·0	40	13·7	34·1	74	216	30	0·08	0·74	9·2
Maberry	388·7	49	1·19	0·41	0·23	19·3	14	7·32	52·3	449	858	56	0·27	7·35	27·3
Fyntalloch	341·1	16	0·37	0·21	0·11	29·8	15	7·48	49·9	130	261	8	0·04	0·78	18·2
Ochiltree	341·1	55	0·89	0·58	0·27	30·3	34	7·68	22·6	138	612	52	0·24	2·07	8·6
Castle ...	264·6	39	1·20	0·50	0·30	25·0	11	6·56	59·6	576	966	65	0·36	1·69	4·6
Mochrum	248·15	74	1·50	0·30	0·24	16·0	13	6·75	51·9	609	1173	68	0·36	4·02	11·2
Dornal	386·2	60	0·68	0·34	0·25	37·1	10	5·36	53·6	359	670	26	0·17	2·29	13·5
Kirrieroch	[nearly 700]	23	0·26	0·20	0·10	38·5	15	6·38	46·5	91	197	5	0·03	0·07	2·3
Trool ...	246·35	75	1·68	0·26	0·13	7·7	55	18·39	33·4	161	482	116	0·28	14·26	62·0
		594										527	2·12	35·43*	16·7

\* The drainage area of Loch Ochiltree includes that of Loch of Fyntalloch; that of Mochrum Loch includes that of Castle Loch.

## LOCHS OF THE FLEET BASIN.

THE only loch to be dealt with here is Loch Fleet, which forms the source of the Little Water of Fleet, one of the tributaries of the Water of Fleet flowing into Fleet bay, a branch of Wigtown bay. Loch Whinyeon has been utilised to supply a mill at Gatehouse of Fleet, and its waters have been diverted from the Dee basin, to which it originally belonged, into the Fleet basin; any overflow is into Tarff Water, a tributary of the river Dee, and it will be treated of in that basin.

*Loch Fleet* (see Plate XLVI).—Loch Fleet lies about a mile to the east of Loch Grennoch, over 2 miles to the west of Loch Skerrow, both belonging to the Dee basin, and 8 miles north of Gatehouse of Fleet. Hills rise steeply on all sides of the loch, except to the south-east, where the burn flows out. The loch trends from north-west to south-east, and is over one-third of a mile in length, with a maximum breadth across the upper end of a quarter of a mile, while its waters cover an area of about 43 acres. The basin is simple, the contours approximating to the outline of the loch, and the maximum depth of 56 feet is centrally placed. The volume of water is estimated at 41 million cubic feet, and the mean depth at 22 feet. The loch was surveyed on July 24, 1903, when the elevation was 1112·9 feet above the sea; the Ordnance Survey officers found the elevation to be 1113·4 feet on September 1, 1894. The following temperatures were taken in the deepest part of the loch:—

Surface ...	...	...	...	...	...	60°·2 Fahr.
10 feet ...	...	...	...	...	...	59°·8 „
25 „ ...	...	...	...	...	...	55°·6 „
50 „ ...	...	...	...	...	...	53°·0 „

The range of temperature was 7°·2, the greatest fall, between 10 and 25 feet, being 4°·2.

## LOCHS OF THE DEE (KIRKCUDBRIGHT) BASIN.

THE river Dee and its tributaries drain an extensive area in Kirkcudbrightshire, including many lochs of greater or less importance, of which a dozen were sounded by the Lake Survey, viz. Lochs Dee, Grennoch, Skerrow, Lochenbreck, Woodhall, Dungeon, Harrow, Lochinvar, Ken, the expansions of the river Dee below Loch Ken, Carlingwark, and Whinyeon. The five first-mentioned lochs drain into the Blackwater of Dee branch, while Lochs Dungeon, Harrow, Lochinvar, and Ken drain by the Water of Ken branch, Loch Carlingwark at Castle Douglas drains into the river Dee proper, and Loch Whinyeon into the Tarff Water branch, which joins the Dee near its outfall at the head of Kirkcudbright bay. Five of the lochs exceed a mile in length, Loch Ken, the largest, being  $4\frac{1}{2}$  miles in length. The lochs are not very deep, Loch Dungeon, the deepest, having a depth of 94 feet, Loch Grennoch 68 feet, Loch Ken 62 feet, and Woodhall Loch 49 feet.

*Loch Dee* (see Plate XLIV).—Loch Dee lies about 2 miles east of Loch Trool in the Cree basin, and about 10 miles west of New Galloway, amid high hills. The loch trends from south-west to north-east, and is over a mile in length, with a maximum breadth across the south-western end of about three-quarters of a mile, the mean breadth being one-third of a mile. The superficial area is about 253 acres, and the drainage area  $5\frac{1}{4}$  square miles. The maximum depth of 36 feet was found near the south-western end, the mean depth being estimated at over 14 feet, and the volume of water at 157 million cubic feet. It is an irregular loch, a large peninsula extending into it from the south-eastern shore, and dividing it into two portions, the north-eastern portion being shallow, not exceeding 8 feet in depth, while the south-western portion forms a simple deep basin. More than one-half of the lake-floor is covered by less than 10 feet of water. The shores are mostly rock, but with mounds of sand and gravel and many boulders; the river at the outflow has rock on the north side. The loch was surveyed on July 30, 1903, when the elevation was 739·2 feet above the sea; the water rises about 4 feet, and falls about a foot, from that level. The Ordnance Survey officers found the elevation to be 739·5 feet on October 25, 1893. The following temperatures taken in the deepest part of the loch show a practically uniform temperature from surface to bottom:—

Surface ...	...	...	...	...	...	59°·2 Fahr.
10 feet ...	...	...	...	...	...	59°·2 „
20 „ ...	...	...	...	...	...	59°·2 „
30 „ ...	...	...	...	...	...	59°·0 „

*Loch Grennoch* (see Plate XLIV.).—Loch Grennoch lies about 7 miles south-west of New Galloway. The hills are steep and high on both sides, especially to the west at the south end. Rock is exposed all round the loch, with many boulders and scanty patches of vegetation. The loch trends nearly north and south, and is 2 miles in length, with a maximum breadth of over one-third of a mile, the mean breadth being nearly a quarter of a mile. Its waters cover an area of about 290 acres, or nearly half a square mile, and it drains an area of over  $5\frac{1}{2}$  square miles. The maximum depth of 68 feet was found towards the southern end. The mean depth is estimated at 21 feet, and the volume of water at 263 million cubic feet. The elevation was 690·7 feet above the sea when the loch was surveyed on July 24, 1903, almost identical with that observed by the Ordnance Survey on September 7, 1894, viz. 690·6 feet. A drift-mark was observed 3 feet above the water, which might fall a foot lower. The loch forms a simple basin, the deeper water occupying the southern half; the slope is steep in places, especially off the western shore near the southern end. About 70 per cent. of the lake-floor is covered by less than 25 feet of water. Several streams drain into the loch, the principal ones being the Cuttiemore burn and the Cuttie Shallow burn, entering on the western side. The Pullaugh burn, flowing out at the northern end, is a broad quiet stream with a very gentle fall for a couple of miles.

*Temperature Observations.*—The following serial taken in the deepest part of the loch showed a range from surface to bottom of only 4°·2 Fahr., the greatest fall being one of 1°·3 between 10 and 20 feet:—

Surface ...	...	...	...	...	...	60°·2 Fahr.
10 feet ...	...	...	...	...	...	59°·8 „
20 „ ...	...	...	...	...	...	58°·5 „
30 „ ...	...	...	...	...	...	58°·0 „
40 „ ...	...	...	...	...	...	57°·3 „
50 „ ...	...	...	...	...	...	56°·8 „
65 „ ...	...	...	...	...	...	56°·0 „

*Loch Skerrow* (see Plate XLIV.).—Loch Skerrow lies between Loch Grennoch on the west and Woodhall Loch on the east, being about 2 miles distant from both, and 7 miles north of Gatehouse. The shores are rocky, with numerous scattered boulders, and the islands are mostly of rock, while stones are plentiful, especially towards the south; a few small patches of yellow sand occupy the bays. The surrounding hills are low and bare, with much rock exposed, and strewn with boulders. The loch is subtriangular in outline, with the apex pointing south, and is nearly three-quarters of a mile in length, with a maximum breadth at the north end of half a mile, the mean breadth exceeding a quarter of a mile,

The superficial area is about 125 acres, and the drainage area about  $6\frac{1}{4}$  square miles. The maximum depth of 33 feet is centrally situated, the mean depth being estimated at  $12\frac{1}{2}$  feet, and the volume of water at 68 million cubic feet. About 40 per cent. of the lake-floor is covered by less than 10 feet of water, while a still larger area (about 46 per cent.) is covered by water between 10 and 20 feet in depth. The loch was surveyed on July 17, 1903, the elevation being 413·85 feet above the sea; the water was high at that time—about 3 feet above the normal. The Ordnance Survey officers found the elevation to be 415·6 feet above sea-level on August 23, 1894. The temperature of the water was practically uniform throughout, varying only from  $59^{\circ}3$  to  $59^{\circ}7$  Fahr.

*Lochenbreck Loch* (see Plate XLIV.).—This is a small quadrangular loch lying between Loch Skerrow and Woodhall Loch, distant a little over 2 miles from the former, and a little under 2 miles from the latter, into which it drains. The length from north-west to south-east is nearly half a mile, and the maximum breadth over a quarter of a mile. The superficial area is about 39 acres, and the drainage area over half a square mile. The deepest part lies towards the eastern shore, off which the maximum depth of 15 feet was found. The mean depth is estimated at  $7\frac{1}{2}$  feet, and the volume of water at 13 million cubic feet. When surveyed on July 21, 1903, the elevation was 651·1 feet above the sea; the water might rise about 2 feet above, and fall about a foot below, that level. The Ordnance Survey found the elevation to be 650·7 feet on April 5, 1894.

*Woodhall Loch* (see Plate XLIV.).—This is an elongate loch about 2 miles west of the river Dee, and about 6 miles north-west of Castle Douglas. On the eastern side of the loch are cultivated fields bounded by low grassy hills with few trees. The shores are largely of gravel, with boulders and exposed rock in places, but are mostly hidden by weeds. The loch trends nearly north and south, but with the axis slightly curved, the shore-line being much indented, and is  $1\frac{3}{4}$  miles in length. The maximum breadth is about one-third of a mile, and the mean breadth about one-seventh of a mile, the superficial area being about 168 acres, or a quarter of a square mile. The drainage area is nearly 9 square miles, including that of Lochenbreck Loch. The maximum depth of 49 feet was found towards the northern end. The mean depth is estimated at nearly 20 feet, and the volume of water at 144 million cubic feet. The loch was surveyed on July 28, 1903, the elevation being 172·65 feet above the sea; the water was low at that time, and might rise 3 or 4 feet higher, a drift-mark being observed 2 feet above the surface. The elevation was 174·3 feet above sea-level on August 4, 1894, when visited by the officers of the Ordnance Survey. The outflow is a broad stream flowing first northward, then eastward to join the river Dee. The basin is, on the whole, simple, the contour lines being continuous, but the longitudinal section shows one

or two minor undulations. The axis of maximum depth lies towards the western shore, off which the slope is in places steep. The deepest part, exceeding 40 feet in depth, is situated over a mile from the upper end, and over half a mile from the outflow. About 28 per cent. of the lake-floor is covered by less than 10 feet of water, a rather larger area (about 34 per cent.) being covered by water between 10 and 20 feet in depth.

*Temperature Observations.*—The following serials were taken in the deepest part of the loch :—

Surface ... ..	63°·4 Fahr.
10 feet ... ..	62°·8 "
20 " ... ..	59°·4 "
30 " ... ..	58°·2 "
45 " ... ..	56°·0 "

The range from surface to bottom was 7°·4, the greatest fall being one of 3°·4 between 10 and 20 feet.

*Loch Dungeon* (see Plate XLIV.).—Loch Dungeon lies about 6 miles south of Loch Doon, and a similar distance east of Dalry. Hills rise steeply on the south side, and rugged crags at the west end, culminating in Millfire (2350 feet) and Meikle Millyea (2446 feet). The general trend is from west to east, the loch curving round a large peninsula called the Point of Ringroch. It is nearly a mile in length, with a maximum breadth of a quarter of a mile, the superficial area being about 88 acres. The loch drains an area of  $2\frac{3}{4}$  square miles, the principal feeder being the Hawse burn, entering near the west end, while a few minor streams flow from the steep slopes of the hills to the west and south-west. The loch is divided into three deep basins, the deepest situated at the west end, where the slope is steepest, the maximum depth of 94 feet having been recorded less than 150 yards off the western shore; the basin second in importance lies at the east end, and has a maximum depth of 45 feet, while near the centre of the loch is the smallest basin, having a maximum depth of 34 feet. About 73 per cent. of the lake-floor is covered by less than 25 feet of water. The mean depth is estimated at  $22\frac{1}{2}$  feet, and the volume of water at 87 million cubic feet. The loch was surveyed on August 6, 1903, when the elevation was 1002·3 feet above the sea; a storm-beach was observed 4 feet above the water, which might fall about a foot lower. The southern and western shores are mostly of rock, with alluvial cones laid down by the burus. The main inflow, at the west end, cuts through a long sharp ridge of gravel, which abuts on the steep crags on the south, and joins a ridge of rock on the north. The outflow falls several feet in about 100 yards, and passes first between and over boulders, and then over rock. The water in the loch had a peculiar leaden or greenish-grey slate colour.

*Temperature Observations.*—Serial temperatures taken in the easternmost basin gave identical readings of 54°·8 Fahr. at the surface, at 10

feet, and at 35 feet, while in the deepest part of the loch the following readings were recorded :—

Surface ...	...	...	...	...	...	53°·2 Fahr.
10 feet ...	...	...	...	...	...	53°·2 "
25 "	...	...	...	...	...	53°·2 "
50 "	...	...	...	...	...	53°·2 "
60 "	...	...	...	...	...	52°·2 "
70 "	...	...	...	...	...	45°·2 "
75 "	...	...	...	...	...	44°·8 "
90 "	...	...	...	...	...	44°·6 "

Here also the temperature was uniform from the surface to a depth of 50 feet, but 1°·6 lower than in the eastern basin, the "sprungschicht" lying between 60 and 70 feet, where a fall of 7° was recorded, the total range being 8°·6.

*Loch Harrow* (see Plate XLIV.).—This is a small loch lying about a mile north of Loch Dungeon, and about 7 miles north-west of Dalry. The highest hill in the neighbourhood, Corserine, rises steeply to a height of 2668 feet to the westward of the loch, which trends east and west, and is nearly half a mile in length, with a maximum breadth of about one-fifth of a mile, and a superficial area of about 38 acres. It drains an area of  $1\frac{1}{2}$  square miles, the main inflow being the Folk burn entering on the northern shore. The maximum depth of 29 feet was observed towards the east end, the mean depth being estimated at  $11\frac{1}{2}$  feet, and the volume of water at 19 million cubic feet. The loch was surveyed on August 3, 1903, when the elevation was 811·8 feet above the sea, nearly identical with that determined on September 10, 1894, by the Ordnance Survey, viz. 811·6 feet; the water might rise 2 feet above, and fall a foot below, that level. The basin is simple, the deeper water being centrally placed, but towards the northern shore. About 52 per cent. of the lake-floor is covered by less than 10 feet of water. Temperatures taken at the surface, at 10 feet, 20 feet, and 25 feet gave identical readings of 58°·5 Fahr.

*Lochinvar* (see Plate XLIV.).—This small loch is situated about 3 miles north-east of Dalry. It is irregular in outline, trending nearly north and south, and over half a mile in length, with a maximum breadth of one-third of a mile. The superficial area is about 68 acres, and the drainage area  $1\frac{1}{4}$  square miles. Three soundings were taken at the maximum depth of 10 feet, two towards the eastern shore, and the third off the western shore near the north end. The mean depth is estimated at  $6\frac{1}{2}$  feet, and the volume of water at 19 million cubic feet. The loch was surveyed on July 20, 1903, when the elevation was found to be 736·6 feet above the sea; the Ordnance Survey found it to be 735·4 feet on July 7, 1894. The outflow is by dam and sluice, the water at the time of the survey being exactly at the level of the overflow. A drift-mark was observed two feet above the water. The loch is flat-bottomed in character, most of the

soundings taken giving a depth of 9 feet. The shores are mostly of rock, with stony *débris*, sandy gravel covering the eastern shore at the narrow part near the north end. The temperature of the surface water on the date of the survey varied from  $58^{\circ}\cdot 5$  to  $60^{\circ}\cdot 5$  Fahr., a reading at a depth of 8 feet giving  $58^{\circ}\cdot 0$ .

*Loch Ken* (see Plate XLV.).—Loch Ken is the largest in the basin, trending from north-west to south-east, the northern end being over a mile south of New Galloway, and the southern end about 7 miles north of Castle Douglas, the confluence of the Black Water of Dee with the river Dee being looked upon as the southern limit of Loch Ken. The length exceeds  $4\frac{1}{2}$  miles, the maximum breadth across the centre of the loch at the entrance of the Dullarg burn being about half a mile, and the mean breadth over a quarter of a mile. The waters of the loch cover an area of about 867 acres, or  $1\frac{1}{3}$  square miles, and the area draining into it is very large, extending far to the north and west, and including the other lochs within the basin dealt with in the preceding pages, as well as a few lochs which were not surveyed. The total drainage area thus amounts to about 282 square miles. The maximum depth of 62 feet was recorded about a mile from the upper end. The volume of water is estimated at 792 millions of cubic feet, and the mean depth at 21 feet. The loch was surveyed on July 14, 1903, the elevation being 142·0 feet above the sea.

The floor of Loch Ken is irregular, there being six separated areas where the depth exceeds 25 feet, and two areas where the depth exceeds 50 feet. The 20-foot contour would be continuous almost from end to end, except for a slight break opposite the entrance of the Arvie burn, where the deepest sounding was 19 feet. The deepest basin occupies the wide portion at the head of the loch, where there is a 25-foot area over  $1\frac{1}{2}$  miles in length, enclosing a 50-foot area over three-quarters of a mile in length, the maximum depth of 62 feet having been observed towards the eastern shore. The second 50-foot area, based on a sounding in 52 feet, lies less than a mile from the foot of the loch, occupying a central position in a 25-foot area three-quarters of a mile in length. To the south of this area the water deepens again to 31 feet, and near the entrance of the Black Water of Dee another sounding in 33 feet was taken. Of the entire lake-floor 71 per cent. is covered by less than 25 feet of water.

*Temperature Observations.*—Serial temperatures taken in the deepest basin showed a gradual decrease of temperature, the total range from surface to bottom being  $4^{\circ}\cdot 7$  Fahr., as follows:—

Surface ... ..	60°·2 Fahr.
25 feet ... ..	59°·5 "
30 " ... ..	58°·5 "
35 " ... ..	57°·5 "
40 " ... ..	56°·5 "
55 " ... ..	55°·5 "

*Expansions of the River Dee* (see Plate XLV.).—The expansions of the

river Dee immediately to the south of Loch Ken were surveyed on July 15, 1903—the day after Loch Ken had been sounded—when it was found that the water had risen to the extent of about 3 feet, the elevation being 144·9 feet above the sea. This was due to the fact that steady rain set in at 3 p.m. on July 14, and continued almost without intermission all night and all next day. The portion surveyed extends for 4 miles southward from the entrance of the Black Water of Dee, as far as Cross-michael, and consists of a series of widenings and narrowings of the river, the wider parts usually coinciding with an increase in the depth. The largest expansion is nearly half a mile in width, while the mean breadth of the entire part surveyed is only one-sixth of a mile. The portion surveyed covers an area of about 431 acres, or two-thirds of a square mile, the area draining into it including Loch Ken and all the other lochs previously dealt with, and extending to nearly 300 square miles. The maximum depth of 44 feet was observed in the most northerly expansion, but depths of 42 feet were recorded about  $1\frac{1}{2}$  miles lower down, and in the most southerly expansion surveyed, called Kirkland Loop. There are seven areas where the depth exceeds 20 feet, including no fewer than eleven isolated areas where depths exceeding 25 feet were found. The large central expansion has a maximum depth of 27 feet, and the little off-shoot on the western shore called Long Loch varies from 9 to 18 feet in depth. Of the entire area surveyed about 81 per cent. is covered by less than 20 feet of water.

*Temperature Observations.*—The surface temperature during the time spent on the survey varied from  $58^{\circ}\cdot3$  to  $60^{\circ}\cdot6$  Fahr. A series taken in the northernmost deepest basin indicated a slight inversion of temperature, probably as a result of the rainstorm, the surface reading being  $58^{\circ}\cdot3$ , that at 20 feet  $58^{\circ}\cdot6$ , and that at 39 feet  $58^{\circ}\cdot8$ .

*Carlingwark Loch* (see Plate XLIV.).—Carlingwark Loch lies close to the town of Castle Douglas, and drains into the river Dee by a straight stream called Carlingwark Lane,  $1\frac{1}{4}$  miles in length. The loch is sub-rectangular in outline, and trends nearly north and south, being three-quarters of a mile in length, and over one-third of a mile in maximum breadth. The superficial area is about 105 acres, and the drainage area over half a square mile. The maximum depth of 17 feet is centrally placed, and of the entire lake-floor about 74 per cent. is covered by less than 10 feet of water. The mean depth is estimated at 7 feet, and the volume of water at 31 million cubic feet. The loch was surveyed on July 17, 1903, when the elevation was 143·0 feet above the sea; the elevation as observed by the Ordnance Survey on April 23, 1894, was 142·3 feet.

*Loch Whinyeon* (see Plate XLIV.).—Loch Whinyeon is a little sub-circular loch about 5 miles north-east of Gatehouse of Fleet. When surveyed on July 22, 1903, the elevation could not be determined by

SUMMARY TABLE.

Giving Details concerning the Lochs in the Fleet and Dee Basins.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.		Depth.		Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.	Max. Feet.	Mean Feet.	Mean per cent. of max.	Max.	Mean.	Total in square miles.			Ratio to area of loch.	
Fleet ...	1112.9	41	0.38	0.24	0.18	46.6	21.81	56	43.6	40	92	41	0.07	0.50	7.1
Dee ...	739.2	79	1.18	0.70	0.33	28.0	14.25	36	39.6	173	437	157	0.40	5.25	13.1
Grennoch	690.7	92	2.02	0.36	0.22	11.1	20.82	68	30.6	157	512	263	0.45	5.64	12.5
Skerrrow	413.85	56	0.70	0.48	0.28	40.0	12.63	33	38.0	112	293	68	0.19	6.25	33.0
Lochenbreck	651.1	34	0.42	0.28	0.14	34.3	7.61	15	50.8	143	291	13	0.06	0.54	9.0
Woodhall	172.65	76	1.79	0.32	0.14	8.2	19.67	49	40.1	193	480	144	0.26	8.85	34.0
Dungeon	1002.8	85	0.93	0.26	0.15	15.9	22.64	94	24.1	52	217	87	0.14	2.75	19.6
Harrow	811.8	95	0.42	0.18	0.14	33.4	11.61	29	40.0	76	191	19	0.06	1.44	24.0
Lochinvar	736.6	41	0.52	0.34	0.21	39.4	6.41	10	64.1	275	429	19	0.11	1.20	11.0
Ken ...	142.0	177	4.62	0.43	0.29	6.3	21.0	62	33.8	393	1163	792	1.36	281.72	20.7
River Dee	144.9	106	4.02	0.44	0.17	4.2	13.90	44	31.6	482	1526	261	0.67	297.00	44.3
Carlingwark	143.0	75	0.70	0.36	0.23	33.4	6.86	17	49.0	264	539	31	0.16	0.53	3.3
Whinyeon	[over 700]	57	0.56	0.44	0.29	52.3	12.22	33	37.0	90	242	56	0.16	0.36	5.3
		954										1951	4.09	298.89*	73.0

\* The drainage area of the expansions of the river Dee below Loch Ken includes those of Lochs Dee, Grennoch, Skerrrow, Lochenbreck, Woodhall, Dungeon, Harrow, Lochinvar, and Ken.

levelling, but was between 700 and 725 feet above the sea; the water was said to be high, and might fall several feet. The loch supplies water to mills at Gatehouse by a tunnel made about 85 years ago through the hill to the west into High Creoch burn. Originally the outflow was to the east into the Tarff by a rocky channel, the overflow being over rock showing glacial striæ, and if the water were a foot higher than on the date of the survey, it would overflow on the east, and some of the water would reach the Tarff by the Glengap burn. The diameter from east to west is over half a mile, and from north to south rather less than half a mile, the superficial area being about 105 acres. The maximum depth of 33 feet was found towards the western shore. The volume of water is estimated at 56 million cubic feet, and the mean depth at  $12\frac{1}{4}$  feet. The 10-foot contour is continuous, and encloses an area equal to two-thirds of the entire lake-floor. There are two 20-foot areas, one towards the eastern shore, based on two soundings in 22 feet, separated by a shallowing with 15 feet on it from the deepest part of the loch lying to the west. The bottom is stony, no mud coming up in the sounding tube, and few weeds were noticed anywhere.

From the table on p. 121 it will be seen that in the thirteen lochs under consideration 954 soundings were taken, and that the aggregate area of the water surface is about 4 square miles, so that the average number of soundings per square mile of surface is 238. The aggregate volume of water contained in the lochs is estimated at 1951 millions of cubic feet. The area drained by these lochs is nearly 299 square miles, or 73 times the area of the lochs.



Auchenreoch, Milton, and Arthur. Rising among the hills in the north of Kirkcudbrightshire, the Urr water enters the Rough firth, an inlet from the Solway firth, 2 or 3 miles south of the town of Dalbeattie. Near its source is Loch Urr, and a few miles farther south, at the Haugh of Urr, it is joined by a burn coming from Auchenreoch Loch, while Milton Loch and Loch Arthur drain by the Kirkgunzeon lane into Urr water at Dalbeattie.

*Loch Urr* (see Plate XLIII).—Loch Urr is a picturesque loch of rhomboid form lying in the moorland about 13 miles north of Castle Douglas; the surrounding hills are highest to the north-east (Bogrie hill, 1416 feet). The shores are of peat and gravel with boulders, rock being seen only on the White isle promontory. It is two-thirds of a mile in length from north-west to south-east, and the breadth a little less, the area being about 106 acres. The basin is simple, deepest towards the east shore, where the maximum depth of 42 feet was found close to Rough island. The contour-lines show that the slope is gentle from the shore to 20 feet, then steeper to the centre. The mean depth is estimated at 12 feet, and the volume of water at 56 million cubic feet. The area drained is about 3 square miles, the only important feeder, Lochurr lane, coming from the north-east, and the outflow is south-westward by the Urr water. The loch was surveyed on July 23, 1903, when the elevation was 624·0 feet above the sea—almost indetical with that determined by the Ordnance Survey on June 13, 1894, viz, 623·9 feet. The water was low at the time of the survey, and might rise 2 or 3 feet.

*Auchenreoch Loch* (see Plate XLIII).—Auchenreoch Loch is a long narrow loch near the village of Kirkpatrick Durham, and 9 miles west of the town of Dumfries. It trends from north-east to south-west, and is a mile in length, with a maximum breadth of nearly one-third of a mile near the southern end, whence it narrows gradually towards the northern end. The superficial area is about 86 acres, and the drainage area nearly 2 square miles. The maximum depth of 34 feet was recorded in two places—(1) near the middle of the loch, and (2) towards the southern end. The volume of water is estimated at 44 million cubic feet, and the mean depth at nearly 12 feet. The loch was surveyed on May 3, 1905, when the elevation was found to be 345·0 feet above the sea—nearly identical with that determined by the Ordnance Survey on August 20, 1892, viz. 344·9 feet. The longitudinal section of the loch is undulate, though the cross-lines of soundings give regular transverse sections. About a quarter of a mile from the northern end, where the loch is very narrow, a depth of only 8 feet was found, with deeper water both to the north and south. The central deep area is of very limited extent, the single sounding in 34 feet being surrounded by much shallower water, the deepest soundings in the vicinity being in 16 feet of water. In the wide southern portion of the loch there is a 20-foot area about 300 yards in length. Of the

entire lake-floor about 42 per cent. is covered by less than 10 feet of water, and about 8 per cent. by more than 20 feet of water, so that one-half is covered by water between 10 and 20 feet in depth. The temperature of the water was practically uniform throughout, the surface reading being  $48^{\circ}0$  Fahr., while a reading at 34 feet gave  $47^{\circ}2$ .

*Milton Loch* (see Plate XLIII).—Milton Loch lies less than a mile to the east of Auchenroch Loch, and about 8 miles from Dumfries. It is irregular in outline and conformation, the general trend being from north to south, but the southern portion curves round Milton point towards the east. The loch exceeds a mile in length, with a maximum breadth of half a mile. The superficial area is about 153 acres, or nearly a quarter of a square mile, and the drainage area is nearly 2 square miles. The maximum depth of 15 feet was recorded both in the northern and southern parts of the loch, there being two 10-foot areas separated by shallower water at the central narrows, the greatest depth between Green island and the opposite shore being 9 feet. The volume of water is estimated at 45 million cubic feet, and the mean depth at nearly 7 feet. Of the entire lake-floor about 78 per cent. is covered by less than 10 feet of water. The loch was surveyed on May 3, 1905, when the elevation was 410·0 feet above the sea, or rather higher than that determined by the Ordnance Survey on December 5, 1893, viz. 409·6 feet. The temperature of the water was uniform throughout, identical readings of  $47^{\circ}0$  Fahr. being taken at the surface and at 15 feet.

*Loch Arthur* (see Plate XLIII).—Loch Arthur (or Lotus Loch) is situated about 4 miles to the east of Milton Loch, and drains into the Kirkgunzeon lane at Killywhan Bridge. It is surrounded by cultivated stony fields, with a strip of wood nearly all round and a plantation on the north-east; the shores are stony, with granite boulders. The loch is two-thirds of a mile in length from east to west, with a maximum breadth across the middle of nearly one-third of a mile, the superficial area being about 74 acres. The basin is simple, the contour-lines coinciding with the outline of the loch, and fairly deep. The maximum depth of 50 feet was observed towards the south-eastern angle, but there is a considerable area approximately in the centre of the loch, equal to one-fourth of the total area, in which the depth exceeds 40 feet. The mean depth is estimated at nearly 26 feet, or over one-half of the maximum depth, and the volume of water at 83 million cubic feet. The loch was surveyed on May 4, 1905, when the elevation was 239·8 feet above the sea, as compared with 240·1 feet determined by the Ordnance Survey on January 23, 1894. The temperature of the water was practically uniform throughout, a reading at the surface giving  $47^{\circ}2$  Fahr., and at 45 feet  $46^{\circ}9$ .

## LOCHS OF THE NITH BASIN.

THE extensive basin of the river Nith, which in its upper part winds for so many miles through mountainous country, with several important tributary glens, is in this upper part almost entirely devoid of lochs. A few insignificant patches of water near New Cumnock were not surveyed. The five lochs surveyed are found on small tributaries in the lower part of the system, and on the west side of the river, the most northerly being Lochs Howie and Skae, which drain by the Cluden Water into the river Nith near Dumfries, while Lochrutton Loch, Lochaber Loch, and Loch Kindar lie within a few miles of the town of Dumfries, and the tributaries on which they are situated drain into the tidal portion of the river, where it expands into the Solway firth.

*Loch Howie* (see Plate XLVI).—Loch Howie is a small, narrow loch on the north side of the Blackeraig hill, 18 miles west of Dumfries, and 5 miles north-east of New Galloway village. The Black Craig rises steeply on the south to 1332 feet; on the north the hills are lower. The shores are of stony *débris*, with rock exposed at one part on the south. The loch trends from south-west to north-east, and is three-quarters of a mile in length, the maximum breadth near the east end being one-eighth of a mile, and the superficial area about 45 acres. There are two distinct basins, the western one having a maximum depth of 39 feet, and the eastern one 37 feet, separated by a shallow with only 7 feet on it. The mean depth is 16 feet, and the volume 31 million cubic feet. The drainage area is half a square mile. The outflow is by the Mid burn northward into the Blackmark burn, thence into the Castlefern burn and Cairn water and Cluden water. Loch Howie was surveyed on July 23, 1903, when the elevation was 757.15 feet above the sea; on May 12, 1894, the Ordnance Survey found the elevation to be 757.9 feet. The variation in the level of the water is small.

*Loch Skae* (see Plate XLVI).—A very small, subcircular loch to the north of Blackeraig hill, and half a mile east of Loch Howie. On the east the hill rises steeply to over 300 feet above the loch; the west side is low. The maximum diameter from north to south is a quarter of a mile, the superficial area being about 20 acres. There is a small, deep area towards the west shore, enclosing the maximum depth of 35 feet.

The mean depth is  $9\frac{1}{2}$  feet, and the volume of water 8 million cubic feet. The outflow is by a small burn flowing out over rock northward to the Blackmark burn. The loch was surveyed on July 29, 1903, when the elevation was 864·5 feet above the sea, as compared with 864·7 feet observed by the Ordnance Survey on May 15, 1894. A drift-mark was noticed a foot above the water.

*Lochrutton Loch* (see Plate XLVI.).—A fair-sized loch used for the supply of water to the town of Dumfries, which lies about 5 miles to the north-east, while Milton Loch in the Urr basin lies about 3 miles to the west. It trends nearly north and south, and is three-quarters of a mile in length, with a maximum breadth across the middle of half a mile, the mean breadth being a quarter of a mile. The superficial area is about 129 acres, and the drainage area exceeds 3 square miles. The maximum depth of 58 feet was observed off the central part of the western shore, in close proximity to the islet called Dutton's cairn; but the deep water is of very limited extent, the loch as a whole being flat-bottomed in character, varying in depth from 10 to 15 feet. In fact, two-thirds of the lake-floor is covered by water between 10 and 20 feet in depth, while only 4 per cent. is covered by more than 20 feet of water. The mean depth is estimated at 13 feet, and the volume of water at 73 million cubic feet. The loch was surveyed on May 1, 1905, when the elevation was 305·7 feet above the sea, as compared with 305·2 feet determined by the Ordnance Survey on November 6, 1893. The temperature of the water was  $48^{\circ}0$  Fahr. throughout.

*Lochaber Loch* (see Plate XLVI.).—A small, picturesque loch less than 2 miles south-east of Lochrutton Loch. The stony shores are wooded, and the surrounding hills steep, the outflow at the north-western angle being artificial. The loch is sub-triangular in outline, and over half a mile in length from north-west to south-east, the maximum breadth across the centre a quarter of a mile. The superficial area is about 52 acres, and the drainage area exceeds a square mile. The maximum depth of 55 feet was observed towards the south-eastern end, the mean depth being estimated at  $20\frac{1}{2}$  feet, and the volume of water at 47 million cubic feet. The loch is simple in conformation, but the deeper water lies towards the southern end, the northern portion being shallow and weedy. About 71 per cent. of the lake-floor is covered by less than 25 feet of water. The loch was surveyed on May 4, 1905, but the elevation could not be determined; on January 16, 1894, the Ordnance Survey found it to be 298 feet above the sea. Temperatures in the deepest part gave  $48^{\circ}2$  Fahr. at the surface, and  $47^{\circ}0$  at 45 feet.

*Loch Kindar* (see Plate XLVI.).—This picturesque loch is situated about a mile inland from the Solway firth, at the mouth of the river Nith. The shores and islands are stony, the latter probably moraine mounds.

The western shore is wooded where rises the steep slope of Criffel, covered with numerous boulders, while the eastern shore is bordered by cultivated fields. The portion to the east of the large island is mostly filled with reeds, and there are narrow strips of reeds on many parts of the western shore. The burn flows out among stones at the north end, and joins the New Abbey Pow. The general trend is from south-south-east to north-north-west, but the southern portion curves round a broad promontory on the eastern shore to the north-eastward. Loch Kindar exceeds three-quarters of a mile in length, the maximum breadth being one-third of a mile, and the mean breadth a quarter of a mile. Its waters cover an area of about 134 acres, and it drains an area of over a square mile. The maximum depth of 41 feet was found towards the northern end. The mean depth is estimated at  $14\frac{1}{4}$  feet, and the volume of water at 83 million cubic feet. The soundings show that the conformation of the bottom is rather irregular, comparatively shallow water occupying the central and southern parts of the loch, while the deeper water occupies the northern part, and sends out two branches, the longer one skirting the western shore, and the shorter one running towards the eastern shore. Of the entire lake-floor, about 35 per cent. is covered by less than 10 feet of water, while 47 per cent. is covered by water between 10 and 20 feet in depth. The loch was surveyed on May 2, 1905, when the elevation was 88.05 feet above the sea, as compared with 88.3 feet determined by the Ordnance Survey on February 19, 1894. Little variation was indicated in the temperature of the water by observations taken in the deepest part of the loch, the surface-reading being  $49^{\circ}0$  Fahr., while readings at 28 and 38 feet both gave  $48^{\circ}5$ .

## LOCHS OF THE ANNAN BASIN.

THE large area drained by the river Annan (see Index Map, Fig. 14) is remarkably devoid of lochs, apart from a group of half a dozen small lochs clustered near the town of Lochmaben, four of which were sounded by the Lake Survey. The only other loch is the little Loch Skeen, situated far to the north, on the borders of Dumfries- and Selkirk-shires, near the source of the Moffat water, a tributary of the Annan. Loch Skeen lies at an elevation of nearly 1750 feet above the sea, while the Lochmaben lochs are all less than 200 feet above sea-level. The deepest loch is Mill Loch, with a maximum of 55 feet; Loch Skeen coming next with a maximum of 36 feet; then Kirk Loch, with a maximum of 25 feet; while Castle Loch and Hightae Mill Loch are less than 20 feet in depth. The trout-fishing in Loch Skeen is sometimes very good, but variable, while the Lochmaben lochs are remarkable for their variety, Castle Loch, for instance, being said to contain ten different species, including pike, perch, roach, bream, chub, loch-trout, and vendace—the last mentioned a rare fish, peculiar to Castle Loch and Mill Loch, which takes no lure, but is caught with the net.

*Loch Skeen* (see Plate XLVII.).—Loch Skeen lies about 9 miles north-east from Moffat, and only 5 miles from St. Mary's Loch in the Tweed basin. When engaged on the survey of St. Mary's Loch, our surveyors were informed that there was no boat on Loch Skeen; but one of them went up to study the geology, taking a boatman with him, when they found a boat without oars. With oars improvised from a broken fence, they made a zigzag the whole length of the loch, a strong wind preventing them from running transverse lines of soundings. The loch is elongate in outline, trending from north-west to south-east, and three-quarters of a mile in length, the maximum breadth being one-fifth of a mile. The superficial area is about 69 acres, and the drainage area less than a square mile. The deeper water is centrally placed, the maximum depth of 36 feet being recorded rather nearer the northern than the southern end. A sounding in 24 feet was taken near the northern end; and a sounding in 26 feet off the central part of the eastern shore shows a steep slope in that position. The mean depth is estimated at 18 feet, or one-half of the maximum depth, and the volume of water at 53 million cubic feet. The loch was surveyed on May 7, 1905, but the elevation above the sea could not be determined.



and nearly half a mile in length, with a maximum breadth of one-fifth of a mile. The superficial area is about 32 acres, and the drainage area exceeds half a square mile. The maximum depth of 55 feet was taken towards the southern end. The volume of water is estimated at 36 million cubic feet, and the mean depth at  $25\frac{1}{3}$  feet. The basin is simple, the deeper water lying in the southern portion of the loch, the upper end being comparatively shallow, with weeds in the northern angle. Off the south-western shore the slope is steep, soundings in 26, 27, and 35 feet having been taken close inshore; and off the central part of the opposite shore a sounding in 38 feet was taken a short distance out. The deepest part of the loch is flat-bottomed in character, no less than three consecutive soundings being taken at the maximum depth of 55 feet, and the area of the lake-floor covered by more than 50 feet of water is equal to 16 per cent. of the total area, while that covered by less than 25 feet of water is equal to 58 per cent. The loch was surveyed on April 28, 1905, when the elevation was 171·8 feet above the sea. The temperature of the water varied to the extent of less than  $1^{\circ}$  Fahr. from surface to bottom, the reading at the surface being  $46^{\circ}\cdot 5$ ; at 25 feet  $46^{\circ}\cdot 2$ ; and at 53 feet  $45^{\circ}\cdot 6$ .

*Kirk Loch* (see Plate XLVII.).—Kirk Loch lies to the south of Mill Loch, and to the west of the northern portion of Castle Loch, into which it drains by the Vendace burn. It is surrounded by stony fields, a circular hill, called Castle hill, rising between it and Castle Loch. Kirk Loch trends nearly north and south, and is less than half a mile in length, covering an area of about 33 acres. The maximum depth of 25 feet was taken towards the northern end, the mean depth being 10 feet, and the volume of water 15 million cubic feet. The basin is simple, with the deeper water occupying the northern portion of the loch, soundings in 12 and 13 feet being taken quite close to the northern end. More than half the lake-floor is covered by less than 10 feet of water. The loch was surveyed on April 28, 1905, when the elevation was 157·15 feet above the sea. The temperature of the water was practically uniform throughout, the reading at the surface being  $47^{\circ}\cdot 4$  Fahr., and at 23 feet  $47^{\circ}\cdot 2$ .

*Castle Loch* (see Plate XLVII.).—Castle Loch, the largest within the basin, is situated immediately to the south of Lochmaben. The shores of the loch are gentle, grassy slopes, with patches of wood, and there is a fringe of weeds nearly all round; the eastern shore where free from reeds is stony. It receives the drainage from Mill and Kirk Lochs, and the outflow is by a large burn (Valison burn) at the southern end through a peaty flat. The loch is subtriangular in outline, the length from north-west to south-east exceeding three-quarters of a mile, the maximum breadth across the wide southern portion being two-thirds of a mile, while the mean breadth is one-third of a mile. The superficial area is about 193 acres, or nearly one-third of a square mile, the drainage area extending to nearly

4 square miles. Castle Loch is simple in conformation, and of a flat-bottomed character, the deeper water, over 15 feet, occupying the central and eastern parts of the loch, three soundings at the maximum depth of 18 feet being recorded to the north-east of the island. Of the entire lake-floor, only 28 per cent. is covered by less than 5 feet of water, while 38 per cent. is covered by more than 10 feet of water. The mean depth is estimated at  $8\frac{1}{2}$  feet, and the volume of water at 72 million cubic feet. The loch was surveyed on April 27, 1905, when the elevation was 135.7 feet above the sea, as compared with 137.1 feet determined by the Ordnance Survey on February 22, 1899. The temperature of the water was uniform throughout, readings at the surface giving  $46^{\circ}.9$  Fahr., and at 18 feet  $46^{\circ}.8$ .

*Hightae Mill Loch* (see Plate XLVII.).—A small loch, pyriform in outline, to the south of Castle Loch. Though the smallest of the group, it drains the largest area, the overflow being carried by the Mill burn into the Valison burn just before entering the river Annan. The loch trends from north-west to south-east, tapering gradually towards the outflow at the southern end, and nearly one-third of a mile in length, the superficial area being about 19 acres, and the drainage area about  $6\frac{1}{2}$  square miles—an area over two hundred times greater than that of the loch. The basin is simple, the deeper water lying in the broadest part of the loch towards the upper end, the maximum depth of 13 feet having been found a short distance from the north-eastern shore. The mean depth is  $7\frac{1}{3}$  feet, or more than half the maximum, and the volume of water 6 million cubic feet. The elevation was 137.2 feet above the sea on the date of the survey (April 29, 1905), when identical readings of  $49^{\circ}.0$  Fahr. were taken at the surface and at 12 feet.

From the following table it will be seen that in the fourteen lochs under consideration, 599 soundings were taken, and that the aggregate area of the water-surface is about  $1\frac{3}{4}$  square miles, so that the average number of soundings per square mile of surface is 335. The aggregate volume of water contained in the lochs is estimated at 652 millions of cubic feet. The area drained by these lochs is about  $24\frac{3}{4}$  square miles, or  $13\frac{1}{2}$  times the area of the lochs.

## SUMMARY TABLE.

Giving Details concerning the Lochs in the Urr, Nith, and Annan Basins.

Loch.	Height above sea. Feet. °	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.		Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.		
				Max.	Mean.		Max. Feet.	Mean Feet.	Mean per cent. of max.	Max.			Mean.	Total in square miles.	Ratio to area of loch.
Urr ...	624.0	58	0.62	0.60	0.27	43.5	42	12.06	28.7	78	271	0.17	2.89	17.0	
Auchonroch ...	345.0	49	1.08	0.30	0.12	11.4	34	11.69	34.4	168	488	0.13	1.85	14.2	
Milton ...	410.0	55	1.10	0.50	0.22	19.8	15	6.67	44.5	387	874	0.24	1.88	7.8	
Arthur ...	239.8	44	0.63	0.30	0.18	29.0	50	25.77	51.5	66	129	0.12	0.94	7.8	
Howie ...	757.15	44	0.74	0.12	0.09	12.8	39	15.69	40.2	100	249	0.07	0.57	8.1	
Skae ...	864.5	27	0.26	0.18	0.12	46.8	35	9.52	27.2	39	144	0.08	0.21	7.0	
Lochrutton ...	305.5	64	0.77	0.50	0.26	33.9	58	13.03	22.5	70	312	0.20	3.15	15.7	
Lochaber ...	298.0	31	0.59	0.26	0.14	23.3	55	20.57	37.4	56	152	0.08	1.16	14.5	
	[Jan. 16, 1894]														
Kindar ...	88.05	55	0.80	0.33	0.26	32.7	41	14.22	34.7	103	297	0.21	1.14	5.4	
Skeen ...	[nearly 1750]	28	0.72	0.20	0.15	20.6	36	17.87	49.6	105	213	0.11	0.80	7.3	
Mill ...	171.8	33	0.43	0.21	0.12	27.4	25	25.83	46.1	90	41	0.05	0.54	10.8	
Kirk ...	157.15	31	0.42	0.18	0.12	29.6	25	9.96	39.8	89	223	0.05	0.34	6.8	
Castle ...	135.7	56	0.83	0.65	0.36	43.9	18	8.58	47.7	243	511	0.30	3.82	12.7	
Hightae Mill ...	137.2	24	0.30	0.16	0.10	33.3	13	7.31	56.2	122	217	0.08	6.36	212.0	
		599											24.77*	13.7	

\* The drainage area of Castle Loch includes those of the Mill and Kirk Lochs.

## LOCHS OF THE TWEED BASIN

THE large area drained by the river Tweed (see Index Map, Fig. 15) is on the whole remarkably devoid of lochs. It is true there are a dozen little lochs on the borders of Roxburghshire and Selkirkshire, drained by the Teviot branch of the Tweed, but they are very small, and were not sounded by the Lake Survey. The principal loch is the well-known St. Mary's Loch, with the adjacent Loch of the Lowes, in Selkirkshire, on

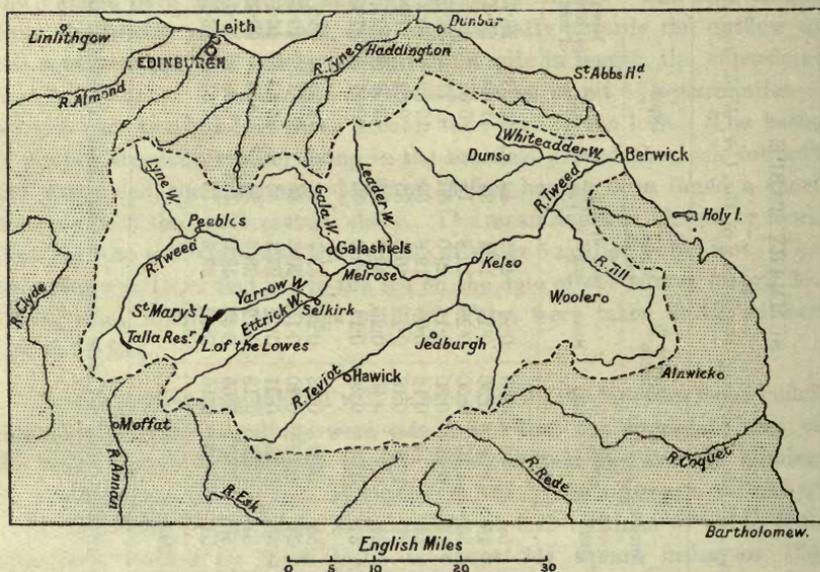


FIG. 15.—INDEX MAP OF THE TWEED BASIN.

the Yarrow branch of the Tweed, while a notable addition has recently been made by the construction, for the supply of water to the city of Edinburgh and surrounding district, of the Talla reservoir in Peeblesshire, which lies about 6 miles west of St. Mary's Loch, on the Talla branch of the Tweed. Of the three lochs surveyed, St. Mary's Loch is the largest and the Loch of the Lowes the smallest, Talla reservoir being intermediate in point of size:—St. Mary's Loch slightly exceeds 3 miles in length, Talla reservoir is nearly  $2\frac{1}{2}$  miles in length, while the Loch of the Lowes is less than a mile in length; the superficial area of St. Mary's

Loch is about 635 acres, of Talla reservoir about 299 acres, and of the Loch of the Lowes about 99 acres, the aggregate area covered by the three lochs being about  $1\frac{2}{3}$  square miles; the maximum depth of St. Mary's Loch is 153 feet, of Talla reservoir 73 feet, and of the Loch of the Lowes 58 feet. These lochs are situated among the moorland hills of the Southern Uplands of Scotland, the highest point being Broad Law (2754 feet), the scenery of the district being pastoral in character. The fishing in St. Mary's Loch and the Loch of the Lowes includes trout, pike, and perch, while the fishing in Talla reservoir is governed by regulations drawn up by the Water Trust.

*Talla Reservoir* (see Plate XLVIII).—Talla reservoir is situated about 10 miles north of Moffat, 14 miles south of Peebles, and about 20 miles west of Selkirk, lying in a narrow valley, with high hills, smooth, grassy, and round-topped, on both sides. The valley rises very steeply at the head of the loch, and the inflowing river descends by a series of cascades—the “Talla Linns”; there was formerly a bog on the site of the lower part of the loch. The Act of Parliament authorizing the construction of this reservoir was passed in 1895, and ten years later the work was completed. A huge embankment, 1300 feet in length, 600 feet in breadth across the base and tapering to 20 feet in breadth across the top, was thrown across the valley, the top of the embankment being 957 feet above sea-level, and 7 feet above the sill of the waste weir, which is 200 feet in length. On the date of the survey (July 24, 1906) the surface of the water in the reservoir was  $3\frac{1}{2}$  feet below the sill at the overflow, or 946.5 feet above the sea.

Talla reservoir\* trends from south-east to north-west, and is  $2\frac{1}{2}$  miles in length, the maximum breadth exceeding a quarter of a mile, while the mean breadth is about one-fifth of a mile. The superficial area is about 299 acres, or nearly half a square mile, and the drainage area extends to about 10 square miles. The principal feeders are the Gameshope burn and the Talla water entering at the head of the reservoir, while the overflow is carried by the Talla water into the river Tweed at Tweedsmuir. The maximum depth of 73 feet was observed quite near the embankment at the northern end, whence the water shoals gradually towards the head. The volume of water is estimated at 443 million cubic feet, and the mean depth at  $34\frac{3}{4}$  feet.

The following notes on the stocking of the Talla reservoir with life are supplied by Mr. James Murray:—

“It was thought that the formation of the Talla reservoir would give a good opportunity to study the incoming of life to a lake, and it was intended to make as frequent visits as circumstances permitted, with that object.

\* We are indebted to Mr. W. A. Tait, C.E., the engineer of the Edinburgh and District Water Trust, for permission to trace the outline of the reservoir, reproduced in the accompanying map (Plate XLVIII).

The reservoir did doubtless afford the opportunity, but, as it turned out, it would have been necessary to visit it at very short intervals. In January there was an almost total absence of life; in the following July the process of stocking was almost completed—if all the kinds of life found in old lochs had not arrived, those which had arrived were very well established and distributed all through the water. In January, 1906, a few months after the reservoir was filled, the temperature was 36° Fahr. at the surface. No life whatever was found except a few individuals of a kind of crustacean, a *Cyclops* not of the common species found in lakes.

“It was not convenient to visit Talla again till July, 1906, when the bathymetrical survey was made. The surface temperature was then 56°. The three commonest lacustrine crustacea were present—*Daphnia hyalina* was scarce; *Cyclops strenuus* was abundant, but mostly immature, only a few carrying eggs; *Bosmina obtusirostris* was in extreme abundance. The plankton rotifers found were *Anuræa cochlearis*, *Polyarthra platyptera*, *Synchæta pectinata*, and *Conochilus volvox*. *Noteus quadricornis*, a rotifer we have already found in Scottish lochs, and only in very shallow ones, was fairly abundant at the surface over the deepest part.

“In March, 1907, the crustacea were the same, but less abundant, and the two rotifers *Notholca longispina* and *Furcularia reinhardti* were observed for the first time. The temperature of the surface was 41°, and at 30 feet 39°·5.

“In contrast to the very rapid stocking of Talla is the case of the new reservoir at Holl, in the Lomond Hills, in Fife, where we found none of the common lake organisms after the reservoir had been open for a year or two. In Logan reservoir, after three or four years of existence, the phytoplankton was found very well developed, the diatoms imparting a yellowish colour to the water, but the zooplankton was much less abundant. These contrasted instances show how little we yet know about the factors governing the stocking of a new lake.”

*Loch of the Lowes* (see Plate XLIX.).—The Loch of the Lowes lies at the head of St. Mary's Loch, into which it flows by a stream about 150 yards in length, the fall between the two lochs being only about a foot; at one time they probably formed a continuous sheet of water. The loch is rectangular in outline, and trends almost north and south, being nearly a mile in length, and less than a quarter of a mile in maximum breadth. The superficial area is about 99 acres, and the drainage area exceeds 10 square miles. The maximum depth of 58 feet was observed towards the southern end of the loch. The volume of water is estimated at 157 million cubic feet, and the mean depth at 36½ feet, or nearly two-thirds of the maximum. The basin is simple in conformation, and flat-bottomed in character, as is shown by the fact that, while 25 per cent. of the lake-floor is covered by less than 25 feet of water, 34 per cent. is covered by more than 50 feet of water, although the maximum depth is only 58 feet. The loch was surveyed on May 5, 1905,

when the elevation was 810·5 feet above the sea, nearly identical with the elevation determined by the Ordnance Survey on May 18, 1896, viz. 810·4 feet.

*Temperature Observations.*—The following temperatures were taken in the deepest part of the loch :—

Surface ... ..	46°·0 Fahr.
5 feet ... ..	44°·3 „
10 „ ... ..	44°·0 „
25 „ ... ..	44°·0 „
56 „ ... ..	43°·0 „

The range from surface to bottom was 3°, a fall of 1°·7 being observed between the surface and a depth of 5 feet, while the readings at 10 and 25 feet were identical.

*St. Mary's Loch* (see Plate XLIX.).—St. Mary's Loch is situated about 10 miles south of Peebles, 12 miles south-west of Selkirk, and 13 miles north-east of Moffat, and is somewhat crescentic in outline, the narrower upper portion trending nearly north and south, while the wider lower portion trends in a north-easterly direction. It is 3 miles in length, the maximum breadth exceeding half a mile, the mean breadth being one-third of a mile. The superficial area is about 635 acres, or 1 square mile, while the drainage area, including the area draining into the Loch of the Lowes, extends to about 42 square miles. The maximum depth of 153 feet was observed in the wider part of the loch, about 1½ miles from the northern end. The volume of water is estimated at 2018 millions of cubic feet, and the mean depth at 73 feet, or nearly half the maximum. There are two deep basins exceeding 100 feet in depth, separated at the entrance of the Megget water by a ridge, on which a maximum depth of 88 feet was found: the larger and deeper one towards the lower end is nearly 1½ miles in length, while the smaller one towards the southern end has a maximum depth of 112 feet, and is over half a mile in length. The areas between the contour-lines, and the percentages to the total area, are as follows :—

Feet.	Acres.	Per cent.
0 to 50 ... ..	229	35·9
50 „ 100 ... ..	207	32·6
100 „ 150 ... ..	193	30·4
Over 150 ... ..	6	1·1
	635	100·0

The loch was surveyed on May 5 and 6, 1905, when the elevation was found to be 809·5 feet above the sea, or more than a foot higher than the elevation determined by the Ordnance Survey officers on May 18, 1896, viz. 808·2 feet.

*Temperature Observations.*—The following temperatures taken in the deepest part of the loch at 6·30 p.m. on May 5, 1905, showed that the range from surface to bottom was only 1°·8 Fahr. :—

Surface ... ..	42°·8 Fahr.
50 feet ... ..	42°·0 "
100 ,, ... ..	41°·7 "
140 ,, ... ..	41°·0 "

Dr. L. W. Collet, who took part in the survey, supplies the following notes on the formation of St. Mary's Loch and the Loch of the Lowes:—

“During the great Ice Age the Yarrow valley was occupied by a glacier, as is shown by the U-shaped section and the moraine matter on the slopes of the hills. In this valley we find the two picturesque lochs, St. Mary's Loch and the Loch of the Lowes, which are both due to burn deltas damming the valley. Three dams are manifest: (1) one situated at the very head of the Loch of the Lowes, formed by the junction of the deltas of two lateral streams, the Chapelhope burn and the Riskinhope burn; a small loch was very likely formed at one time behind this dam, as shown now by an alluvial tract, which is the result of the filling up of the loch by detrital matter brought down by the principal burn; (2) one at the lower end of St. Mary's Loch, due also to the junction of the deltas of two burns, the Kirkstead burn and the Thorny cleuch; this dam held back at one time only one big loch; (3) one formed by the deltas of the Ox cleuch and the Thirlestane burn, which divided the big loch into two separate ones, now represented by the Loch of the Lowes and St. Mary's Loch; this dam has led to the gradual filling up of the Loch of the Lowes by the detrital matter brought down by the streams, as shown by the soundings, the deepest recorded being 58 feet, while on the other hand the deepest sounding recorded in the upper basin of St. Mary's Loch is 112 feet.

“St. Mary's Loch is fed by many streams: the first one on the western shore is the Summerhope burn, the detrital matter brought down by which causes a sinuosity in the 50-feet contour-line in that region; the Mare cleuch has given rise to a small delta, which has little effect on the contour-lines; the most important tributary is the Megget water, which has laid down a huge delta protruding across the lake, forming a sub-lacustrine barrier, on which the maximum depth recorded is 88 feet; the Copper cleuch has also formed a small delta, and has raised the floor of the bay into which it flows.

“From a bathymetrical point of view, St. Mary's Loch is divided into two basins separated by the sub-lacustrine ridge due to the deposition of material brought into the lake by the Megget water. The deeper basin is situated in the north-eastern part of the loch, and might be ascribed to the combined effect of the two glaciers, the Yarrow glacier and the Megget glacier, uniting at that place. It is difficult to decide whether St. Mary's Loch is simply a barrier basin, or whether it partakes of the character both of a barrier basin and a rock basin.”

Mr. James Murray supplies the following notes on the biology of St. Mary's Loch:—

“During the discussion as to the suitability of St. Mary's Loch as a

source of water-supply for the city of Edinburgh, objection was made to the water on account of the presence of certain organisms in it, and especially of the small crustacean (*Daphnia*) commonly called the Water-flea. It was pointed out at the time by those conversant with such matters that these crustacea are usually present in all impounded waters, and we shall see that the organisms found in the water of St. Mary's Loch are those which are characteristic of all freshwater lakes in this country, even of those which are reputed purest. Their presence does not, therefore, in itself constitute any objection to the water.

"The water of St. Mary's Loch was examined by the Lake Survey on two occasions, early in May, 1905, and in the middle of January, 1906. In May the water was fairly clear, and there were only a few species of animals and some microscopic plants found in it. There were four species of crustacea: *Diatomus gracilis*, Sars, *Cyclops strenuus*, Fischer, *Daphnia hyalina*, Leydig, and *Bosmina obtusirostris*, Sars; one rotifer, *Notholca longispina*, Kellicott; and three diatoms, *Asterionella formosa*, Hass., *Tabellaria flocculosa*, Kütz., and *T. fenestrata*, Kütz., var. *asterionelloides*, Grun. No other organism was at all abundant.

"All the species above enumerated are among the commonest of lacustrine organisms, and it would be difficult to find a loch in Scotland in which all of them are not present.

"In January the condition of the water was very different. The quantity of life was immensely greater, and rendered the water of a dull yellowish colour, and so turbid that bright objects could only be seen at a depth of about 3 feet. All the same species were present, but some of them were more abundant than in May, and many species were present which were not found in May. The crustacea were the same, but the larvæ of the copepods were very abundant, and some of the *Cyclops* were carrying eggs. Of rotifers four additional species were found: *Anuræa cochlearis*, *Conochilus* sp., *Polyarthra platyptera*, and *Triarthra longiseta*. The contrast was greatest in the vegetable life. One greenish alga, forming little clusters easily visible to the naked eye, was mainly responsible for the turbidity of the water.

"This 'flowering of the lake' in winter is not unfamiliar in Scotland, and has been seen in Loch Earn, etc. It takes place when the temperature is low (in St. Mary's 38° Fahr.). As the increase of life is not due to high temperature, occurring, in fact, when the lochs are coolest, it may be supposed that pollution of the water by sewage may have something to do with it. At any rate, both St. Mary's Loch and Loch Earn receive a good deal of sewage. These facts concern the open water of the loch, which alone is of much importance in relation to water-supply for towns. The life of the margin of St. Mary's, and of the mud on the bottom, was also studied.

"The life of the margin, chiefly found among the mosses and other aquatic plants, is much more abundant than that of the open water. It

includes animals and plants of a great many different classes, but the flora and fauna of this region resemble those of any highland lochs which we have studied, and there is little calling for remark. A new species of rotifer, *Philodina hamata*, Murray, a parasite on *Gammarus* (the fresh-water shrimp), was found here.

“The mud of the bottom proved to resemble that of Loch Ness, and other highland lochs in the comparative paucity of life. A few worms, crustacea, and molluscs are the commonest inhabitants of this region. The depth of St. Mary’s being moderate, some species were found which are absent from the deeper muds of Loch Ness. Water-mites (Hydrachnida) of several species were found, and a single small stickleback.”

## LOCHS OF THE MONIKIE BASIN.

WITHIN the area drained by the Monikie burn (see Index Map, Fig. 16), which flows into the North sea at Carnoustie, are two (or rather three) reservoirs used for the supply of water to Dundee, that were sounded by the Lake Survey, viz. Monikie reservoirs and Crombie Den reservoir, situated 7 or 8 miles south-east of Forfar, and about 4 miles north-west of Carnoustie, at an elevation of nearly 500 feet above the sea.

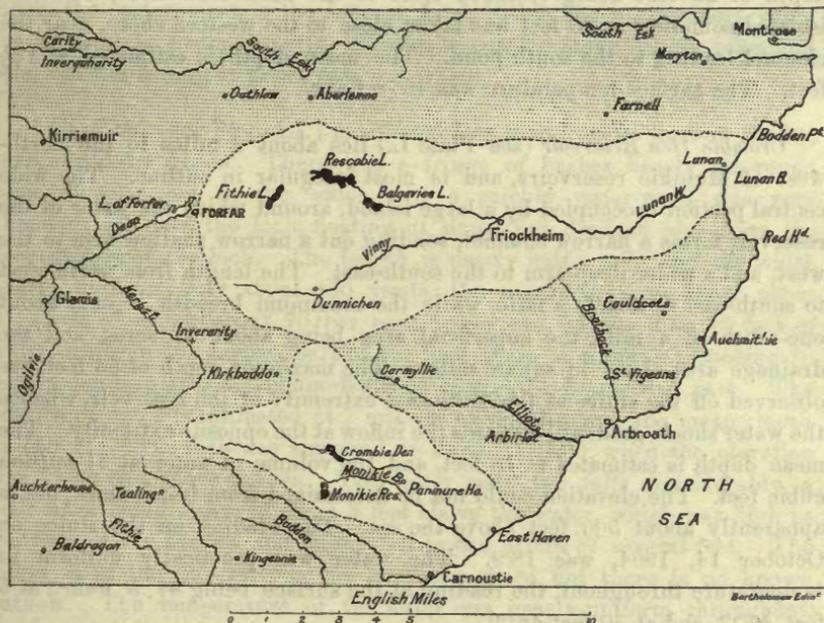


FIG. 16.—INDEX MAP OF THE MONIKIE AND LUNAN BASINS.

*Monikie Reservoirs* (see Plate L.).—The two reservoirs together resemble the capital letter B in outline, and when full they stand at the same level, but on the date of the survey (October 13, 1904) there was a difference in level of nearly 2 feet, the elevation of the south pond being 476.6 feet, and of the north pond 474.8 feet, above the sea. The clear-water basin could not be sounded, as it was under repair; it has a flat

bottom, with drains running through it, and overflows when the depth of water at the north end attains 10 feet, the south end being about 3 feet deeper. The area draining into the reservoirs is about 4 square miles.

*South Settling Reservoir.*—The south pond is the larger of the two, being nearly half a mile in length, by nearly one-third of a mile in breadth, covering an area of about 73 acres, and containing about 43 million cubic feet of water. The deepest sounding in 26 feet was taken near the middle but towards the west side, where there is a considerable area, equal to about 21 per cent. of the total area, covered by more than 20 feet of water. The mean depth is estimated at  $13\frac{1}{2}$  feet. The temperature of the water was nearly uniform throughout, the reading at the surface being  $47^{\circ}1$  Fahr., at 10 feet  $47^{\circ}0$ , and at 25 feet  $46^{\circ}8$ .

*North Settling Reservoir.*—The north pond is nearly half a mile in length, by a quarter of a mile in maximum breadth, covering an area of about 47 acres, and containing about 26 million cubic feet of water. The deepest water occupies the north-eastern part of the pond, the maximum depth of 22 feet being recorded close to the north-east shore, while an isolated sounding in 20 feet was taken close to the western shore, near the channel leading to the south pond. The mean depth is estimated at  $12\frac{1}{2}$  feet. The surface temperature was  $46^{\circ}8$  Fahr.

*Crombie Den Reservoir* (see Plate L.) lies about 2 miles to the north-west of Monikie reservoirs, and is most irregular in outline. The wide central portion is occupied by a large island, around which the water of the reservoir forms a narrow channel, sending out a narrow shallow arm to the west, and a wider deep arm to the south-east. The length from north-west to south-east is nearly a mile, while the maximum breadth is only about one-ninth of a mile, the superficial area being about 41 acres, and the drainage area about  $2\frac{1}{2}$  square miles. The maximum depth of 53 feet was observed off the sluice at the south-east extremity of the reservoir, whence the water shoals gradually towards the inflow at the opposite extremity. The mean depth is estimated at 18 feet, and the volume of water at 31 million cubic feet. The elevation could not be determined from bench-mark, but is apparently about 500 feet above the sea. The reading on the sluice on October 14, 1904, was 18.9. The water was practically uniform in temperature throughout, the reading at the surface being  $47^{\circ}5$  Fahr., at 5 feet  $47^{\circ}2$ , and at 50 feet  $46^{\circ}9$ .

## LOCHS OF THE LUNAN BASIN.

THE area draining by the Lunan water (see Index Map, Fig. 16) into Lunan bay, on the east coast of Scotland, between Arbroath and Montrose, includes three small lochs sounded by the Lake Survey, viz. Lochs Fithie, Rescobie, and Balgavies. They lie towards the head-waters of the Lunan, 10 miles or more from the sea, and 2 to 5 miles east of the town of Forfar, forming a series trending generally in an east and west direction. Rescobie Loch, the central one of the series, is the largest, though Balgavies Loch, the easternmost, is the deepest, Loch Fithie, the westernmost, being the smallest in every respect. The lochs contain trout, perch, pike, and eels, but the fishing is preserved.

*Loch Fithie* (see Plate LI.) is situated less than 2 miles east of Forfar, surrounded by woods. There was a fringe of bushes nearly all round some distance out in the water, and a prickly water-weed was very abundant all over the loch, floating at times, but dredged also from the deepest part of the loch. The length is nearly half a mile, and the width nearly uniform, only about 150 yards, the superficial area being about 21 acres, of which about 70 per cent. is covered by less than 10 feet of water, while in the eastern part of the loch there is a basin exceeding 10 feet in depth, with a maximum depth of 16 feet in its central part. The volume of water is estimated at 7 million cubic feet, and the mean depth at  $7\frac{1}{2}$  feet. The loch was surveyed on June 30, 1903, when the elevation was 215.5 feet above the sea. The water rises and falls considerably, a drift-mark being observed about 5 feet above the water, which was high at the time of the survey, and might fall to the extent of several feet. The inflow is at the east end on the southern shore, but there is no known outflow. The temperature of the water was nearly uniform throughout, the readings at the surface and at 10 feet being  $62^{\circ}.2$  Fahr., and at 15 feet  $62^{\circ}.1$ .

*Rescobie Loch* (see Plate LI.) lies about 3 miles east of Forfar, surrounded by cultivated fields, with a strip of wood on the north shore at the east end. The loch is  $1\frac{1}{4}$  miles in length, by one-third of a mile in maximum breadth, the mean breadth being one-fifth of a mile. The superficial area is about 158 acres, or a quarter of a square mile, of which about 57 per cent. is covered by less than 10 feet of water. The

10-foot basin is continuous, and about a mile in length, approaching comparatively close to the east end. The maximum depth of 23 feet was observed immediately to the east of the central constriction, the depth in the narrows being 14 feet, and in the large western expansion the greatest depth is 19 feet. The volume of water is estimated at 69 million cubic feet, and the mean depth at 10 feet. The area draining into the loch is about  $5\frac{1}{2}$  square miles. The survey was made on June 29, 1903, when the elevation was 194·6 feet above the sea; the Ordnance Survey map gives 196·0 feet, but the date when levelled is not indicated. A drift-mark was observed 3 feet above the water, which might fall perhaps a foot lower, giving a range in level of about 4 feet. The water was very dirty and green in colour, and nearly uniform in temperature, the readings at the surface and at 10 feet being 61°·9 Fahr., at 15 feet 61°·8, and at 20 feet 61°·5.

*Balgavies Loch* (see Plate LI.) is situated less than half a mile to the east of Rescobie Loch, and about 5 miles from Forfar. The length is half a mile, and the width nearly uniform, 250 to 300 yards, the superficial area being about 52 acres, of which about 60 per cent. is covered by less than 10 feet of water. The deepest part lies near the east end, where the maximum depth of 32 feet was recorded, but there is an isolated basin in the south-western portion of the loch with a greatest depth of 18 feet. The volume of water is estimated at 22 million cubic feet, and the mean depth at  $9\frac{3}{4}$  feet. Balgavies Loch drains directly an area of two-thirds of a square mile, but since it receives the overflow from Rescobie Loch, the total drainage area is about 6 square miles. The loch was surveyed on June 29, 1903, when the elevation was 194·5 feet above the sea; the Ordnance Survey map gives 195·1 feet, but the date when levelled is not indicated. A drift-mark was observed 2 feet above the water, which might fall a foot lower. Serial temperatures were taken in the deepest part of the loch, with the following results:—

Surface ... ..	62°·5 Fahr.
10 feet ... ..	62°·4 „
20 „ ... ..	55°·8 „
30 „ ... ..	52°·5 „

There was a range of 10° throughout the body of water, the upper 10 feet being practically uniform, while between 10 and 20 feet there was a fall of 6°·6, and between 20 and 30 feet a further fall of 3°·3.

## LOCHS OF THE DEE (ABERDEEN) BASIN.

THE drainage basin of the river Dee (Aberdeenshire) is an extensive one, exceeding 800 square miles, and includes one important loch (Loch Muick) and several small ones, of which half a dozen were sounded by the Lake Survey, viz. Lochs Callater, Muick, Davan, Kinord, Aboyne, and Skene (see Index Map, Fig. 17). Loch Builg might also be included among the lochs of the Dee basin, since a certain proportion of its overflow drains through the moraine matter at its southern end into the river

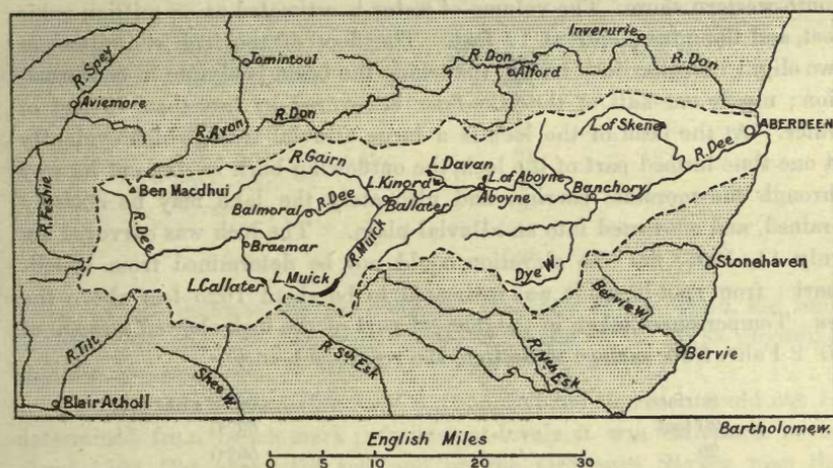


FIG. 17.—INDEX MAP OF THE DEE (ABERDEEN) BASIN.

Gairn, but as its normal outflow is at the northern end into the river Avon, it will be dealt with among the lochs of the Spey basin. Lochs Muick, Callater, and Builg were made the subject of a short paper by Drs. Johnston and Collet.\*

Lochs Callater and Muick are situated in the upper reaches of the river, to the south-west of Ballater, on the flanks of Lochnagar, the highest peak attaining an altitude of 3786 feet, while the other lochs are connected with the lower reaches of the river, to the east of Ballater. The fishings

\* "On the Formation of Certain Lakes in the Highlands," *Proc. Roy. Soc. Edin.*, vol. 26, p. 107 (1906).

in the lochs are preserved; in Loch Callater there are a few trout, and salmon late in the season, with pike and eels, and Loch Muick contains trout, while Lochs Davan and Kinord contain pike and perch.

The upper lochs are mountain valley-basins, Loch Muick partaking both of the character of a rock-basin and of a barrier-basin, while Loch Callater is a true barrier-basin. The other lochs occur in the cup-shaped and irregular depressions of the so-called morainic country generally found at the base of a mountain region.

*Loch Callater* (see Plate LII.) lies about 5 miles south of Braemar. On both sides of the loch the hills rise with fairly steep slopes, especially at the south-east end of the loch. No outcrops could be detected on the shores, which are stony and composed of moraine matter. The loch trends in a north-west and south-east direction, and is nearly a mile in length, with a maximum breadth of one-fifth of a mile, the superficial area being about 73 acres, and the drainage area nearly 8 square miles. The largest feeder is the Allt an Loch, entering at the southern end. The maximum depth of 30 feet was observed near the middle of the loch, but towards the south-western shore. The volume of water is estimated at 38 million cubic feet, and the mean depth at 12 feet. The floor of the loch shows one or two slight irregularities, but on the whole the basin is simple in conformation; nearly one-half of the lake-floor is covered by less than 10 feet of water. At the head of the loch is a large alluvial tract, which evidently at one time formed part of the loch, the outflowing burn having cut its way through the morainic barrier, and ultimately the lake may be entirely drained, and converted into an alluvial plain. The loch was surveyed on July 11, 1905, but the elevation could not be determined from benchmark; from spot-levels it was estimated to be about 1625 feet above the sea. Temperatures taken in the deepest part of the loch showed a range of 10°·2 Fahr. from surface to bottom, the readings being—

Surface ...	...	...	...	...	...	66°·2 Fahr.
20 feet ...	...	...	...	...	...	59°·0 "
29 "	...	...	...	...	...	56°·0 "

*Loch Muick* (see Plate LIII.), the largest and most picturesque of the lochs in the Dee basin, lies about 8 miles south-west of Ballater amid wild and magnificent scenery. On both sides of the loch the mountain-slopes rise precipitously from the water's edge. The shores are stony, with many big boulders. The loch trends in a south-west and north-east direction, the axis being slightly curved, and is  $2\frac{1}{4}$  miles in length, half a mile in maximum breadth, the mean breadth exceeding one-third of a mile. The superficial area is about 549 acres, or nearly a square mile, while the drainage area exceeds 14 square miles. The loch is fed by numerous small streams, the largest feeder being the Allt an Dubh-loch, coming from the Dubh Loch lying towards the head of the valley at an elevation of about 2100 feet. The Glas Allt enters on the northern shore near the

south-west end, and has laid down a large delta, which is covered by vegetation, thus contrasting with the other lake-shores, which are but scantily clothed with vegetation. The Black burn, entering near the middle of the southern shore, has not formed a delta, as it runs down a rocky steep slope. The maximum depth is 256 feet, while the mean depth is estimated at over 116 feet, and the volume of water at 2771 millions of cubic feet. The ratio of maximum depth to length is 46, and of mean depth to length 101; these figures show the relatively great depth of the basin, for in Loch Morar, the deepest of all British lakes (1017 feet), the ratio of maximum depth to length is 61, and of mean depth to length 217, while the Lake of Geneva is 230 times longer than deep.

The basin is simple in conformation, the shores sloping on all sides to the deepest part of the loch, which is centrally placed. At the south-west end the 50-foot and 100-foot contours are sinuous, due to the deposition of material brought down by the burns. The mud from the deepest part is black and peaty. The approximate areas between the contour-lines drawn in at equal intervals, and the percentages to the total area, are as follows:—

Feet.		Acres.	Per cent.
0 to 50	... ..	170	31·1
50 „ 100	... ..	96	17·5
100 „ 150	... ..	69	12·5
150 „ 200	... ..	91	16·5
200 „ 250	... ..	113	20·7
Over 250	... ..	10	1·7
		—	—
		549	100·0

These figures indicate the flat-bottomed character of the basin, the zone between 200 and 250 feet being larger than any of the three preceding shallower zones.

The loch was surveyed on July 8, 1905, but the elevation could not be determined from bench-mark; from spot-levels it was estimated to be about 1308 feet above the sea, and on the Ordnance Survey map the elevation of 1309·8 feet is given, though the date when levelled is not indicated. The surface of the water was 1·2 feet below the large stone at the south-east corner of the pier at His Majesty's boathouse. The water was then very low—about 2 feet below the ordinary level—and might rise 4 or 5 feet above ordinary level, the range being about 7 feet.

*Temperature Observations.*—At noon on the date of the survey the temperature of the surface water was 58°·2, and at 7 p.m. serial temperatures gave the following results:—

Surface	... ..	56°·1	Fahr.
50 feet	... ..	47°·2	„
100 „	... ..	44°·3	„
225 „	... ..	43°·0	„

The range of temperature throughout the body of water was thus  $15^{\circ}2$ , a fall of  $8^{\circ}9$  being recorded between the surface and a depth of 50 feet, and a further fall of  $2^{\circ}9$  between 50 and 100 feet.

*Loch Davan* (see Plate LIV.) lies about 5 miles north-east of Ballater, and in close proximity to Loch Kinord. These two lakes are situated in true "morainic country," that is to say, in hollows of the covering of detritus left on the surface of the country when the ice-sheets retreated. Loch Davan is three-quarters of a mile in length from east to west, the greatest breadth from north to south being nearly two-thirds of a mile, and the mean breadth one-third of a mile. Its waters cover an area of about 146 acres, or nearly a quarter of a square mile, and the drainage area extends to  $11\frac{1}{2}$  square miles. The maximum depth recorded was 9 feet, three soundings having been taken at this depth towards the south-eastern shore. The volume of water is estimated at 25 million cubic feet, and the mean depth at 4 feet. The elevation could not be determined, but on the date of the survey (July 10, 1905) the surface of the water was 1.7 feet below the platform of the boathouse. The loch is in process of being choked up by the water-lilies, which have increased since the Ordnance Survey map was prepared. The 5-foot contour-line approximately indicates the extension of the lilies, about 67 per cent. of the lake-floor being covered by less than 5 feet of water. The temperature of the surface water was  $66^{\circ}4$  Fahr.

*Loch Kinord* (see Plate LIV.)—Loch Kinord (or Ceander) lies immediately to the south of Loch Davan, though the two lochs are drained by independent streams. Loch Kinord is a true "lake of the plains," lying in a depression between low hills composed of moraine matter, which has been thrown down very irregularly. The length of the loch from north-west to south-east exceeds a mile, and the maximum breadth exceeds two-thirds of a mile, the mean breadth being a quarter of a mile. The superficial area is about 186 acres, or over a quarter of a square mile, the catchment area being nearly 3 square miles. The maximum depth of 12 feet was recorded near the eastern shore. The volume of water is estimated at 41 million cubic feet, and the mean depth at 5 feet. The loch is irregular both in outline and conformation, and there are many islets composed of boulders. About 56 per cent. of the lake-floor is covered by less than 5 feet of water. The elevation above the sea could not be determined, but at the time of the survey (July 10, 1905) the surface of the water was 1.5 feet below the platform of the boathouse. The temperature of the surface water was  $65^{\circ}9$  Fahr.

*Loch of Aboyne* (see Plate LII.)—The Loch of Aboyne is an artificial one, the embankment at the boathouse having been made to form the loch, which encloses one large and one smaller island. The elevation above the sea could not be determined, but is estimated from spot-levels at about 430

feet; on the date of the survey (July 13, 1905) the water was a foot below the platform of the boathouse. The superficial area is about 38 acres, and the area draining into it exceeds a square mile. The maximum depth of 11 feet was recorded between the large island and the western shore. The volume of water is estimated at 10 million cubic feet, and the mean depth at 6 feet. The basin is of a flat-bottomed character, about 62 per cent. of the lake-floor being covered by more than 5 feet of water. The surface temperature was  $67^{\circ}\cdot 9$  Fahr.

*Loch of Skene* (see Plate LII.).—The Loch of Skene is situated about 9 miles to the west of Aberdeen, and is a mile in length by two-thirds of a mile in maximum breadth. The superficial area is about 294 acres, or nearly half a square mile, while the drainage area extends to about  $17\frac{1}{4}$  square miles. The volume of water is estimated at 60 million cubic feet. The elevation could not be determined from bench-mark, but on the date of the survey (July 17, 1905) the water was 1.5 feet below the platform of the Dunecht boathouse; the Ordnance Survey officers found the elevation to be 274.8 feet above the sea on October 17, 1899. The loch forms a shallow flat-bottomed basin, the great majority of the soundings being taken at the maximum depth of 6 feet, the mean depth being nearly 5 feet; in fact, about 73 per cent. of the lake-floor is covered by more than 5 feet of water. The surface temperature was  $64^{\circ}\cdot 2$  Fahr.

## LOCHS OF THE SLAINS BASIN.

THE little Sand Loch, lying close to the sea near Kirktown of Slains, was surveyed along with the other Aberdeenshire lochs.

*Sand Loch* (see Plate LV.) is a small shallow basin situated amid flat and uninteresting surroundings close to the seashore between Aberdeen and Peterhead. It is a quarter of a mile in length, covers an area of about 10 acres, and contains barely a million cubic feet of water. The deepest water is in the extreme north-eastern portion of the loch, where soundings in 4 feet were taken, shallowing thence to the southward. The surface temperature on July 15, 1905, was 67°·1 Fahr.

From the following table it will be seen that in the sixteen lochs under consideration 879 soundings were taken, and that the aggregate area of the water-surface is nearly  $4\frac{1}{4}$  square miles, so that the average number of soundings per square mile of surface is 207. The aggregate volume of water contained in the lochs is estimated at 5762 millions of cubic feet. The area drained by these lochs is over 121 square miles, or about  $28\frac{1}{2}$  times the area of the lochs.

## SUMMARY TABLE.

Giving Details concerning the Lochs in the Tweed, Monikie, Lunan, Dee, and Slains Basins.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.		Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. Feet.	Mean. Feet.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
Talla ...	946.5	62	2.47	0.28	0.19	7.7	84.70	179	385	4.43	0.47	10.84	22.0	
Lowes ...	810.5	36	0.84	0.22	0.18	21.8	36.55	58	119	157	0.15	10.28	68.2	
St. Mary's ...	809.5	127	3.02	0.53	0.33	10.9	79.98	153	219	2018	0.99	41.86	42.3	
Monikie (North)	474.8	48	0.42	0.24	0.18	42.9	12.58	22	101	26	0.07	4.08	58.3	
" (South)	476.6	69	0.48	0.31	0.24	50.0	13.47	26	97	188	0.12	0.38	3.2	
Crombie Den	[about 600]	48	0.86	0.11	0.07	8.1	17.64	53	86	31	0.06	2.56	42.7	
Fithie ...	215.5	38	0.46	0.08	0.07	15.4	7.42	16	152	7	0.08	1.14	38.0	
Rescobie ...	194.6	60	1.24	0.34	0.20	16.1	9.99	23	285	69	0.25	5.40	21.6	
Balgavies ...	194.5	43	0.50	0.18	0.16	32.4	9.76	32	83	22	0.08	6.06	75.8	
Caithier ...	[1625 app.]	54	0.84	0.20	0.13	16.0	11.99	30	148	38	0.11	7.63	69.3	
Muick ...	[1308 app.]	87	2.22	0.50	0.38	17.3	116.30	256	46	2771	0.85	14.28	16.8	
Davan ...	—	45	0.74	0.60	0.31	41.9	3.98	12	434	25	0.23	11.51	50.0	
Kinord ...	—	60	1.06	0.68	0.27	25.8	5.08	9	466	41	0.29	2.66	13.3	
Aboyne ...	[430 app.]	48	0.36	0.32	0.16	45.6	6.03	11	173	10	0.06	1.29	21.5	
Skene ...	274.8	37	0.98	0.64	0.47	47.9	4.69	6	862	60	0.46	17.26	37.5	
Sand ...	[Oct. 17, 1899]	17	0.29	0.14	0.06	19.5	2.00	4	383	1	0.02	0.52	26.0	
		879								5762	4.24	121.19*	28.6	

\* The drainage area of St. Mary's Loch includes that of the Loch of the Lowes; that of Monikie reservoir (north) includes that of Monikie reservoir (south); that of Loch Balgavies includes that of Loch Rescobie.



Near the source of the river is the little Loch Spey, and another small hill-loch lies a short distance to the south. Proceeding eastward from Loch Spey for about 8 miles, the river, having been joined by many mountain streams, receives the outflow from Loch Crunachan, lying in Glen Shirra, about 2 miles north of the head of Loch Laggan in the Lochy basin. About 2 miles farther down, the Markie burn flows in from the north and the Mashie water from the south; and another 2 miles further down, the Allt Breakachy flows in from the south, bearing the outflow from Loch Caol na Doire; while about 4 miles still further down, the river Truim flows in from the south, carrying the outflow from Loch na Cuaich. At Newtonmore the river Calder flows in from the north, and near Kingussie the river Tromie comes in from the south, bearing the outflow from a connected series of three lochs (Lochs an Duin, Bhradain, and an t-Seilich). About 4 miles down from Kingussie, Loch Insh lies in the direct course of the river; and in the immediate vicinity the river Feshie flows in from the south. About 3 miles farther down, the river, now flowing in a northerly direction, receives the overflow from Loch Alvie, lying immediately to the west, and from Loch Gambna and Loch an Eilein, lying immediately to the east. At Aviemore the river Druie flows in from the east, bearing the outflow from Loch Morlich and Loch Eunach; and a short distance further down, Loch Phitiùlais lies close to the river on the east; while Loch Garten lies to the east near Boat of Garten. About 4 miles down from Boat of Garten the river Nethy comes in from the south-east, and about 15 miles farther down, the river Avon, probably the most important of all the tributaries of the Spey, flows in from the south-east, carrying the outflow from Loch Avon and Loch Builg. Thence the river pursues a sinuous course to the sea, the river Fiddich coming in on the east, about 10 miles down from the entrance of the river Avon.

Of the numerous small lochs within the basin, thirteen were sounded by the Lake Survey, viz. Lochs Crunachan, Caol na Doire, na Cuaich, an Duin, Bhradain, an t-Seilich, Insh, Alvie, Gambna, an Eilein, Morlich, Phitiùlais, and Builg. The most important of the lochs which could not be sounded are Lochs Eunach and Avon, lying at a high elevation in the Cairngorm mountains. With one exception, the lochs surveyed exceed half a mile in length, five of them exceeding a mile in length; in maximum depth they vary from 25 to 102 feet, nine exceeding 50 feet in depth. Loch Insh contains the largest volume of water, while Loch Morlich covers the largest area, nearly half a square mile. Loch Builg lies on the border between the Spey and the Dee basin, to which latter basin it contributes to some extent, as mentioned when dealing with the lochs of the Dee basin. Most of the lochs are situated in Inverness-shire, Loch an Duin lying partly in Perthshire and partly in Inverness-shire, the county boundary crossing the central part of the loch; but Loch Builg lies in Banffshire, just on the border of Aberdeenshire. The fishings in the lochs are

preserved; they contain trout, with pike in Lochs Alvie and Caol na Doire, salmon in Loch an t-Seilich, and char in Loch Builg.

*Loch Crunachan* (see Plate LVI.) lies about 7 miles to the north-west of Dalwhinnie on the Highland railway, and 11 miles to the south-west of Newtonmore, Loch Laggan hotel, at the head of Loch Laggan, being less than 2 miles to the south. The loch trends in a north-east and south-west direction, and is two-thirds of a mile in length, with a maximum breadth of a quarter of a mile, covering an area of about 68 acres, and draining an area of nearly 4 square miles. The maximum depth of 25 feet was observed towards the south-west end of the loch. The volume of water is estimated at 23 million cubic feet, and the mean depth at nearly 8 feet. The loch was surveyed on June 5, 1902, but the elevation could not be determined; on December 18, 1872, the officers of the Ordnance Survey found it to be 878·9 feet above the sea. The loch forms a simple shallow basin, a considerable area at the northern end being under a foot in depth, and about 78 per cent. of the lake-floor is covered by less than 10 feet of water. Weeds are abundant, especially at the north-eastern angle, where the burn flows out.

*Temperature Observations.*—Temperatures taken in the deepest part of the loch gave the following results:—

Surface ...	...	...	...	...	...	56°·0 Fahr.
5 feet ...	...	...	...	...	...	54°·0 „
10 „ ...	...	...	...	...	...	48°·2 „
20 „ ...	...	...	...	...	...	47°·5 „

These observations show a range of 8°·5 from surface to bottom, the greatest fall being one of 5°·8 between 5 and 10 feet—a fall exceeding 1° per foot of depth.

*Loch Caol na Doire* (see Plate LVI.).—Loch Caol na Doire (or Coul-tree) lies about 3 miles from Dalwhinnie, and about 5 miles to the east of the head of Loch Laggan. In outline it is pear-shaped, trending nearly east and west, and nearly three-quarters of a mile in length, with a maximum breadth across the wide western portion of nearly one-third of a mile. The superficial area is about 77 acres, and the drainage area nearly 1½ square miles. The maximum depth of 55 feet was observed approximately in the centre of the wide western portion of the loch. The volume of water is estimated at 77 million cubic feet, and the mean depth at 23 feet. The loch was surveyed on May 14, 1904, but the elevation could not be determined; on December 2, 1872, the Ordnance Survey officers found it to be 1140·7 feet above the sea. The loch is simple in conformation, and relatively deep, one-half of the lake-floor being covered by more than 20 feet of water. The surface temperature was 45°·0 Fahr.

*Loch na Cuaich* (see Plate LVII.) lies on the east side of Glen Truim, about 5 miles north-east from the head of Loch Ericht. *Stac Meall na Cuaich* rises to a height of 3000 feet immediately to the east of the loch. Trending in a north-east and south-west direction, the loch is nearly a mile in length, with a maximum breadth of a quarter of a mile near the south-west end, whence it narrows gradually towards the opposite end. The superficial area is about 116 acres, and the drainage area exceeds  $2\frac{1}{2}$  square miles. The maximum depth of 85 feet was observed approximately near the centre of the loch, but towards the south-west end. The volume of water is estimated at 214 million cubic feet, and the mean depth at  $42\frac{1}{2}$  feet. The loch was surveyed on May 12, 1904, and the elevation from spot-levels was estimated to be about 1296 feet above the sea. The loch forms a simple basin, the contour-lines coinciding approximately with the outline, but approaching closer to the eastern than to the western shore, indicating a steep slope on the eastern side; in fact, in one place a sounding in 50 feet was taken about 50 feet from the eastern shore, equal to a gradient of 1 in 1. The surface temperature was  $41^{\circ}8$  Fahr.

*Loch an Duin* (see Plate LVII.) lies about 7 miles to the east of the head of Loch Ericht, and 5 miles south-east from Loch na Cuaich, at an elevation of 1600 feet among the mountains, which rise on the west to 2707 feet, and on the east to 2844 feet, above the sea, the lower slopes forming steep screes of small material. The shores are all stony, and the outflow to the north is among stones. Loch an Duin drains northward into Loch Bhradain, and thence into Loch an t-Seilich. It is a long and narrow loch, trending almost north and south, and over a mile in length, the maximum breadth being less than one-fifth of a mile. The superficial area is about 102 acres, and the drainage area exceeds a square mile. The maximum depth of 102 feet was observed in the middle of the loch. The volume of water is estimated at 134 million cubic feet, and the mean depth at over 30 feet. The basin is simple, the deeper water occupying a central position, where the contour-lines approach close to the shores, showing that the sides are very steep; in one place off the eastern shore a sounding in 45 feet was taken about 50 feet from shore. The 25-foot basin is rather more, and the 50-foot basin rather less, than half a mile in length, the two ends of the loch being comparatively shallow, about two-thirds of the lake-floor being covered by less than 25 feet of water. The deep, central part is flat-bottomed, with the U-shaped section characteristic of ice-eroded basins. The loch was surveyed on October 14, 1904, but the elevation could not be determined; from spot-levels it was estimated to be about 1590 feet above the sea. A gravelly beach was seen at places 2 feet above the water. Temperatures taken in the position of the deepest sounding showed that the water was practically uniform in temperature throughout, the reading at the surface being  $44^{\circ}2$  Fahr.; while at 50 and 100 feet identical readings of  $44^{\circ}0$  were recorded.

*Loch Bhradain* (see Plate LVIII.).—Loch Bhradain (or Vrotten) lies midway between Loch an Duin and Loch an t-Seilich, receiving the outflow from the former and draining into the latter. Trending in a south-west and north-east direction, it exceeds half a mile in length, with a maximum breadth of one-fifth of a mile, covering an area of about 53 acres, and draining an area of 7 square miles, including Loch an Duin. The basin is simple, with a maximum depth of 41 feet, recorded near the middle of the wide northern part of the loch. The volume of water is estimated at 34 million cubic feet, and the mean depth at 15 feet. The loch was surveyed on May 18, 1904, but the elevation could not be determined; from spot-levels it was estimated to be about 1452 feet above the sea. The surface temperature was 43°·4 Fahr.

*Loch an t-Seilich* (see Plate LVIII.) lies about four miles to the east of Loch na Cuaich, flanked on the west by Bogha-cloiche (2945 feet) and on the east by Mullach Coire nan Dearcag (2846 feet). It is the longest of the Spey lochs, but is inferior in superficial area to Loch Morlich and Loch Insh. In outline the loch is sub-rectangular, trending nearly north and south, and is  $1\frac{1}{4}$  miles in length, with a maximum breadth of nearly half a mile at the southern end, whence it narrows slightly towards the north, the mean breadth being one-third of a mile. The superficial area is about 249 acres, and the area draining into it is nearly 25 square miles, including Lochs an Duin and Bhradain. The maximum depth of 98 feet was observed in two places, separated by shallower water: (1) nearly half a mile from the northern end towards the eastern shore, and (2) over a quarter of a mile from the southern end in a central position. The volume of water is estimated at 448 millions of cubic feet, and the mean depth at over 41 feet. The floor of the loch is somewhat irregular, showing slight undulations both longitudinally and transversely, and the contour-lines are sinuous in places; the deep water approaches very close to the southern end, a sounding in 75 feet being recorded less than a hundred yards from the southern shore. The loch was surveyed on May 17, 1904, but the elevation could not be determined; from spot-levels it was estimated to be about 1390 feet above the sea. Temperatures taken in the southern deep basin showed a range of only 1°·7 Fahr. from surface to bottom, the readings being—

Surface ... ..	44°·0 Fahr.
10 feet ... ..	43°·5 "
20 " ... ..	43°·1 "
40 " ... ..	42°·7 "
60 " ... ..	42°·6 "
80 " ... ..	42°·3 "

*Loch Insh* (see Plate LIX.) is situated about 5 miles to the north-east of Kingussie, surrounded by woods (see Fig. 33), and may almost be regarded as a large expansion of the river Spey. Though containing the

largest volume of water of the Spey lochs, it is inferior in superficial area to Loch Morlich. Of irregular outline, it exceeds a mile in length from south-west to north-east,—from inflow to outflow,—and from east to west the diameter is little less than a mile, the mean breadth being nearly half a mile. The superficial area is about 280 acres, or less than half a square mile, and the total drainage area exceeds 316 square miles, including the other lochs lying above it. The maximum depth of 100 feet was observed towards the south-eastern shore. The volume of water is estimated at 454 million cubic feet, and the mean depth at over 37 feet. When the loch was surveyed on October 9, 1903, the elevation could not be determined, but was estimated to be about 4 feet higher than shown on the Ordnance Survey map, where the elevation is given as 721·4 feet above the sea, though the date when levelled is not indicated, the water being rather high, and flooding the shore in some places. Weeds were abundant at the inlet and outflow of the river. The floor of the loch is somewhat irregular, as shown by the sinuosity of the contour-lines, apparently brought about by the deposition of material by the inflowing river, the contour-lines being pushed out into the centre of the loch. The deep water lies in the eastern portion of the loch, sending out a tongue along the western shore into the south-western portion of the loch. Nearly one-half of the lake-floor is covered by less than 25 feet of water. The temperature of the water was practically uniform from surface to bottom, the readings at the surface and at 50 feet being identical, viz. 45°·3 Fahr., while a reading at 85 feet gave 45°·1.

*Loch Alvie* (see Plate LIX.) is situated about 2 miles south-west of Aviemore, and about 8 miles north-east from Kingussie. It is irregular in outline, consisting of a wide central portion, sending out an arm to the west and another arm to the north-east. The loch is nearly a mile in length, with a maximum breadth of almost half a mile, covering an area of about 139 acres, and draining an area of 11 square miles. The deepest part lies in the north-eastern portion of the loch, the maximum depth of 70 feet having been observed less than one-third of a mile from the north-east end. An isolated deep basin was also found in the western part of the loch, soundings in 50 and 52 feet being recorded less than one-third of a mile from the west end, while the wide central portion is less than 50 feet in depth. One-half of the lake-floor is covered by less than 25 feet of water. The volume of water is estimated at 163 million cubic feet, and the mean depth at 27 feet. The loch was surveyed on October 9, 1903, but the elevation could not be determined; from spot-levels the elevation is apparently about 685 feet above the sea. The surface temperature was 47°·0 Fahr.

*Loch Gamhna* (see Plate LX.), the smallest of the Spey lochs surveyed, lies about 2 miles to the south-east of Loch Alvie, on the opposite bank of

the River Spey, and immediately to the south of Loch an Eilein, into which it drains. Irregular in outline, the loch trends in a south-west and north-east direction, and is less than half a mile in length by one-fifth of a mile in maximum breadth, covering an area of about 25 acres. The maximum depth of 41 feet was recorded in a small basin at the south-west end of the loch; there is a second deep basin, having a maximum depth of 29 feet, lying in the wide part of the loch towards the north-east end, these two basins being separated by a shoaling covered by only 4 feet of water, where the outline of the loch is constricted. The volume is estimated at 10 million cubic feet, and the mean depth at  $9\frac{1}{2}$  feet, nearly three quarters of the lake-floor being covered by less than 10 feet of water. The loch was surveyed on October 14, 1903, when the elevation was found to be 889.3 feet above the sea, or 6 feet lower than that determined by the Ordnance Survey officers in September, 1868, viz. 895.2 feet. This lowering is due to the banks of the stream giving way, and consequent outflow into Loch an Eilein. The surface temperature was  $46^{\circ}1$  Fahr.

*Loch an Eilein* (see Plate LX.) lies about 3 miles south of Aviemore, amid picturesque surroundings. At the time of the survey, a couple of ospreys were nesting in the ruins of the castle on the island (see Fig. 34). Somewhat crescentic in outline, the loch exceeds a mile in length, along the axis of maximum depth from south-west to north-east, the maximum breadth being nearly half a mile. The superficial area is about 130 acres, and the drainage area, including Loch Gamhna, is about  $2\frac{3}{4}$  square miles. The maximum depth of 66 feet was recorded towards the south-west end, and deep water occurs also near the north-east shore, where soundings in 51 and 47 feet were taken, the water shoaling in the central part of the loch to a depth of 20 feet. The volume of water is estimated at 144 million cubic feet, and the mean depth at  $25\frac{1}{2}$  feet, 54 per cent. of the lake-floor being covered by less than 25 feet of water.

The loch was surveyed on October 14, 1903, when the elevation was found to be 839.6 feet above the sea, or nearly a foot lower than that observed by the Ordnance Survey officers on September 21, 1868, viz. 840.4 feet above sea-level. Temperatures taken in the deepest part of the loch showed a range from surface to bottom of only  $\frac{1}{2}^{\circ}$  Fahr. :—

Surface ... ..	49°·2 Fahr.
10 feet ... ..	49°·0 „
20 „ ... ..	48°·8 „
30 „ ... ..	48°·8 „
40 „ ... ..	48°·8 „
50 „ ... ..	48°·7 „
60 „ ... ..	48°·6 „

*Loch Morlich* (see Plate LXI.), the largest of the Spey lochs in superficial area, lies in Glen More, surrounded by woods, about 4 miles east of Aviemore. The loch is sub-rectangular in outline, the length from

east to west exceeding a mile, the maximum breadth being two-thirds of a mile. The superficial area exceeds 300 acres, or nearly half a square mile, and the drainage area is large—exceeding 17 square miles. The maximum depth of 49 feet was recorded comparatively close to the east shore, whence the water shoals gradually towards the west, the western portion of the loch being very shallow; nearly 60 per cent. of the entire lake-floor is covered by less than 10 feet of water. The volume is estimated at 192 million cubic feet, and the mean depth at nearly 15 feet. The loch was surveyed on October 10, 1903, when the elevation was 1045·0 feet above sea-level, as compared with 1045·8 feet determined by the officers of the Ordnance Survey on August 16, 1866. The temperature of the surface water was 49°·1 Fahr.

*Loch Phitiùlais* (see Plate LX.), a small but relatively deep loch, lies less than 2 miles north-east of Aviemore, and about 3 miles north-west from Loch Morlich. The loch is over half a mile in length from north to south, and a quarter of a mile in maximum breadth, covering an area of about 67 acres, and draining an area of about  $2\frac{1}{2}$  square miles. The maximum depth of 74 feet was observed approximately near the centre of the loch, but towards the northern end, the basin being simple in conformation. About 69 per cent. of the lake-floor is covered by less than 25 feet of water. The volume is computed at 67 million cubic feet, and the mean depth at over 23 feet. The loch was surveyed on October 12, 1903, when the elevation was found to be 674·3 feet above the sea; the Ordnance Survey map gives the elevation as 673·9 feet, but the date when levelled is not indicated. Temperatures taken in the deepest part of the loch showed a range from surface to bottom of only  $\frac{1}{2}$ ° Fahr.:—

Surface ... ..	50°·0 Fahr.
10 feet ... ..	49°·8 "
20 " ... ..	49°·8 "
30 " ... ..	49°·6 "
40 " ... ..	49°·6 "
50 " ... ..	49°·4 "
70 " ... ..	49°·4 "

*Loch Builg* (see Plate LXI.) lies nearly 20 miles east of Aviemore, and about 6 miles north-west from Balmoral castle, in a valley running north and south between Glen Avon and the head of Glen Gairn. A small proportion of the overflow finds its way into the river Gairn, and thence into the river Dee, as already stated; but the normal outflow is to the north, by the Builg burn and the river Avon, into the river Spey. The reader is referred to the paper by Drs. Johnston and Collet, already cited, for some remarks on the formation of Loch Builg. The loch is less than a mile in length, by a quarter of a mile in maximum breadth, the superficial area being about 77 acres. The maximum depth of 86 feet was observed approximately in the middle of the loch. The volume of water

is estimated at 93 million cubic feet, and the mean depth at nearly 28 feet. The floor of the loch is somewhat irregular, there being three deep basins separated by two ridges. The largest and deepest basin occupies the central portion of the loch, while towards the northern end two soundings in 50 feet were taken, the greatest depth recorded on the intervening ridge being 34 feet; near the southern end a depth of 36 feet was found, the deepest sounding on the ridge separating it from the central deep basin being 21 feet. About 58 per cent. of the lake-floor is covered by less than 25 feet of water.

The loch was surveyed on July 12, 1905, when the elevation was found to be 1585.0 feet above the sea; the elevation given on the Ordnance Survey map is 1585.3 feet, but the date when levelled is not indicated. Temperatures taken in the deepest part of the loch showed a range from surface to bottom of 12° Fabr., the readings being as follows:—

Surface ... ..	61°.5 Fabr.
25 feet ... ..	56°.5 „
50 „ ... ..	52°.4 „
85 „ ... ..	49°.5 „

From the opposite table it will be seen that in the thirteen lochs under consideration, 663 soundings were taken, and that the aggregate area of the water-surface is over  $2\frac{1}{2}$  square miles, so that the average number of soundings per square mile of surface is 252: The aggregate volume of water contained in the lochs is estimated at 2053 millions of cubic feet. The area drained by these lochs is  $350\frac{1}{2}$  square miles, or about 133 times the area of the lochs.

SUMMARY TABLE.

Giving Details concerning the Lochs in the Spey Basin.

Lochs.	Height above sea, Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. Feet.	Mean. Feet.	Mean per cent. of max.	Max.	Mean.			Total in square miles.	Ratio of area of loch.
Crunachan ...	878.9 [Dec. 18, 1872]	49	0.68	0.24	0.16	23.8	25	7.79	31.2	14.4	461	23	0.11	3.78	33.9
Caol na Doire	1140.7 [Dec. 2, 1872]	33	0.70	0.30	0.17	24.6	55	23.04	41.9	67	160	77	0.12	1.30	10.8
na Cnaich	[about 1296]	56	0.94	0.27	0.19	20.4	85	42.48	50.0	58	117	214	0.18	2.62	14.9
an Duin	[about 1390]	55	1.18	0.18	0.13	11.4	102	30.88	29.8	61	205	134	0.16	1.22	7.6
Bhradain	[about 1452]	35	0.58	0.19	0.14	24.8	41	14.83	36.2	75	206	94	0.08	7.09	88.6
an t-Seilich	[about 1390]	93	1.26	0.42	0.31	24.6	98	41.30	42.1	68	161	448	0.39	24.73	68.4
Insh ...	[721.4, date ?]	50	1.03	0.66	0.43	41.7	100	37.31	37.3	54	146	454	0.44	316.42	719.1
Alvie ...	[about 685]	48	0.94	0.48	0.28	24.5	70	27.02	38.6	71	184	163	0.22	10.95	49.8
Gamhna	889.3	24	0.42	0.20	0.09	21.4	41	9.56	20.9	54	232	10	0.04	0.35	8.8
an Eillein	839.6	55	1.10	0.46	0.18	16.4	66	25.47	38.6	88	238	144	0.20	2.71	13.5
Mortlich	1045.0	66	1.02	0.66	0.46	45.1	49	14.62	29.8	110	368	192	0.47	17.34	37.0
Phitthlais	674.3	32	0.58	0.26	0.18	31.0	74	23.15	31.3	41	132	67	0.10	2.45	24.5
Builg ...	1585.0	62	0.80	0.22	0.15	18.9	86	27.75	32.3	49	152	93	0.12	0.63	5.3
		663										2053	2.63	350.50*	133.3

\* The drainage area of Loch Insh includes those of Lochs Crunachan, Caol na Doire, na Cnaich, an Duin, Bhradain, and an t-Seilich; and that of Loch an Eillein includes that of Loch Gamhna.

## LOCHS OF THE LOSSIE BASIN.

WITHIN this basin (see Index Map, Fig. 19) the only loch surveyed was the little Loch Spynie, lying between Elgin and Lossiemouth, which drains into the Moray firth at Lossiemouth, not by the river Lossie, but by the Spynie canal.

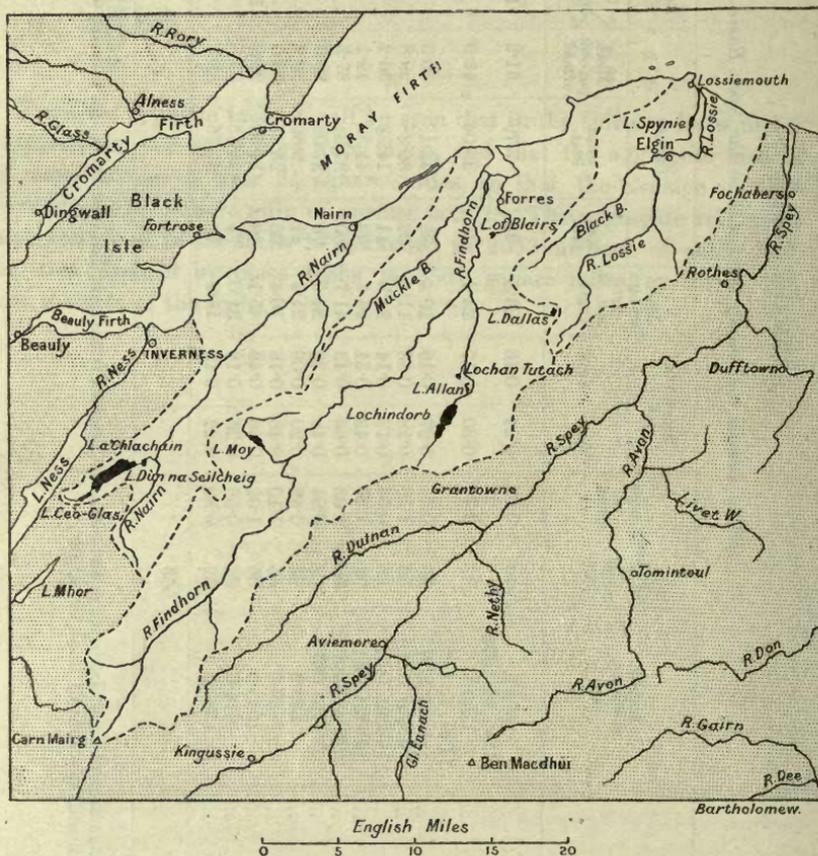


FIG. 19.—INDEX MAP OF THE LOSSIE, FINDHORN, AND NAIRN BASINS.

*Loch Spynie* (see Plate LV.) is said to have been reclaimed from the sea in 1860, but it now stands about 5 feet above the sea-level, and the water is

quite fresh. It trends in a south-west and north-east direction, and is two-thirds of a mile in length, by a quarter of a mile in maximum breadth, covering an area of about 60 acres. The loch is very shallow, 93 per cent. of the lake-floor being covered by less than 5 feet of water, and the south-west end is filled with weeds. The maximum depth of 6 feet was observed in two places, the mean depth being estimated at  $2\frac{3}{4}$  feet, and the volume of water at 7 million cubic feet. The drainage area is about 3 square miles. On May 25, 1904, the surface temperature was  $58^{\circ}0$  Fahr.

## LOCHS OF THE FINDHORN BASIN.

WITHIN the catchment area of the river Findhorn (see Index Map, Fig. 19) six lochs were surveyed, viz. Loch Moy, Lochindorb, Loch Allan, Lochan Tùtach, Loch Dallas, and Loch of Blairs, the two first-mentioned being the most important. Loch Moy is situated in Inverness-shire, while Lochindorb and Lochan Tùtach lie on the borders of Elginshire and Nairnshire, the other three being situated in Elginshire. The lochs contain trout, but the fishings are preserved.

*Loch Moy* (see Plate LXII.) lies about 9 miles south-east of Inverness, surrounded by woods, the Highland Railway running along the western shore. Moy hall, the residence of The Mackintosh, stands on the northern shore, and on the larger island (Isle of Moy) is a granite monument, 70 feet high, erected to the memory of Sir Æneas Mackintosh in 1824, and the ruins of an old castle, while the smaller island (Eilean nan Clach) was formerly used as a temporary prison. The loch trends in a north-west and south-east direction, and exceeds a mile in length by nearly half a mile in maximum breadth. Its waters cover an area of about 187 acres, or over a quarter of a square mile, and it drains an area exceeding 15 square miles. The maximum depth of 50 feet was recorded in the south-eastern part of the loch, midway between the Isle of Moy and the eastern shore. The volume of water is estimated at 157 million cubic feet, and the mean depth at over 19 feet.

The soundings show some minor irregularities of the lake-floor, nearly two-thirds of which is covered by less than 20 feet of water. The contour-lines circle round the Isle of Moy, deep water being found both to the east and west of that island; off the western shore of the loch a sounding in 33 feet was recorded about 50 feet from shore, indicating a steep slope in that position. The loch was surveyed on October 15, 1903, but the elevation could not be determined from bench-mark; judging from spot-levels, it is about 880 feet above the sea. The temperature of the surface water was 46°·0 Fahr.

*Lochindorb* (see Plate LXIII).—Lochindorb (or Loch an-Dorb) lies 6 miles to the north-west of Grantown-on-Spey, and about 14 miles south of Forres, draining by the Dorbock burn into the river Findhorn. Near the eastern shore is a small island, with the ruins of Lochindorb Castle,

where human remains were found in 1866. The loch is sub-elliptical in outline, trending in a south-west and north-east direction, and exceeds 2 miles in length. It is widest in the northern portion, where the maximum breadth is two-thirds of a mile, narrowing towards the southern end, the mean breadth exceeding one-third of a mile. Its waters cover an area of about 540 acres, and it receives the drainage from about 12 square miles of the surrounding country. The maximum depth of 51 feet was observed over half a mile from the northern end and towards the western shore, but the mean depth is only about  $12\frac{1}{2}$  feet, nearly one-half of the lake-floor being covered by less than 10 feet of water. The deeper water (over 20 feet in depth) lies in the wide northern portion of the loch, to the north and west of the island. The volume of water is estimated at 291 million cubic feet.

The loch was surveyed on May 20, 1904, when the elevation was found to be 968.6 feet above the sea; the level determined by the Ordnance Survey officers on April 4, 1866, was 969.4 feet above sea-level. The temperature of the surface water was  $49^{\circ}6$  Fahr.

*Loch Allan* (see Plate LXII.) lies about  $1\frac{1}{2}$  miles to the north of Lochindorb, and is peculiar in outline, consisting of three distinct basins, separated by two narrows. The southernmost basin is the largest and deepest, having a maximum depth of 29 feet; the central basin has a maximum depth of 7 feet, with a comparatively large island near the middle; while the northernmost basin has a maximum depth of 10 feet, with a small island near the middle. The length of the entire loch is about half a mile, the southern and central basins trending nearly north and south, while the northern basin trends nearly east and west, its waters covering an area of about 22 acres, the volume of water being estimated at 10 million cubic feet, and the mean depth at  $10\frac{1}{2}$  feet. The loch was surveyed on May 23, 1904, the elevation being estimated at about 900 feet above the sea. The surface temperature was  $52^{\circ}0$  Fahr.

*Lochan Tùtach* (see Plate LXII.) lies about a mile north-west of Loch Allan, and about 2 miles north of Lochindorb. It is subcircular in outline, and about a quarter of a mile in maximum diameter, with a superficial area of about 19 acres. The volume of water is estimated at 4 million cubic feet, and the mean depth at nearly 5 feet. The loch forms a simple basin, the deeper water (exceeding 10 feet) occupying a central position, with a maximum depth of 16 feet. The bottom is covered with peaty mud and decomposing vegetable matter, from which a strong smell emanates. The loch was surveyed along with Loch Allan on May 23, 1904, the surface temperature being  $51^{\circ}6$  Fahr.

*Loch Dallas* (see Plate LXII.) lies about 8 miles south of Forres, at an elevation of over 1000 feet above the sea. It is nearly half a mile in length from north to south, by a quarter of a mile in maximum breadth,

covering an area of about 41 acres. It is very shallow, the maximum depth being 8 feet, and the mean depth  $3\frac{1}{2}$  feet, the volume of water being estimated at 6 million cubic feet. The water was very brown and soft at the time of survey (May 27, 1904), the surface temperature being  $68^{\circ}\text{Fahr}$ .

*Loch of Blairs* (see Plate LXII.) is a small shallow loch lying 2 miles to the south of Forres, a short distance to the east of the river Findhorn, but draining by an independent stream (the Altyre burn) into Findhorn bay. The length is one-third of a mile, and the superficial area about 28 acres. The maximum depth is 5 feet, and the mean depth  $2\frac{1}{2}$  feet, the volume of water being estimated at 3 million cubic feet. On May 26, 1904, the surface temperature was  $64^{\circ}\text{Fahr}$ .

## LOCHS OF THE NAIRN BASIN.

THE three lochs within the Nairn basin (see Index Map, Fig. 19) that were sounded by the Lake Survey are situated in Inverness-shire at the head of the river, over 20 miles to the south-west of the town of Nairn, and comparatively close to the eastern shore of Loch Ness, being, indeed, sandwiched between Lochs Ashie and Ruthven of the Ness basin. They form a connected series, Loch Ceò-Glas flowing into Loch Dùn na Seilcheig, the most important of the series, and thence into Loch a' Chlachain. They all contain trout, and Loch Dùn na Seilcheig also contains char, but the fishing in it is preserved.

*Loch Ceò-Glas* (see Plate LXIV.) lies about 11 miles south of Inverness, and only a mile and a half from the eastern shore of Loch Ness, opposite Urquhart bay. Elongate in form, it trends in a south-west and north-east direction, and is nearly a mile in length, though the maximum breadth is only about one-seventh of a mile, the superficial area being about 54 acres. The northern portion of the loch is shallow, with the deeper water in the southern half, the maximum depth of 32 feet having been recorded little more than a quarter of a mile from the southern end, and towards the western shore, which is bordered by vertical and overhanging cliffs. The volume of water is estimated at 24 million cubic feet, and the mean depth at a little over 10 feet. Nearly two-thirds of the lake-floor is covered by less than 10 feet of water. The loch was surveyed on May 1, 1903, when the elevation was found to be 762·9 feet above the sea, or a foot lower than the level observed by the Ordnance Survey officers on March 28, 1871. Temperatures taken in the deepest part of the loch showed that the water was nearly uniform in temperature from surface to bottom, the readings being:—

Surface ... ..	46°·3	Fabr.
10 feet ... ..	46°·2	„
20 „ ... ..	46°·1	„
30 „ ... ..	46°·0	„

*Loch Dùn na Seilcheig* (see Plate LXIV.)—Loch Dùn na Seilcheig (or Duntelchaig) is a large and deep loch lying about half a mile to the north-east of Loch Ceò-Glas, the difference in level being about 60 feet. Somewhat irregular in outline and variable in width, the loch trends in a south-west and north-east direction, and is nearly  $3\frac{1}{2}$  miles

in length, the maximum breadth towards the northern end exceeding a mile, while the mean breadth exceeds half a mile. Its waters cover an area of nearly 2 square miles, and the area draining into it, including Loch Ceò-Glas, is about  $8\frac{1}{2}$  square miles. The maximum depth of 205 feet was observed about a mile from the southern end, but an isolated sounding in 200 feet was recorded about half a mile farther north, with shallower water between these two deep soundings. The volume of water contained in the loch is estimated at 4599 millions of cubic feet, and the mean depth at  $84\frac{1}{2}$  feet. The soundings indicate generally a gentle shore-slope, the steepest gradient being observed off the south-eastern shore at the widest part near the foot of the loch, where a sounding in 66 feet was recorded about 120 feet from shore. The floor of the loch is somewhat irregular, the contour-lines being in places sinuous in character, and the cross lines of soundings, especially in the northern half of the loch, show several undulations. Thus the third line of soundings from the northern end, proceeding from the south-eastern shore, shows a deepening of the water to 65 feet, then a shoaling to 46 feet, then a deepening to 70 feet, before finally rising towards the opposite shore. The fourth line of soundings from the northern end, across the widest part of the loch, proceeding also from south-east to north-west, shows that the water deepens to 115 feet, then shoals slightly to 112 feet; deepens again to 127 feet, shoals again to 96 feet; deepens slightly to 99 feet, shoals again to 65 feet; and then deepens to 76 feet before finally rising on approaching the shore. The next line of soundings (the fifth from the northern end) shows a shoaling near the middle covered by 105 feet, the water deepening on both sides to 122 feet and 140 feet respectively. The next line of soundings (the sixth from the northern end) shows a shoaling towards the south-eastern shore covered by 60 feet, the water deepening to 86 feet between it and the shore. The next line of soundings (the seventh from the northern end) reveals a shoaling towards the middle of the loch, which is the more conspicuous because it is in close proximity to one of the deepest soundings in the loch. Proceeding from the south-eastern shore, the soundings deepen gradually to a depth of 154 feet, then a slight shoaling to 143 feet was recorded, followed by soundings in 179 feet and then 200 feet, when the bottom rises towards the north-western shore. The following table, giving the approximate areas between the contour-lines and the percentages to the total area, shows a larger area in the zone between 100 and 150 feet than in the shallower zone between 50 and 100 feet, 40 per cent. of the lake-floor being covered by more than 100 feet of water:—

Feet.				Acres.		Per cent.
0 to 50	...	...	...	441	...	35·3
50 „ 100	...	...	...	310	...	24·8
100 „ 150	...	...	...	317	...	25·4
150 „ 200	...	...	...	180	...	14·4
Over 200	...	...	...	1	...	0·1
				1249		100·0

The loch was surveyed on April 17 and 18, 1903, when the elevation was found to be 702·9 feet above the sea, or a little higher than that observed by the Ordnance Survey officers on April 8, 1871, viz. 702·3 feet above sea-level. Temperatures taken on April 18 showed that the water was practically uniform in temperature throughout, the readings being:—

Surface ... ..	39°·5 Fahr.
100 feet ... ..	39°·4 „
190 „ ... ..	39°·2 „

*Loch a' Chlachain* (see Plate LXIV.) lies immediately to the east of Loch Dùn na Seilcheig, the difference in level being about 20 feet. The western shore consists of moraine mounds, which, where cut through by the road, are seen to be composed of yellow gravel, with many immense boulders, some perched; a very large boulder forms a projecting point near the northern end of the loch. To the east the whole hillside is strewn with large boulders, with perched blocks on the higher hills.

The loch is irregular in outline, trending nearly north and south, and is half a mile in length by one-third of a mile in maximum breadth, covering an area of about 60 acres. The drainage area exceeds 10 square miles, including Lochs Ceò-Glas and Dùn na Seilcheig. The loch forms a simple basin with an extensive shallow flat at the southern end, due, apparently, to the deposition of material by the inflowing stream. The deeper water lies towards the central part of the eastern shore, off which two soundings at the maximum depth of 80 feet were recorded. The volume of water is estimated at 78 million cubic feet, and the mean depth at 30 feet, nearly one-half of the lake-floor being covered by less than 25 feet of water. The loch was surveyed on April 29, 1903, when the elevation was found to be 683·7 feet above the sea, or a little higher than that observed by the Ordnance Survey officers on April 13, 1871, viz. 683·3 feet.

The temperature of the water from surface to bottom varied little, the reading at the surface being 42°·7 Fahr.; at 10, 25, and 50 feet, 42°·5; and at 75 feet, 42°·0.

From the following table it will be seen that in the ten lochs under consideration 655 soundings were taken, and that the aggregate area of the water-surface is  $3\frac{1}{2}$  square miles, so that the average number of soundings per square mile of surface is 187. The aggregate volume of water contained in the lochs is estimated at 5179 millions of cubic feet. The area drained by these lochs is nearly  $42\frac{1}{2}$  square miles, or about twelve times the area of the lochs.

## SUMMARY TABLE.

Giving Details concerning the Lochs in the Lossie, Findhorn, and Nairn Basins.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. Feet.	Mean. Feet.	Mean per cent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
Spynie	[about 5]	37	0.69	0.22	0.14	19.7	6	2.71	45.1	607	1347	7	0.09	3.08	34.2
Moy	[about 880]	52	1.08	0.46	0.28	27.2	50	19.31	38.6	109	282	157	0.29	15.17	52.3
Lochindorb	968.6	154	2.18	0.68	0.39	17.7	51	12.42	24.4	87	357	291	0.84	12.06	14.3
Allan	[about 900]	51	0.52	0.12	0.07	12.5	29	10.40	35.8	95	264	10	0.03	0.16	5.3
Tutach	—	23	0.22	0.17	0.13	60.9	16	4.88	30.5	73	238	4	0.03	0.48	16.0
Dallas	1015.7 [June 9, 1866]	35	0.43	0.29	0.15	34.4	8	3.50	43.7	284	649	6	0.06	0.66	11.0
Blairs	—	33	0.36	0.24	0.12	33.4	5	2.55	51.0	380	746	3	0.04	0.48	12.0
Ceò-Glas	762.9	50	0.88	0.15	0.09	10.2	32	10.14	31.7	145	458	24	0.08	1.66	20.8
Dùn na Seilcheig	702.9	178	3.41	1.02	0.57	16.7	205	84.55	41.2	88	213	4599	1.95	8.60	4.4
a' Chlachain	683.7	42	0.48	0.33	0.19	39.6	80	29.84	37.3	32	85	78	0.09	10.32	114.7
		655										5179	3.50	42.41*	12.1

\* The drainage area of Loch a' Chlachain includes those of Lochs Ceò-Glas and Dùn na Seilcheig.

## THE LOCHS OF LISMORE.

THE Island of Lismore (see Index Map, Fig. 5), lying at the junction of the Firth of Lorne with the Sound of Mull and Loch Linnhe, some 5 miles north-west of Oban, is a long narrow island less than 10 miles in length, trending from south-west to north-east, and includes three small lochs which were sounded by the Lake Survey, viz. Lochs Baile a' Ghobhainn, Kilcheran, and Fiart. These lochs trend generally in the same direction as the island, Loch Baile a' Ghobhainn lying towards the northern end, while the other two are situated towards the southern end, Loch Fiart, the southernmost, less than 2 miles from the southern extremity of the island. The island is on the whole flat, the highest point, Barr Mor, between Lochs Fiart and Kilcheran, being only 417 feet above sea-level. The lochs, though small (one-half to two-thirds of a mile in length), are relatively deep, all exceeding 50 feet in depth, the deepest, Baile a' Ghobhainn, having a depth of 88 feet; they contain trout, but the fishing is preserved. The water of the lochs is impregnated with lime derived from the limestone formation of the island, and the plants become thickly encrusted with it; sometimes *Myriophyllum spicatum* becomes so weighted with lime that the plants are prevented from rising to the surface, and in consequence do not bear fruit.

*Loch Baile a' Ghobhainn* (see Plate LXV.).—Loch Baile a' Ghobhainn (or Balnagowan) is the largest of the three lochs in all respects, but its drainage area is very small. The loch is widest and deepest in the southern portion, narrowing and shallowing gradually towards the northern end. The stones and reeds around the margin are thickly encrusted with lime. The length is two-thirds of a mile, and the superficial area about 33 acres. The maximum depth is 88 feet, the mean depth nearly 39 feet, and the volume of water 55 million cubic feet. The soundings show that Loch Baile a' Ghobhainn forms a simple deep basin with steep shore-slopes; gradients exceeding 1 in 1 were observed off the western shore towards the southern end, where soundings in 61 feet and 22 feet were recorded about 60 feet and 10 feet respectively from the shore, and off the eastern shore, towards the northern end, where a sounding in 44 feet was recorded about 30 feet from shore. The two ends of the loch are comparatively shallow, and hence 41 per cent. of the lake-floor is covered by less than 25 feet of water, but the deep basin partakes of a flat-bottomed character, since over 17 per cent. of the lake-floor is covered by more than

75 feet of water, while only 15 per cent. is covered by water between 50 and 75 feet in depth.

Serial temperatures taken in the position of the deepest sounding on August 12, 1904, showed a range from surface to bottom amounting to 15° Fahr., the fall between 25 and 50 feet being equal to about half a degree per foot of depth, the readings being :—

Surface ... ..	62°·5 Fahr.
10 feet ... ..	62°·4 "
25 " ... ..	61°·5 "
35 " ... ..	56°·5 "
50 " ... ..	49°·3 "
88 " ... ..	47°·5 "

*Kilcheran Loch* (see Plate LXV.) is half a mile in length, and covers an area of 28 acres. At the northern end there is a narrow prolongation, which could not be sounded because it was found impossible to get a boat through the reeds at the narrows. The main body of the loch forms a simple basin, the water deepening gradually on proceeding from the southern end until the maximum depth of 60 feet is met with about a quarter of a mile from the two ends. The mean depth is estimated at 21 feet, and the volume of water at 26 million cubic feet. Temperatures taken on August 13, 1904, gave the following results :—

Surface ... ..	59°·4 Fahr.
10 feet ... ..	59°·8 "
30 " ... ..	59°·5 "
60 " ... ..	50°·5 "

There was heavy rain at the time, and for 10 hours previously, which may account for the uniform temperature from the surface to 30 feet; between 30 and 60 feet a fall of 9° was recorded.

*Loch Fiart* (see Plate LXV.) is nearly two-thirds of a mile in length, and covers an area of about 33 acres. The maximum depth of 58 feet was recorded less than a quarter of a mile from the southern end. The longitudinal line of soundings shows a slight irregularity of the lake-floor, for, proceeding from the northern end, the water deepens gradually to 48 feet, then shoals to 36 feet, whence the water deepens again to the point of maximum depth. The volume of water is estimated at 34 million cubic feet, and the mean depth at 23 feet.

## THE LOCHS OF MULL.

THE island of Mull (see Index Map, Fig. 20) was the scene of some of the preliminary work carried on by Sir John Murray and the late Mr. Fred. P. Pullar. With the small machine designed by Dr. Ule, they sounded

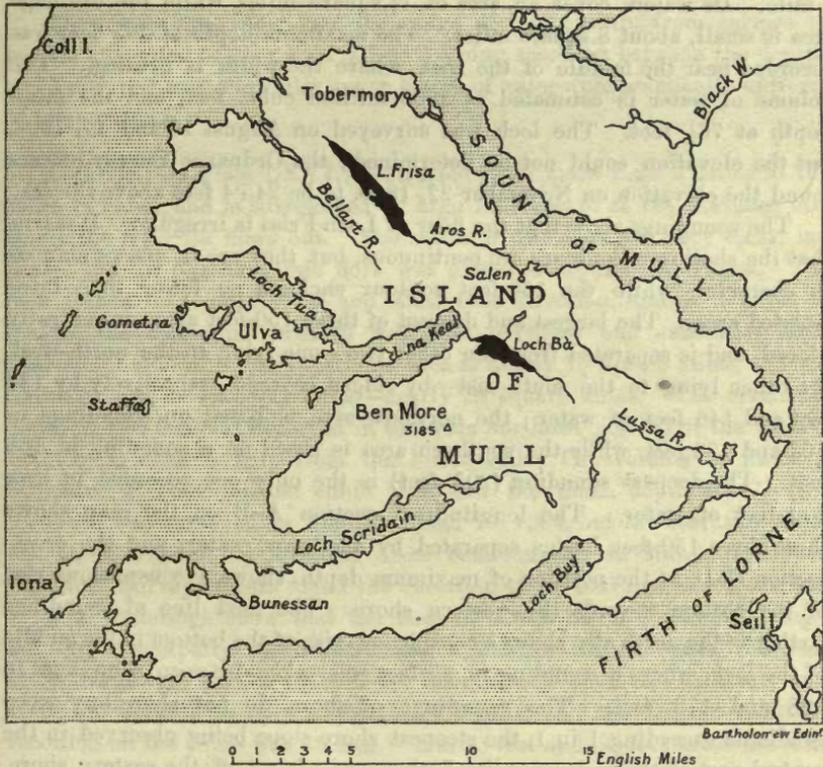


FIG. 20.—INDEX MAP OF THE ISLAND OF MULL.

Lochs Frisa, Bà, and Uisg, but, being led to doubt the trustworthiness of that machine, they never published the results, and Mr. Pullar set to work designing a new machine, which has since been used in sounding most of the Scottish lochs. At the time of the visit of the Lake Survey staff only

the two largest lochs in the island (Lochs Frisa and Bà) could be sounded. The first-named lies in the northern portion of the island near Tobermory, while the other lies near the head of Loch na Keal, an arm of the sea which nearly cuts the island into two portions, the connecting isthmus between Loch na Keal and Salen bay being less than 3 miles across. The scenery around the lochs is very fine, and the fishing, which is preserved, includes salmon, grilse, *Salmo ferax*, sea-trout, and brown trout.

*Loch Frisa* (see Plate LXVII.) is the largest loch in the island, and is distant about 3 miles from Tobermory. The margin is nearly all stony and free from weeds, except at the south-east end, where the Ledmore river flows out through an alluvial flat. The loch is elongate in outline, and trends north-east and south-west, being  $4\frac{1}{2}$  miles in length by over half a mile in maximum breadth, the mean breadth exceeding one-third of a mile. Its waters cover an area of  $1\frac{2}{3}$  square miles, while the drainage area is small, about 8 square miles. The maximum depth of 205 feet was recorded near the middle of the loch, where the width is greatest. The volume of water is estimated at 3603 million cubic feet, and the mean depth at  $76\frac{1}{2}$  feet. The loch was surveyed on August 16 and 17, 1904, but the elevation could not be determined; the Ordnance Survey officers found the elevation on November 22, 1866, to be 245.4 feet above the sea.

The soundings show that the floor of Loch Frisa is irregular. It is true that the shallower contours are continuous, but they are in places sinuous in character, while the 150-foot contour encloses no fewer than three isolated areas. The largest and deepest of these 150-foot areas is centrally placed, and is separated from the other two—one lying to the north-west, the other lying to the south-east—by ridges covered respectively by 138 feet and 146 feet of water; the northern area is based on soundings in 163 and 173 feet, while the southern area is based on a sounding in 165 feet. The deepest sounding (205 feet) is the only one recorded in over 200 feet of water. The longitudinal section A-B on the map shows these three 150-foot basins separated by shallower water, and the cross-section C-D, at the position of maximum depth, shows a conspicuous rise of the bottom towards the western shore. The next line of soundings farther to the north also shows a conspicuous rise of the bottom in the middle of the loch, where a sounding in 95 feet was taken between soundings in 128 and 170 feet. The soundings off-shore do not show any steep gradients exceeding 1 in 1, the steepest shore-slope being observed in the central part of the loch, opposite Lettermore, where, off the eastern shore, a sounding was taken in 36 feet at a distance of 40 feet from shore, and off the western shore soundings in 60 feet and 85 feet were taken at distances of 80 and 100 feet respectively from shore.

The following table shows the approximate areas between the contour-lines, and the percentages to the total area of the loch :—

Feet.	Acres.	Per cent.
0 to 50 ... ..	420 ...	38·8
50 „ 100 ... ..	303 ...	27·9
100 „ 150 ... ..	272 ...	25·1
150 „ 200 ... ..	85 ...	7·9
Over 200 ... ..	3 ...	0·3
	1083	100·0

Temperature observations in the deepest part of Loch Frisa on August 17, 1904, gave the following results :—

Surface ... ..	59°·1 Fahr.
20 feet ... ..	59°·0 „
50 „ ... ..	58°·7 „
75 „ ... ..	58°·7 „
100 „ ... ..	56°·6 „
175 „ ... ..	55°·2 „

These readings show that the range of temperature from surface to bottom amounted to only 4°, a fall of 2° being recorded between the depths of 75 and 100 feet, while the upper layers of water were practically uniform in temperature.

*Loch Bà* (see Plate LXVI.) is situated little more than 2 miles to the south of Salen, and is surrounded by high hills except at the northern end where the river Bà flows out. The water in the loch was very clear, not peaty, and no phanerogamic flora was observed around the shores. The loch trends in a north-west and south-east direction, and is 3 miles in length, the maximum breadth near the northern end exceeding three quarters of a mile. The superficial area is nearly  $1\frac{1}{4}$  square miles, and the drainage area is relatively large—nearly 20 square miles. The maximum depth of 144 feet was observed in the wide northern portion of the loch, a little more than a mile from the lower end. The volume of water is estimated at 1602 million cubic feet, and the mean depth at  $47\frac{1}{2}$  feet. The loch was surveyed on August 15 and 16, 1904, but the elevation could not be determined by levelling from bench-mark; in March, 1867, the Ordnance Survey officers found the elevation to be 40·6 feet above the sea.

The soundings show that the floor of Loch Bà is somewhat irregular, due principally to the fact that a shallow ridge crosses the loch at its narrowest part, a little more than a mile from the southern end. Here the breadth is only a quarter of a mile, and the deepest sounding recorded on the ridge was 60 feet. The 25-foot and 50-foot areas are thus continuous, and extend nearly the whole length of the loch, but the 75-foot area is cut into two portions, the smaller portion to the south-east of the ridge having a maximum depth of 95 feet, while the larger portion to the north-west of the ridge includes the deepest water in the loch, the 100-foot basin being nearly a mile in length. The longitudinal section A-B on the map shows the shallow ridge referred to, while the cross-section C-D, taken at the position of maximum depth, shows a regular bottom, but one or two



## THE LOCHS OF BENBECULA.

THE island of Benbecula (see Index Map, Fig. 21) is in its physical features a continuation of the low moorland tract of the south-eastern portion of North Uist, the whole surface forming in like manner a maze of

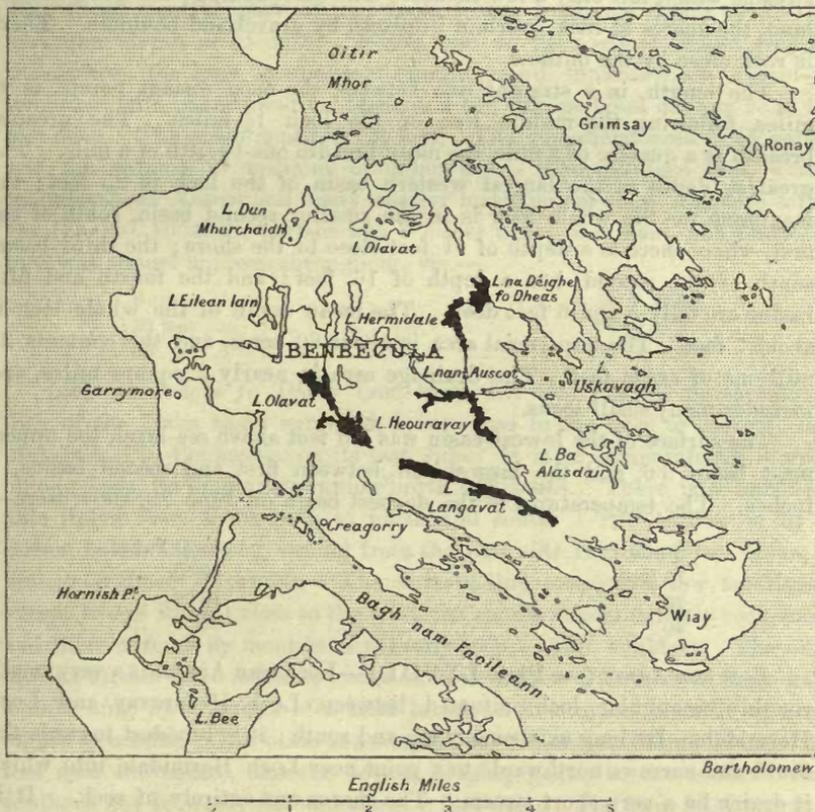


FIG. 21.—INDEX MAP OF THE ISLAND OF BENBECULA.

land and water. There is no part of the island of any extent without lochs. Most of these lochs are insignificant in size, and, like the lochs of North Uist, they are of irregular form, contain numerous islands, and many of them are to an even greater extent dotted over with boulders. A

casual inspection satisfies us that they can be of no great depth. The selection of the lochs to be surveyed was determined by the presence of boats, which were found only on some half-dozen of the larger lochs.

*Loch Heouravay* (see Plate LXVIII).—Loch Heouravay is a loch of extremely irregular form, lying close to the sea-shore on the east side of the island, where Loch Uskavagh cuts so deeply into the interior of the land. It drains into Heouravay bay, an inlet from Loch Uskavagh, by a stream a few yards in length. We were told that there was formerly a mill on this stream and that the surface of the loch was kept at a higher level by a dam with a sluice. When that was the case Loch Heouravay might be a single loch; the removal of the dam has divided it into five distinct little lochs, differing slightly in level, and connected by very short streams which fall only a few inches. The surroundings are rough moorland, the shores of rock, overlain in places by gravel and boulders. There is rock close by the outflow.

The length, in a straight line between the most distant points, is  $1\frac{1}{3}$  miles, following the middle line of the loch  $1\frac{2}{3}$  miles. The greatest breadth is a quarter of a mile, the mean breadth one-twelfth of a mile. The greatest depth in the largest western basin of the loch is 25 feet; the maximum for the whole loch is in the smaller second basin, south of the first, where there is a depth of 41 feet close to the shore; the third basin, south of the second, has a depth of 16 feet; and the fourth and fifth basins are only 5 and 6 feet deep. The mean depth of the whole loch is about 7 feet. The superficial area is about 80 acres, and the contents 26 millions of cubic feet. The drainage area is nearly 2 square miles, and includes many small lochs.

The surface of the lowest basin was 8·3 feet above sea-level, the uppermost basin 9·6, and the largest fall, between first and second basins, 9 inches. The temperatures in the deepest basin on June 29, 1904, were—

Surface ...	...	...	...	...	...	60°0 Fahr.
15 feet ...	...	...	...	...	...	59°0 "
25 ,, ...	...	...	...	...	...	56°6 "
40 ,, ...	...	...	...	...	...	55°6 "

*Loch nan Àiscot* (see Plate LXVIII).—Loch nan Àiscot is a very small, roughly triangular loch, situated between Loch Heouravay and Loch Hermidale. Its long axis runs north and south; it is broadest towards the south and narrows northwards to a point near Loch Hermidale into which it drains by a very short stream. The shores are entirely of rock. It is a quarter of a mile long, one-tenth of a mile in greatest breadth, and one-twentieth of a mile in mean breadth. Relatively it is the deepest loch surveyed in Benbecula, the maximum depth being 39 feet, and the mean depth 17 feet. The area of the surface is only about 8 acres, and it receives only surface drainage. The surface level was 13·0 feet above the sea. The basin is quite simple, with deep water (of over 35 feet) in a straight

line along the centre line to near both ends. The temperature on June 30, 1904, had a range of  $3^{\circ}2$ , viz.—

Surface ... ..	59°·2 Fahr.
20 feet ... ..	58°·2 „
35 „ ... ..	56°·0 „

*Loch Hermidale* (see Plate LXVIII.).—Loch Hermidale is the middle loch of the chain of three lochs which were surveyed in the Haka basin. It is of irregular form, broadest in the middle and tapering to each end. Its long axis, somewhat curved, runs nearly north and south. It is surrounded by low moorland and has rocky shores. It receives the burns coming from Loch Àiscot and from many little lochs to east and west, and overflows into Loch na Déighe fo Dheas. It is fully three-quarters of a mile long, a quarter of a mile broad, and one-eleventh of a mile in mean breadth. The broad central part of the loch forms a simple basin, with the maximum depth of 41 feet; a lesser basin to the north is 16 feet deep in the centre; the long narrow part running south towards Loch Àiscot is irregular, with islands and boulders, and has various holes of from 15 to 18 feet deep. The mean depth is  $12\frac{1}{2}$  feet. The superficial area is 54 acres, and the volume 29 millions of cubic feet. The drainage area, which includes Loch Àiscot and many smaller lochs, is just about a square mile. On June 30, 1904, the surface was 8·7 feet above the sea. The temperature was almost uniform throughout, viz.—

Surface ... ..	59°·2 Fahr.
20 feet ... ..	59°·0 „
35 „ ... ..	58°·8 „

*Loch na Déighe fo Dheas* (see Plate LXVIII.) is the northernmost loch of the Haka basin surveyed, lying close to the base of Rueval, the highest hill in Benbecula, on its east side. It is of comparatively simple oblong form, its long axis running north and south. There is a considerable inflow from lochs both to north and south. The outflow is by a stream half a mile long, issuing from the east side into the Oban Haka, a branch of Loch Uskavagh. The surrounding country is low moorland, except where Rueval rises to the west, the shores almost entirely rock, here and there covered by mounds of gravelly *débris* with boulders. The outflowing stream is bounded by rocks on both sides. The loch is fully half a mile long by a quarter of a mile broad, with a mean breadth of one-eighth of a mile. The basin is a simple one, with the maximum depth of 34 feet near the centre, and the bottom sloping gently to the centre. The southern bay is nearly flat and about 8 feet deep. The long inlet running north has a depth of 9 feet at its mouth and 18 feet within. The mean depth is  $10\frac{1}{2}$  feet. The area of the surface is 52 acres, and the volume of water 24 millions of cubic feet. The drainage area is  $1\frac{1}{3}$  square miles. On June 30, 1904, the surface was 7·5 feet above the sea. The temperature varied only  $0^{\circ}2$  of a degree from the surface, which was  $59^{\circ}7$  Fahr., to a depth of 30 feet.

*Loch Olavat* (see Plate LXIX.).—Loch Olavat, one of two lochs of the same name, is situated nearly in the middle of the island, lying part on each side of the main road, but nearer the south ford than the north one; the other Loch Olavat lies close to the north ford and is tidal. It is extremely irregular in form, but is longest from north-west to south-east, in which line it measures about  $1\frac{2}{3}$  miles. In area it is the largest loch surveyed in the island, measuring fully 140 acres, but is inferior in length to both Loch Heouravay and Loch Langavat. Its greatest breadth is half a mile, and mean breadth one-seventh of a mile. It is the shallowest of the lochs, being only 12 feet in greatest depth, and 4 feet in mean depth. The volume, 26 millions of cubic feet, is equal to that of Loch Heouravay and about half that of Loch Langavat. When surveyed on July 1, 1904, the height of the surface above sea-level was 16.6 feet. It is chiefly fed by surface drainage from the boggy moor around, and by small burns from many adjoining lochs. The outflow is controlled by a sluice in connection with a corn mill some quarter of a mile to the south. The area drained is considerable ( $2\frac{1}{8}$  square miles). Rock shows almost everywhere round the shores, but is in many places covered with great numbers of angular stones. The bottom of the loch is pretty regular, with no abrupt deepenings, probably indicating that the silt is spread out and levelled by the waves around and between the boulders and islands. The temperature at the surface and at 10 feet was  $59^{\circ}2$  Fahr.

*Loch Langavat* (see Plate LXVIII.).—Loch Langavat is a long, straight, and extremely narrow loch, running nearly east and west, close to the south shore of the island, and east of the road. It is the longest loch in Benbecula, being  $2\frac{1}{5}$  miles long, but only a quarter of a mile in maximum breadth, and less than one-tenth of a mile in mean breadth. The shores are rock, forming low cliffs in the central and eastern parts. Towards the west the north shore for nearly a mile is of stones and peat. Several narrow inlets go off from the south shore, and there are many islands, all narrow and running east and west. The maximum depth, 34 feet, is equal to that of Loch na Déighe fo Dheas, and less than that of the other lochs except Loch Olavat, but the mean depth, 8 feet, slightly exceeds that of Loch Heouravay. The superficial area, about 124 acres, is only inferior to that of Loch Olavat, while in volume (44 millions of cubic feet) the loch is by far the largest in Benbecula. The loch is fed only by small burns from many little lochs and by local drainage, and has its outflow to the east into Loch a' Laip, through Oban Uaine. The area drained is only 1 square mile. When surveyed on July 4, 1904, the surface was 15.95 feet above sea-level. Narrow as it is throughout, Loch Langavat is divided into two nearly equal parts by a canal-like strait, one-third of a mile long and only 5 feet deep. West of this it is on the whole very shallow, with one small depression of 20 feet in the broadest part. East from the strait it is relatively deep throughout, the deepest part of the main loch (30 feet)

## SUMMARY TABLE.

Giving Details concerning the Lochs in Lismore, Mull, and Benbecula.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. Feet.	Mean. Feet.	Mean per cent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
Baile a' Ghobhainn ...	—	29	0·68	0·12	0·08	11·0	38·77	44·1	41	98	55	0·05	0·28	5·6	
Kilcheran ...	—	16	0·50	0·14	0·09	17·8	21·11	35·2	44	125	26	0·04	0·86	21·5	
Fiart ...	—	24	0·62	0·12	0·08	13·6	23·13	39·9	56	141	34	0·05	0·67	13·4	
Bà ...	40·6 [Mar. 9, 1867]	124	3·04	0·81	0·40	13·1	47·42	32·9	111	338	1602	1·21	19·20	15·8	
Frisa ...	245·4 [Nov. 22, 1866]	170	4·50	0·55	0·38	8·4	76·40	37·3	116	311	3603	1·69	7·99	4·7	
Heouravay ...	8·3	82	1·68	0·26	0·08	4·5	7·37	18·0	216	1204	26	0·13	1·85	14·2	
nan Aiscot ...	13·0	9	0·27	0·09	0·05	18·3	16·78	43·0	37	85	6	0·01	0·09	9·0	
Hermidale ...	8·7	48	0·90	0·29	0·09	10·4	12·49	30·5	116	380	29	0·08	0·90	11·3	
na Déighe fo Dheas ...	7·5	41	0·62	0·34	0·13	21·2	10·54	31·0	96	311	24	0·08	1·30	16·3	
Olavat ...	16·6	81	1·60	0·50	0·14	8·6	4·20	35·0	704	2010	26	0·22	2·34	10·6	
Langavat ...	15·95	104	2·20	0·25	0·09	4·0	8·12	24·2	387	1430	44	0·19	1·05	5·5	
		728									5475	3·75	35·54*	9·5	

\* The drainage area of Loch na Déighe fo Dheas includes those of Lochs nan Aiscot and Hermidale.

being close to the east end. The maximum depth of 34 feet is in one of the inlets, just south of Rudha Cam Direach. The temperature at the surface and 25 feet alike read  $58^{\circ}0$  Fahr., a gale prevailing at the time accounting for the homogeneity.

From the table on p. 181 it will be seen that in the eleven lochs under consideration 728 soundings were taken, and that the aggregate area of the water-surface is  $3\frac{3}{4}$  square miles, so that the average number of soundings per square mile of surface is 194. The aggregate volume of water contained in the lochs is estimated at 5475 millions of cubic feet. The area drained by these lochs is just over  $35\frac{1}{2}$  square miles, or  $9\frac{1}{2}$  times the area of the lochs.



Eaval, 1138 feet) gives an impressive bird's-eye view of the curious conformation of country. In the western part of the island is an extensive elevated tract, with few lochs, culminating in Marrival, 757 feet in height. The lower ground towards the shore is, even in the western part of the island, studded with little lochs. A great many of the lochs are tidal or brackish, and the shore-line is further broken up by long ramifying arms of the sea, which penetrate to the very heart of the island. When a panoramic view is taken from one of the higher hills, it is obvious, from the complicated shore-line, numerous islands, and absence of broad stretches of water anywhere, that no great depth is to be expected. The lochs are in fact shallow, with irregular bottoms, and bear no evidence of being rock-basins, except in a few instances close to the bases of Lee and Eaval. The considerable depth of 150 feet (having regard to the conformation of the land) was observed in Loch Obisary.

The conditions under which the survey had to be made were peculiar. Though we had the permission of the proprietor, Sir A. J. Campbell-Orde, Bart., to use the estate boats, we found that very few lochs had boats on them. The hotel had boats on a few of the best fishing lochs. The difficulty was overcome through the kindness of the hotel proprietor, Mr. McFadyean, of Lochmaddy, who allowed us to move his boats from one loch to another, and provided us with gillies to assist in the transfer. Most of the lochs are so chained together that the boats had usually to be taken over very narrow isthmuses, but in some instances they had to be laboriously hauled over ridges 100 feet or more higher than the lochs, and for distances of about half a mile. Owing to this mode of survey many small lochs were sounded, which would not have been regarded as worth the trouble, because they happened to lie on the chain through which the boat had to be taken. For the same reason many salt or brackish lochs were sounded, but in many of these cases we were unaware of their character till too late. Every gradation as to saltness is found, from lochs filled at every tide to those which only receive at long intervals an exceptionally high tide, and which are fresh enough to be drinkable, and to support the usual freshwater fauna.

In measuring the height of the various lochs above sea-level we had very few bench-marks to help us. There were no bench-marks except on a few of the lochs near the road. The great number and close proximity of the lochs rendered levelling over great distances comparatively easy. Nearly all the lochs north of Loch Eport could be measured from one or other of the ramifications of Loch Scadavay. From one bench-mark on the Carnish road all the lochs to the south of Loch Eport, some of them 7 miles from the bench-mark, had to be measured.

The lochs of North Uist are on the whole of such a uniform character that it is considered needless to describe each loch in detail. Loch Scadavay, besides being by far the largest of the lochs, shows in peculiar perfection those features which are possessed in some degree by the great

majority of the lochs. This loch will therefore be described with some fulness, and those which essentially resemble it, differing mainly in size, will be included in the summary table giving the principal dimensions. A few of the other large lochs, and any of rather different structure or coming nearer true rock-basins, as well as Loch Obisary, on account of its size and depth, will be described with more detail.

Of the thirty-nine lochs which were surveyed thirty-two are fresh-water, and the remaining seven are more or less salt. Some of those regarded as fresh may receive very exceptional tides. Lochs Duin, Strumore, Oban a' Chlachain, and Leodsay are purely tidal, receiving ordinary tides, though their level is only moderately affected by the tides. Loch Strumore rises and falls about 2 feet, while the whole tide is about 18 feet. Loch Oban nam Fiadh is of an intermediate character, the flora and fauna towards the lower end being purely marine, while in the upper part the fauna is fresh-water. Loch Caravat is so fresh that we only learned its tidal character from the account of the natives.

There are no important streams in North Uist. In the western part of the island are some a few miles in length, and large enough to be dignified by names, but in the part surveyed, where most of the lochs are situated, they are extremely short, generally only a few yards long. The stream which drains Loch Scadavay and its connected chain of lochs, though of fair size, is of inconsiderable length. This stream, with those connecting all the larger tributary lochs, has a total length of only about a mile, and the longest portion of it, from Loch Scadavay to Loch Garbh-Abhuinn Ard, is less than half a mile long.

The thirty-nine lochs surveyed belong to nineteen distinct basins. Most of these contain only one loch, which usually drains directly to the sea by a short channel, often no longer than the width of the public road. There are twelve of these lochs, which are the only lochs in the basins to which they belong, or the only lochs surveyed. They are Lochs Veiragvat, an Dùin, nan Geireann, Hosta, Oban a' Chlachain, Leodsay, an Tomain, Obisary, a' Chladaich, Tormasad, a' Bharpa, and Buaille. The only important lochs among these are Lochs Obisary and nan Geireann.

There are only six of the basins in which more than one loch was surveyed. These basins cannot be distinguished by the names of the streams draining them, as these are usually nameless. They are here distinguished by the name of the most important loch in the basin, or by that of the lowest, into which the others drain.

*The Scadavay Basin.*—This is by far the largest of the basins, and includes ten lochs which were sounded, besides many smaller ones. The combined surface areas of all the lochs have a total measurement of nearly  $3\frac{1}{2}$  square miles, Loch Scadavay itself contributing nearly half of this. The combined drainage area extends to  $14\frac{1}{2}$  square miles, and of this Loch Scadavay alone, excluding its tributary lochs, drains more than half, or over

8 square miles. The lowest loch of the basin is Loch nan Geireann, which is tidal and communicates with the sea by a mere drain under the road. Going up stream we come next to Loch Skealtar, then Loch Garbh-Abhuinn, then Loch Garbh-Abhuinn Ard, and finally to Loch Scadavay. Above Loch Scadavay there are two separate chains of lochs—on the west that of Loch nan Eun, which communicates separately with Lochs na Moracha and Huna; on the east Loch a' Bhuid, which communicates with Loch an Tairbeirt Stuadaich, and that with Loch Deoravat.

*Loch Deoravat* (see Plate LXX.).—Loch Deoravat is the uppermost of the chain of lochs running east from Loch Scadavay. It is only an inch or two higher than Loch an Tairbeirt Stuadaich, into which it drains; level, 21·3 feet above the sea. It is of simple oblong form, two-thirds of a mile long from east to west, and one-third of a mile in greatest breadth. Its simple shape does not correspond with a simple basin. The centre of the loch is filled with large islands, and the contour of the bottom is very irregular. There are a number of holes of from 23 to 32 feet in depth. The maximum, 32 feet, lies between two of the islands. The loch is picturesque, the shores rocky, rising to cliffs at the west end. The islands are of varied character, some heather-covered and dark, others bare, grassy, and green. One was blue from the profusion of the wild hyacinth. On June 2, 1904, the temperature varied from 59°·2 Fahr. at the surface to 54°·5 at 30 feet.

*Loch an Tairbeirt Stuadaich* (see Plate LXX.).—An insignificant little lochan, through which the overflow of Loch Deoravat passes to Loch a' Bhuid and Loch Scadavay. Though only a quarter of a mile long, and very narrow, the loch is of some interest. Its outline is cruciform. The shores are ranges of vertical cliffs, similar to those of the adjacent arm of Loch Scadavay. The height of the surface above sea-level is 21·15 feet, or 2½ feet higher than Loch a' Bhuid.

*Loch a' Bhuid* (see Plate LXX.).—This loch is entirely similar to Loch Scadavay, from which it is only cut off by a narrow barrier. It is fully three-quarters of a mile long, by one-third of a mile in greatest breadth. It consists of two portions, elongate from west to east, connected by a channel at the west end. The southern portion has an east and a west expansions connected by a very narrow strait, from 4 to 9 feet deep. The western expansion is shallow (deepest 18 feet), and filled with stones and small islands. One of these is of the horseshoe shape, examples of which are found in Lochs Scadavay and Fada. The eastern expansion is shallow (9 or 10 feet) in the middle, but depths of 22 to 25 feet are found close to shore. The northern portion is a narrow triangle of fair depth, with the maximum of 36 feet about the centre. The shores are rocky. There was a range of temperature of 8½° from surface to bottom on May 31, 1904:—

Surface ... ..	61°·0 Fahr.
15 feet ... ..	54°·4 „
25 „ ... ..	52°·8 „
35 „ ... ..	52°·5 „

*Loch Huna* (see Plate LXXI.).—The uppermost loch of the Scadavay basin, and the highest, being 21·6 feet above sea-level. In outline it is less irregular than most Uist lochs, and somewhat resembles Loch Hunder in form. It is nearly a mile long and half a mile broad. The bottom is very uneven, and there are many small islands. On one of the largest there is a Dùn, and a long causeway leads to the west shore. The loch is on the whole very shallow. There is a hole 23 feet deep in the northern part, and another, with the maximum depth of 25 feet, in the southern part. Many boulders are scattered around, as well as in, the loch. The shores are partly of rock, partly of mounds of gravel.

On May 31, 1904, there was a difference of  $6\frac{1}{2}^{\circ}$  between the surface and bottom temperatures:—

Surface ... ..	64°·0 Fahr.
5 feet ... ..	61°·0 „
10 „ ... ..	60°·0 „
20 „ ... ..	57°·5 „

*Loch na Moracha* (see Plate LXXI.).—A loch of somewhat simple form, draining, through a barrier a few yards wide, into Loch nan Eun. From the north end three narrow inlets diverge to north and east and west. In these are some islands. The body of the loch has no islands except close inshore, and is a simple basin. The 10-foot contour follows the outline, but is closer to the shore on the north-east, showing that the slope is steeper there. Within are two depressions: 19 feet near the north end, and 20 feet near the south-east corner. The greater part of the shore is of rock. The temperature on May 11, 1904, was nearly uniform throughout, viz. 49°·2 Fahr. at the surface, and 49°·0 at 15 feet.

*Loch nan Eun* (see Plate LXXI.).—In length Loch nan Eun is exceeded only by Loch Obisary and Loch Scadavay. Many lochs exceed it in area and volume. It is a narrow loch, running from west to east, and measures  $2\frac{1}{3}$  miles in length, by half a mile in greatest breadth. As the centre of the loch at the broadest part is occupied by a large island, Eilean Buidhe, half a mile long, there is no breadth of open water anywhere. The mean depth is only 8 feet, and, as in Loch Scadavay, the deeper soundings, 31 feet, 26 feet, 24 feet, etc., were obtained in isolated holes. The superficial area is half a square mile, and the volume of water 114 millions of cubic feet. The loch drains an area of 4 square miles, which includes Lochs Huna and na Moracha. Besides Eilean Buidhe there are many smaller islands, and innumerable stones obstruct the channel, especially in the western part and to the south of Eilean Buidhe, where it is difficult to get about in a boat.

Our gillies said that the overflow of Loch Huna enters near the west end, but there was no stream when we visited it. A stream, a few yards in length, comes in on the south from Loch na Moracha. A short stream flows from the east end into Loch Scadaway. Rock is exposed at frequent intervals all round the shore, as well as on the larger islands.

The temperature on May 11, 1904, was  $51^{\circ}0$  Fahr. both at the surface and at 15 feet.

*Loch Scadaway* (see Plate LXX).—There is probably no other loch in Britain which approaches Loch Scadaway in irregularity and complexity of outline. It is an extraordinary labyrinth of narrow channels, bays, promontories, and islands. Though it measures  $4\frac{1}{4}$  miles in length, from north-west to south-east, and about 2 miles in greatest breadth, from south-west to north-east, there is really no broad open water in the whole loch, the broadest part being in the westernmost inlet, where there is open water half a mile broad. The ratio of circumference to length will illustrate how very irregular is the form—though only a little over 4 miles in length, a rough measurement indicates a shore-line of 50 miles. Very many islands stud the surface, the largest being nearly a mile in length. The main road round the island now cuts Loch Scadaway into two parts, which are connected by such a small channel under the road that in time of flood the south loch may temporarily rise some feet higher than the other, though normally they are at the same level. There is nowhere any considerable depth, the deepest parts occurring as little holes, while the narrows are usually shallow. A lowering of the surface by no more than 6 feet would divide the loch into a dozen small lochs, and a host of little ponds, while a rise of the same amount would vastly increase its area by including all the higher lochs in the same basin, among them such large lochs as nan Eun, Huna, a' Bhuid, and Deoravat. The deepest holes are 50 feet in the south loch, and 37 feet in the north loch.

The small superficial area is in remarkable contrast to the great shore-line, both portions together measuring only  $1\frac{3}{4}$  square miles. The mean depth, also, is very low, being only about 9 feet. The narrow channels leading into some of the elongate arms are often only from 1 to 2 feet in depth. Some of the islands have been the sites of Duns, and these have been connected with the shores by narrow causeways. The volume of water is only 418 millions of cubic feet. One other loch in North Uist has a greater volume, though of less superficial area, Loch Obisary having about twice the volume. In the shallower parts numerous stones and boulders project above the surface, rendering navigation difficult even in a small rowing-boat. In several instances we were unable to complete lines of soundings from this cause. The shores are in parts of peat, in other parts of stones, or gravel with boulders, but rock appears in many parts. The easternmost arm of the south loch, one-sixth of a mile in length, has precipitous rocky cliffs on both sides. This character is continued in the

little Loch an Tairbeirt Stuidhaich, which is only separated from this arm of Loch Scadavay by a narrow ridge.

Two very short streams enter Loch Scadavay, conveying the overflow of Lochs nan Eun and a' Bhuird, with the higher tributary lochs. The Garbh-Abhuinn, the most considerable stream in this part of the island, flows eastward from the north portion of the loch to Loch Garbh-Abhuinn, which drains through Lochs Skealtar and nan Geireann into Loch Maddy.

When surveyed on May 24 to 30, 1904, Loch Scadavay was 16.15 feet above sea-level; the Ordnance Survey found it to be 16.8 feet on June 11, 1875.

A series of temperatures taken in the deepest part, May 30, 1904, showed a total range of 11°. The temperature at 25 feet was only 0°.6 higher than at the bottom, while from 25 feet to 10 feet there was a rise of 4°.4, and from 10 feet to the surface of 6°.0:—

Surface ... ..	63°·0 Fahr.
10 feet ... ..	57°·0 "
25 " ... ..	52°·6 "
50 " ... ..	52°·0 "

*Loch na Garbh-Abhuinn* (see Plate LXXII.).—A small loch (locally known as Upper Skealtar), about one-third of a mile long by a quarter of a mile broad. It is divided into two nearly equal portions by promontories which nearly meet. The northern half has a depression towards the east end, with a maximum of 20 feet. The south half is entirely shallow, the deepest part only 7 feet. The strait between is only 4 feet deep.

*Loch na Garbh-Abhuinn Ard* (see Plate LXXII.).—In flood this is part of Loch na Garbh-Abhuinn, but when we visited it there was a strong current through the narrow part, though we could detect no difference of level. This loch is so shallow that a boat can with difficulty get about in it. An island occupies the middle of it. In fact, these two lochs are only expansions of the river leading from Loch Scadavay to Loch Skealtar.

*Loch Skealtar* (see Plate LXXII.).—A fairly large loch, nearly a mile in length by half a mile in greatest breadth. It is of irregular outline, and has many islands, but is nevertheless a simple basin. The contours are affected by the islands, so that they do not follow the shore. The deepest part, with the maximum of 42 feet, is in the middle of the loch, between two islands. There is a second little depression of 40 feet a little further west. The burn from Loch Garbh-Abhuinn, one-sixth of a mile long, enters on the west. The outflow is by a little loch, which was not sounded, leading to Loch nan Geireann. Loch Skealtar was 8.75 feet above sea-level on May 9, 1904; the Ordnance Survey found it to be 8.5 feet on June 12, 1875.

When surveyed, the temperature was uniform,  $47^{\circ}7$  Fahr., from surface to bottom, following on a gale of three or four days' duration.

*Loch nan Geireann* (see Plate LXXII).—A little tidal loch near Lochmaddy, the lowest of the Scadavay basin. It is about two-fifths of a mile long by one-fifth of a mile broad. In form it is oblong, with an arm running towards Loch Skealtar. There are some small islands, and the bottom has many large boulders scattered over it, some of which project above the surface. It is a simple basin, but the contours are irregular, and do not closely follow the shore-line. The maximum depth is 31 feet. The stream entering from Loch Skealtar has no appreciable length, there being merely a fall of a foot from a little loch intervening between Lochs nan Geireann and Skealtar. The outflow is a drain under the road into Loch na Ciste, a sea loch. The fauna was that of fresh water. Only high tides come in and raise the surface from 1 to  $1\frac{1}{2}$  feet. The height above sea-level, on May 9, 1904, was 7.45 feet. The temperature at the surface was  $49^{\circ}0$  Fahr., and at 25 feet only  $\frac{1}{2}^{\circ}$  less.

*The Strumore Basin*.—This comprises a chain of three lochs, of which Loch an Strumore (tidal) and Loch Fada (fresh) were surveyed, while the intermediate little Loch Galtarsay was not sounded.

*Loch an Strumore* (see Plate LXXII).—Loch an Strumore (or Loch an Aastrom) is a pretty large tidal loch of oblong form, situated about a mile north-west from Lochmaddy. It is a little more than a mile long, and half a mile in greatest breadth. The outline is irregular, with many little inlets. There are many islands, the largest near the middle, where the loch is much constricted, and lying close to the north shore. Rock and stones alternate on the shore. The bottom is almost level, about 12 feet deep in the central parts, the bays shallower. There is a deeper hole at the east end, near the outflow, with the maximum depth of 22 feet. Ordinary tides enter, and the loch is filled throughout with fucoids, but juncus also grows abundantly. Level on May 10, 1904, when the tide was out, 3.7 feet above the sea. The temperature at the surface was  $49^{\circ}2$  Fahr., and at 18 feet  $47^{\circ}2$ .

*Loch Fada* (see Plate LXXII).—Loch Fada consists of two portions connected by a narrow channel. The north portion is narrow and elongate from west to east. It is studded with islands, on which large numbers of gulls and other birds nest. The greater part of it is less than 10 feet in depth. The maximum depth of 26 feet is found close to an island at the east end. There is also a very narrow channel, with depths up to 25 feet, between the peninsula called Ard Fhada and a chain of small islands. The southern portion of the loch is triangular. It is one of the largest bodies of open water on the island, but even here there is a heap of stones projecting above the surface almost in the centre of the triangle. There

are two holes 45 feet deep, one to the south-east, the other to the south-west, of this heap of stones. The shore and the islands are entirely of rock, except at the east end near the outflow, where there are some mounds of gravel. The total length of the loch is fully  $1\frac{3}{4}$  miles, and the greatest breadth a little under a mile. The superficial area, two-thirds of a square mile, is about equal to that of Loch Geireann Mill, and is only exceeded by Lochs Scadavay and Obisary. The volume of water is 199 millions of cubic feet. The mean depth is 10 feet.

Loch Fada has a very small drainage area,  $3\frac{1}{2}$  square miles, and receives only small local burns. The outflow is by a very short stream into Loch Galtarsay, whence a river half a mile in length leads into Loch an Strumore. The height above sea-level on May 21, 1904, was 29·85 feet.

*Loch Veiragvat* (see Plate LXXII).—A small loch to the north of Loch Fada. It measures fully half a mile in length by a quarter of a mile in greatest breadth. It is of roughly triangular form, broadest towards the east end. The outline is simple, little indented. There are several islands, the largest near the centre; and many boulders appear above the surface at the west end. The islets at the east end are of rock, and rock also appears at a few points on the north shore, and at the west end. The large island is low and grassy, and formed of stones. The bottom is uneven, the greater part of it covered by less than 10 feet of water. The maximum depth of 25 feet occurs in a small hole between the island and the north shore. Loch Veiragvat is the highest loch surveyed in North Uist. Its height on May 12, 1904, 71·85 feet above the sea, is twice that of Loch a' Chonnachair, the next in elevation. The temperature at the surface was  $49^{\circ}\cdot3$  Fahr., and at 10 feet  $49^{\circ}\cdot0$ .

*Loch an Dùin* (see Plate LXXIII).—A tidal loch of exceedingly complex form, consisting of five principal expansions, elongated from east to west, with many lesser inlets and numerous islands. It is nearly a mile long, and two-thirds of a mile in greatest breadth. Some of the branches could not be entered. All are shallow, mostly less than 7 feet deep, except the northern expansion, which is on the whole shallow, but having a hole where the maximum depth is 35 feet. There are two Dùns, from which the loch takes its name, one in the northern branch, another, very well preserved, in the southern expansion. The shores are of rock covered with peat. The two lowest basins communicate separately with the sea, and are filled with *Fucus*, *Zostera*, etc. The uppermost basin is very slightly salt, and fresh-water plants (*Myriophyllum*) grow in it. The level of the loch on May 20, 1904, was 4·5 feet above the sea, and there was no difference of level between 10 a.m. and 5 p.m. The temperature at the surface was  $52^{\circ}\cdot5$  Fahr., at 15 feet  $52^{\circ}\cdot0$ , and at 35 feet  $50^{\circ}\cdot5$ .

*Loch nan Geireann* (see Plate LXXIV.).—As there are two lochs of the same name, this, the larger one, is locally distinguished as Geireann Mill. The stream from the loch formerly supplied a mill, now in ruins. Though one of the largest lochs on the island (it comes fourth in point of length), Loch nan Geireann is so generally similar to Loch Scadavay that a very short description will suffice. It is 2 miles in length and three-quarters of a mile in greatest breadth. Unlike Lochs Scadavay and nan Eun, the bottom is even, and there are no deep holes, though many small islands and numbers of large stones project above the surface. The area is two-thirds of a square mile, and the volume 121 millions of cubic feet. The maximum depth is 18 feet, and the mean depth 6 feet. The shores are almost everywhere of rock, though there are some stony stretches. The rock is in places covered with deep peat and heather; there are many boulders scattered around, and some perched blocks. There are many bays with white sand, and a great part of the bottom is sandy. The distribution of the sand under the influence of wind probably accounts for the filling up of holes and the general uniformity of the bottom. The short stream conveying the overflow to the sea has a rocky channel. The drainage area extends to  $6\frac{1}{2}$  square miles, and includes some small lochs which were not surveyed. The principal streams enter on the west. The loch was surveyed on May 16 to 19, 1904, when the level was found to be 16·4 feet above the sea; on September 23, 1875, the Ordnance Survey found it to be 17·3 feet. The temperature on May 19 was 52°·0 Fahr. at the surface, and 51°·5 at 10 feet.

*Loch Hosta* (see Plate LXXIII.).—A small loch in the extreme west of the island. It is of oblong form, half a mile in length by fully a quarter of a mile in greatest breadth. It differs from most of the other lochs in having a simple little-indented outline. The basin is simple, the sides sloping gently all round, but a little more steeply on the north-east side, to the maximum of 31 feet nearly in the centre. On June 18, 1904, the surface was 23·5 feet above sea-level; on September 11, 1875, the Ordnance Survey found the level to be 23·0 feet. A small burn, half a mile long, runs west to the sea at Raikinish.

*Loch Oban a' Chlachain* (see Plate LXXV.).—A small tidal loch, nearly a mile long by a quarter of a mile broad, draining into the Sound of Monach, opposite the island of Baleshare. It runs from west to east towards the head of Loch Eport, which it so nearly approaches that the island is almost cut across, the isthmus being less than a quarter of a mile across. The loch consists of a narrow western part, filled with seaweeds, and a triangular eastern part, with an almost level bottom about 14 feet deep, the maximum of 19 feet being recorded close to the south shore. The tides affect the level more than in the other tidal lochs sounded. On June 1, 1904, the level of the surface was 3·75 feet above the sea, and

the temperature of the water was found to be uniform, readings at the surface and at 15 feet being identical, 61°0 Fahr.

*Loch Leodsay* (see Plate LXXV.).—A small tidal loch lying just south of Loch Oban a' Chlachain. It is nearly two-thirds of a mile long by a quarter of a mile broad, of very irregular form, with a large western and smaller eastern expansions. The west portion is very shallow, and the greatest depth, 17 to 20 feet, is in the narrow channel between the two expansions.

*The Creige Léithe Basin*.—This basin includes only two lochs, the lower one, Loch na Creige Léithe, very small; the upper, Loch nan Garbh Chlachan, much larger. The basin opens into Loch nan Gealag, a branch from the strait between Uist and Grimsay.

*Loch nan Garbh Chlachan* (see Plate LXXV.).—A small rhomboid loch, from which a number of narrow inlets branch off. It is barely half a mile long by a quarter of a mile broad. The shores are of rock, and it is filled with larger and smaller rocky islands and boulders. It is all shallow, except in the open water east of the principal islands, where there is a depth of 25 feet. The surface on June 9, 1904, was 15·2 feet above the sea. The temperature was 61°0 Fahr. at the surface and at 25 feet.

*Loch na Creige Léithe* (see Plate LXXV.).—A narrow loch, only a quarter of a mile long, with rocky shores. It is at the same level as Loch nan Garbh Chlachan, being only separated by a bar of stones. The maximum depth is 14 feet.

*Loch an Tomain* (see Plate LXXVI.).—A typical Uist loch, with its complexity of form, being almost cut into a number of lochs by narrows and islands. It is nearly  $1\frac{1}{2}$  miles in length and one-third of a mile in extreme breadth. The western of the four chief basins has a maximum depth of 36 feet, the middle basin 37 feet, the eastern basin 31 feet, and the north-eastern basin 44 feet, the maximum depth of the loch. The loch on June 23, 1904, was 14·15 feet above the sea. It drains by a small stream one-third of a mile long into the Little Minch. The shores are steep and rocky on all sides.

*The Crogavat Basin*.—There are only two lochs in this basin—the lower, Loch Crogavat, connected by a short stream with the Little Minch; the upper, Loch a' Ghlinne-Dorcha, the second deepest loch on the island.

*Loch a' Ghlinne-Dorcha* (see Plate LXXVI.).—A dark little loch, occupying the whole of the east flank of Burrival (461 feet high). It is half a mile long by one-third of a mile broad, covering an area of 50 acres, and is divided into two portions by a constriction. The northern part is occupied by a large island. In this part the deepest sounding is close

under the cliffs on the north, where there is a depth of 36 feet. The southern half is a simple basin, free from islands, with fairly steep slopes on all sides, and a maximum depth of 85 feet in the centre. The mean depth of over  $27\frac{1}{2}$  feet is the greatest in the Uist lochs. The shore is entirely steep and rocky, forming cliffs under Burrival, and on the north a burn a few yards in length leads to Loch Crogavat.

The surface on June 25, 1904, was 23·2 feet above sea-level. There was a difference of  $6^{\circ}$  between the temperature at the surface and at the bottom :—

Surface ... ..	55°·0 Fahr.
25 feet ... ..	55°·0 „
50 „ ... ..	54°·5 „
70 „ ... ..	50°·4 „
85 „ ... ..	49°·0 „

*Loch Crogavat* (see Plate LXXVI.).—Loch Crogavat lies to the south of Loch Eport, near its mouth. It approaches at both ends within a few yards of Loch Eport, but it drains eastward into the Little Minch. It is over a mile long, by a quarter of a mile broad, and covers an area of about 84 acres. In general form it is dumb-bell shaped, narrow in the middle and expanded at each end. In the western half is a large island. There is deep water on both sides of this island, depths of 40 feet occurring in the narrow channel to the north of it, as well as in the broader part on the south. The eastern basin is larger, of oblong form, with many small islands. The maximum depth is 55 feet. The channel connecting the two basins is also deep, ranging from 37 feet to 45 feet. The mean depth,  $24\frac{1}{2}$  feet, is relatively high, being only exceeded by Lochs Obisary and a' Ghlinne-Dorcha. The shores and islands are entirely of rock. The temperature on June 25, 1904, was uniform throughout, viz.  $55^{\circ}\cdot 2$  Fahr. at the surface, and at the depths of 25 and 50 feet. Loch Crogavat is less than a foot lower than Loch a' Ghlinne-Dorcha, standing 22·45 feet above sea-level.]

*Loch Obisary* (see Plate LXXVI.).—The largest loch in North Uist, measured by the volume of water, which amounts to 837 millions of cubic feet, or twice that of Loch Scadavay. It is also by far the deepest loch on the island, the maximum depth of 151 feet being nearly twice that of Loch a' Ghlinne-Dorcha, the second deepest. Loch Scadavay, however, is longer, and has a greater superficial area.

Loch Obisary lies at the foot of Eaval, the highest hill in North Uist (1138 feet), which it half encircles, its shores following the curve of the mountain on the north and west. It is roughly crescent-shaped, and measures  $2\frac{1}{3}$  miles in a straight line between the points of the crescent, or over 3 miles following the axis of maximum depth. It is broadest in the northern part, where it measures over one mile across. There are, however, large islands in this part of the loch, so that the broadest open

water is reduced to about half a mile. The outline is extremely irregular, and there are many islands large and small. The northern part of the loch is somewhat triangular, but its centre is filled by three large islands, the largest of which, Eilean Leathann, is fully half a mile long.

As in Loch Scadavay, there are many distinct depressions, separated by shallows. In each of these there is considerable depth. In the narrow part, west of Eaval, there are three basins with maxima of 51, 57, and 50 feet respectively. South of Eilean Leathann is a basin with a depth of 65 feet, and east of the same island one of 58 feet. North of Eilean Leathann is a depth of 48 feet. Between Eilean Mor and the stream flowing out to the north into Loch Eport lies the deepest basin in the loch. It is of very limited extent, measuring only about a quarter of a mile each way, between the islands and the shore, but has the remarkable maximum depth of 151 feet. To the west of this is another very small triangular area, having a depth of 70 feet. The mean depth of  $25\frac{3}{4}$  feet is less than that of Loch a' Ghlinne-Dorcha, and a little more than that of Loch Crogavat. The greater part of the shore is of rock, forming on the west a range of cliffs, with some small stretches of gravel, stones, and peat. Immediately under the north slope of Eaval is the largest stretch of peat-covered gravel, extending about a mile without any exposed rock. The large islands, and most of the small ones, are of rock. On Eilean Leathann mounds of stony *débris* lie over the rock. The level was ascertained on June 15, 1904, by measuring from Loch na Ceithir-Eileana to be 8.2 feet above the sea.

Loch Obisary is tidal. Though the surface level is little affected by the tides, these enter often enough to render the water quite salt, and to permit numerous marine animals to live in it. Mussels (marine) were found adhering to the fresh-water weeds, and marine crustacea abounded among the weeds. Large beds of a slender grass-like plant, which appeared to be *Juncus supinus*, but was not in flower, reached the surface from depths of from 14 to 18 feet. From the deepest part a black gritty mud was obtained.

A series of temperatures was taken in the deep hole at noon, June 25, 1904. There was a range of  $8^{\circ}3$ , and a remarkable inversion was indicated, the thermometer at 50 feet reading  $1^{\circ}$  lower than at the bottom. The readings at 50 feet and 100 feet were repeated, after testing by again reading the surface temperature, and were consistent with the first readings:—

Surface (repeated)	...	...	...	...	55°.5 Fahr.
10 feet	...	...	...	...	55°.5 "
25 "	...	...	...	...	50°.4 "
50 "	(repeated)	...	...	...	47°.2 "
100 "	(repeated)	...	...	...	48°.2 "
150 "	...	...	...	...	48°.2 "

*Loch a' Chladaich* (see Plate LXXV.).—A very small narrow loch on

the south shore of Loch Eport, between the Oban nam Fiadh basin and Loch Obisary. It is nearly one-third of a mile long and one-eighth of a mile in greatest breadth. It is one of the highest lochs surveyed, being 27·95 feet above sea-level on June 7, 1904. It is very shallow, the maximum depth being 9 feet. It drains north into Loch Eport by a short burn.

*The Oban nam Fiadh Basin.*—This comprises seven lochs, of which the lowest, Oban nam Fiadh, is purely tidal; while Loch Caravat, the largest loch of this basin, is very slightly brackish. Two chains of lochs connect with Loch Oban nam Fiadh. On the east Loch na Coinnich, communicating with Loch na Ceithir-Eileana, and on the south Loch Caravat. West from Loch Caravat lies Loch an Iasgaich; east from it Loch 'ic Colla, connected with which is Loch an t-Seasgain.

*Loch Oban nam Fiadh* (see Plate LXXV.).—This loch is of unusual form among the lochs of North Uist. It is elongate and narrow, over a mile long by a quarter of a mile in greatest breadth, and with a mean breadth of one-eighth of a mile, covering an area of about 92 acres. It is divided into three portions by narrows. The main part is of oblong form, its axis, east and west, two-thirds of a mile long. There are several small islands, one in the centre of the loch. The bottom is uniform, 5 or 6 feet in depth, but with two depressions of 10 feet. The middle and upper portions are small, and 4 to 5 feet in depth. They are separated by a low island, and the whole channel here is grown up with reeds. The stream from Loch Caravat enters the upper basin. The shores are of rock.

The loch is interesting from the transition it shows from salt to fresh water, and the corresponding difference in the fauna and flora of the upper and lower basins. The lower part is purely tidal. If not filled by all ordinary tides, it is, at any rate, so frequently filled as to enable sea-weeds to grow and marine animals to live. Yet fresh-water plants also grow in this part, and mussels are found adhering to these. The very narrow channel and the dense growth of *Phragmites* prevent the tides from having much effect on the upper portion in summer. Here the water tastes almost fresh, and such fresh-water crustacea as *Holopedium* are found. Yet high tides must raise this part considerably, as Loch Caravat, at the time of our visit 2 feet higher, is filled through it. The temperature at the surface was 68°·0 Fahr., and at 6 feet 66°·8, on June 7, 1904.

*Loch Caravat* (see Plate LXXV.).—Loch Caravat is the second deepest among the larger lochs of the island, though the little Loch a' Ghlinne-Dorcha is somewhat deeper. In general form it resembles the letter H, there being two narrow portions running east and west, connected by a narrow channel running north and south. In these circumstances it is difficult to define length and breadth; a line drawn from the west end of

the northern branch along the connecting arm, to the east end of the southern branch, would be about 2 miles in length. The northern branch, nearly  $1\frac{1}{2}$  miles in length, is divided into three portions. That in the east, adjoining the outflow, is quadrate, measuring about a quarter of a mile each way; it has an even bottom, with a greatest depth of 20 feet. The middle portion is filled with islands, on one of which, Dùn Scor, is a Dùn. Another, Eilean Dubh Dùn Scor, is connected with a larger island on the east by a long causeway. Among these islands the north branch is deeper than elsewhere, the greatest depth being 30 feet. The west portion of this branch is three-quarters of a mile long, and very narrow and shallow, having a greatest depth of only 11 feet. It is separated from the central part by a large island, connected with the north shore by a causeway, and having the channel on the south full of stones, and from 1 to 3 feet in depth. The burn from Loch an Iasgaich enters the west end of this arm. The narrow passage connecting the northern and southern branches of the loch is shallow in the middle and northern portions, but towards the south it rapidly deepens into one of the basins which form the southern half of the loch. The southern branch of the loch is shorter than the northern, measuring little more than one mile in length, but it is much broader and very much deeper. It contains two distinct basins, the best marked basins in the island, separated by a strait filled with large islands.

The west basin is triangular, three-quarters of a mile long by one-third of a mile broad. Though the island, on which is the Dùn Bàn, lies well out from the shore, it does not destroy the simplicity of the basin. The slope of the bottom is steeper on the south side, more gradual on the north. The deepest sounding in this basin, 50 feet, occurs near a small island at the east end of the basin. The east basin is smaller but deeper. It is fully half a mile long by a quarter of a mile broad. Its axis runs north and south. The contours are more indented than the outline, owing to the presence of a number of submerged promontories. The slopes of the bottom are about equal on all sides, and the deepest part (maximum sounding of the whole loch, 74 feet) is about the middle of the basin. The narrows between the east and west basins is nearly closed by islands, of which Eilean Dubh, one-sixth of a mile long, is the largest. There are three narrow channels among these islands with depths of only 5 or 6 feet. Large portions of the shores are stony, but rock is exposed in many places, and the principal islands are of rock. The stream flowing out of the north-east corner into Loch Oban nam Fiadh, is one-eighth of a mile long, and has a fall of 2 feet. At the south-east corner the burn from Loch 'ic Colla flows in. The superficial area of Loch Caravat is about 374 acres, or over half a square mile. The drainage area, which includes Lochs an Iasgaich, 'ic Colla, an t-Seasgain, and some smaller lochs, has an extent of fully 3 square miles. By volume of water, which amounts to 270 millions of cubic feet, Loch Caravat is the third largest loch in the island. When surveyed on June 8, 1904, the height of the surface above sea-level was

7·2 feet. If there be no error in this measurement the tide must sometimes enter the loch, and the local gillies stated that this was so. Nevertheless the water is fresh enough to be drunk, and maintains the usual fresh-water fauna. Through so many narrow and shallow channels it is probable that the tides can have little effect on the salinity of the more distant parts of the loch.

On June 11, 1904, there was a difference of 7°·6 between the surface and the bottom temperatures. The great part of the difference, 4°·5, occurred between 35 and 40 feet, as shown in the following table:—

Surface ... ..	58°·8 Fahr.
25 feet ... ..	57°·2 „
35 „ ... ..	56°·8 „
40 „ ... ..	52°·3 „
50 „ ... ..	51°·2 „
72 „ ... ..	51°·2 „

*Loch an Iasgaich* (see Plate LXXV.).—A little loch lying west from Loch Caravat and draining into it. It is fully half a mile long, by a quarter of a mile in greatest breadth. It is of the usual irregular outline and uneven bottom, and is studded with small islands. A great part of it is less than 8 feet deep, and the maximum of 16 feet is quite close inshore towards the east end of the loch. The surface is 11·2 feet above sea-level.

*Loch 'ic Colla* (see Plate LXXV.).—An extremely irregular loch (locally called Loch McColl), consisting of several narrow arms almost cut off from one another. It is a mile long, by half a mile in greatest breadth. The south portion has an uneven bottom, the deepest sounding in the loch (34 feet) having been taken near the island towards the east end, and a depth of 26 feet occurs close to the east end. The north portion has a fairly deep basin at its west end, where the maximum depth is 33 feet. A lesser basin of 22 feet in depth lies to the east of this. Loch 'ic Colla, on June 9, 1904, was 16·1 feet above sea-level. Rock is seen at intervals all round the shore, but the stream, about 75 yards long, flowing into Loch Caravat, has a stony channel.

In the deep part the range of temperature from surface to bottom was nearly eight degrees, which occurred between the depths of 25 and 33 feet, the readings at the surface and at 25 feet being identical—

Surface ... ..	60°·2 Fahr.
25 feet ... ..	60°·2 „
33 „ ... ..	52°·3 „

*Loch an t-Seasgain* (see Plate LXXV.).—An insignificant narrow strip of water, partly choked with weeds, lying south from Loch 'ic Colla. Though distinguished by a name of its own, it was at the same level as Loch 'ic Colla, and really forms part of it. The maximum of 18 feet is found in a little hole at the east end.

*Loch na Ceithir-Eileana* (see Plate LXXV.).—The higher of the two lochs of this basin which lie between Loch Oban nam Fiadh and Loch Obisary. It is of somewhat simple outline among the lochs of Uist, and somewhat rhomboid. It is half a mile long by one-third of a mile broad. The bottom is uneven, and, as the name implies, four islands rise above the surface. The two larger islands are on a ridge which runs south-west and north-east, the depths between them and the shores varying from 7 to 9 feet. In the basin east of them, of triangular form, the maximum depth of 42 feet occurs quite close to the shore at the east end, and another sounding of 39 feet is close inshore on the south. West of the larger islands is a deep furrow, where a depth of 37 feet was found. This is the highest loch in the Oban nam Fiadh basin, the surface being 16·85 feet above sea-level on June 7, 1904.

The range of temperature was great, amounting to 12°·6 throughout the body of water, the greatest fall being observed between 20 and 25 feet, —a fall of 5°, or one degree per foot of depth, as shown in the following table :—

Surface ...	...	...	...	...	...	64°·6 Fahr.
5 feet ...	...	...	...	...	...	63°·0 "
15 "	...	...	...	...	...	61°·0 "
20 "	...	...	...	...	...	58°·0 "
25 "	...	...	...	...	...	53°·0 "
35 "	...	...	...	...	...	52°·0 "

*Loch na Coinnich* (see Plate LXXV.).—A little triangular loch, half a mile long, between Loch na Ceithir-Eileana and Loch Oban nam Fiadh. The shores are of rock and the bottom stony. The bottom is very uneven, and the maximum depth of 25 feet is found in the centre of the loch, close to and between two heaps of stones. The surface on June 7, 1904, was only 9·9 feet above sea-level. The range of temperature was here also very high, nearly 16 degrees in the 25 feet of water, the fall between 15 and 20 feet exceeding one degree per foot of depth, as shown in the accompanying table :—

Surface ...	...	...	...	...	...	68°·0 Fahr.
10 feet ...	...	...	...	...	...	63°·0 "
15 "	...	...	...	...	...	62°·6 "
20 "	...	...	...	...	...	57°·0 "
25 "	...	...	...	...	...	52°·3 "

*Loch Tormasad* (see Plate LXXI.).—A narrow and shallow loch, measuring two-thirds of a mile long by one-third in greatest breadth, which lies just west of the head of Loch Eport, into which it drains by a burn half a mile in length. The southern part forms an equilateral triangle, the centre of which is occupied by a low island, joined to the shore by a causeway. The bottom is nearly level, about 7 feet deep, with depressions of 9 and 10 feet.

*Loch a' Bharpa* (see Plate LXXI).—A loch draining into the head of Loch Eport, between Lochs nan Eun and Tormasad. It is fully a mile long, by nearly half a mile in greatest breadth. The western half is narrow and shallow, with several narrow inlets. The eastern half is expanded and forms a simple basin of some depth. The 10-foot and 20-foot contours follow the shore-line. The area over 30 feet in depth is narrow, occupies the centre of the loch, and is divided into two parts, with maxima of 35 and 37 feet.

*Loch a' Buaille* (see Plate LXX).—Loch a' Buaille, on the north side of Loch Eport, between that loch and Loch Scadavay, is half a mile long, but exceedingly narrow. It is shallow on the whole, but depths occur of 14 feet near the south end, and 23 feet (the maximum) near the north end. It drains south, through a smaller loch, into Loch Eport. The surface on June 4, 1904, stood 20·35 feet above the sea. The range of temperature was unusually high, amounting to  $14\frac{1}{2}^{\circ}$  in the 20 feet of water, the fall between the depths of 15 and 20 feet exceeding  $7^{\circ}$ —a fall of nearly  $1\frac{1}{2}^{\circ}$  per foot of depth, as shown in the following table:—

Surface ... ..	67°·0 Fahr.
5 feet ... ..	65°·5 "
10 ,, ... ..	62°·5 "
15 ,, ... ..	59°·6 "
20 ,, ... ..	52°·5 "

*Loch Tarruinn an Eithir* (see Plate LXX).—A loch of very irregular form, lying between Loch Eport and the southern extremity of Loch Scadavay. It is half a mile in length by one-third of a mile in greatest breadth, and consists of a number of very narrow branches of little depth. The widest part, in the north, has a heap of stones in the centre. In this part the maximum depth of 23 feet is found. The principal islands are of rock, the shores of rock, mounds of gravel, boulders, and peat. The loch drains directly by a stream some 50 yards long into Oban Sponish, a branch of Loch Eport. The surface on June 4, 1904, was 16·1 feet above sea-level. The temperature had the high range of  $14\frac{1}{2}^{\circ}$ , as in Loch a' Buaille, and here also the greatest fall was observed between 15 and 20 feet, viz.  $6^{\circ}$ , rather less than in Loch a' Buaille, but still exceeding  $1^{\circ}$  per foot of depth:—

Surface ... ..	66°·7 Fahr.
10 feet ... ..	61°·5 "
15 ,, ... ..	58°·2 "
20 ,, ... ..	52°·3 "

*The Hunder Basin*.—This also contains only two lochs which were surveyed, Lochs Hunder and a' Chonnachair. The lower loch is joined to a branch of Loch Eport on its north side.

*Loch a' Chonnachair* (see Plate LXXVII.), though draining through Loch Hunder into Loch Eport, is situated close to Lochmaddy. It is of





Hosta ...	26	0.49	0.81	0.21	43.1	31	12.47	40.2	83	208	36	0.10	1.54	15.4
Oban a' Chlachain ...	41	0.84	0.28	0.09	10.8	19	9.75	51.3	233	455	20	0.07	0.49	7.0
Leodsay ...	42	0.60	0.82	0.13	21.2	25	7.28	36.9	158	429	16	0.08	0.43	5.4
nan Garbh Chlachain ...	33	0.40	0.88	0.13	33.2	20	7.28	29.1	84	290	11	0.05	0.39	7.8
na Creige Leithe ...	11	0.27	0.10	0.04	16.4	14	7.00	50.0	102	204	2	0.01	0.49	49.0
an Tomain ...	54	1.45	0.31	0.10	7.1	44	16.47	37.4	174	465	69	0.15	0.55	3.7
a' Ghlinne-Dorcha ...	45	0.47	0.83	0.17	35.3	85	27.65	32.5	29	90	60	0.08	0.38	4.1
Crogavat ...	57	1.06	0.23	0.12	11.7	55	24.66	44.8	102	227	90	0.13	0.68	5.2
Obisary ...	334	3.03	1.33	0.39	12.7	151	25.70	17.0	106	622	837	1.17	3.86	3.3
a' Chladaich ...	12	0.31	0.13	0.06	19.7	9	4.50	50.0	182	364	2	0.02	0.09	4.5
Oban nam Fiadh ...	55	1.13	0.23	0.13	11.2	10	4.23	42.3	597	1410	17	0.14	4.85	35.4
Caravat ...	275	1.45	0.50	0.40	27.8	74	16.57	22.4	103	462	270	0.58	3.14	5.4
an Iasgach ...	44	0.59	0.23	0.10	17.5	16	5.55	34.7	195	561	9	0.06	0.25	4.2
'ic Colla ...	88	1.00	0.54	0.13	12.8	34	10.77	31.7	155	490	38	0.13	0.73	5.6
an t-Seasgain ...	18	0.50	0.15	0.05	9.8	18	5.72	31.8	147	461	4	0.02	0.07	3.5
na Ceithir-Eileana ...	16.85	0.56	0.33	0.17	31.2	42	13.81	32.9	70	214	38	0.10	0.85	8.5
na Coimnich ...	9.90	0.51	0.23	0.10	19.8	25	8.62	34.5	108	312	12	0.05	1.02	20.4
Tormasad ...	15.00	0.42	0.69	0.33	16.4	10	5.60	55.7	364	651	12	0.08	0.70	8.8
a' Bharda ...	16.40	87	1.18	0.46	13.6	97	12.43	33.6	168	501	66	0.19	0.98	5.2
a' Buaille ...	20.85	31	0.52	0.12	11.7	23	6.82	29.6	119	403	6	0.03	0.08	2.7
Tarruin an Eithir ...	16.10	59	0.50	0.36	22.7	23	27.7	27.7	115	414	10	0.06	0.20	3.3
a' Chonnachair ...	35.50	69	0.56	0.11	19.0	27	6.88	32.6	109	333	15	0.06	0.62	10.3
Hunder ...	22.55	92	1.26	0.63	18.2	60	18.08	30.1	111	368	146	0.29	2.50	8.6
	3751										3026	8.66	45.29*	5.2

\* The drainage area of Loch nan Geireann includes those of Lochs Deoravat, an Tairbeirt Stuaidhaich, a' Bhuird, Huna, na Moracha, nan Eun, Seadavay, na Garbh-Abhuinn, na Garbh-Abhuinn Ard, and Skealtar; that of Loch an Strumore includes that of Loch Fada; that of Loch na Creige Leithe includes that of nan Garbh Chlachain; that of Loch Crogavat includes that of Loch a' Ghlinne-Dorcha; that of Loch Oban nam Fiadh includes those of Lochs Caravat, an Iasgach, 'ic Colla, an t-Seasgain, na Ceithir-Eileana, and na Coimnich; and that of Loch Hunder includes that of Loch a' Chonnachair.

From the table on pages 202 and 203 it will be seen that in the thirty-nine lochs under consideration 3751 soundings were taken, and that the aggregate area of the water-surface is  $8\frac{2}{3}$  square miles, so that the average number of soundings per square mile of surface is 433. The aggregate volume of water contained in the lochs is estimated at 3026 millions of cubic feet. The area drained by these lochs is about  $45\frac{1}{4}$  square miles, or about five times the area of the lochs.

## THE LOCHS OF LEWIS.

THE island of Lewis and Harris is the largest of the lesser British islands (see Index Map, Fig. 23), only Skye and the Mainland of Shetland nearly approaching it in size. It measures some 60 miles in length by 30 miles in breadth. Its southern half is mountainous, many peaks exceeding 2000 feet in height, and a few exceeding 2500 feet. The northern half is lower.

There are many hundreds of lochs distributed over every part of the island. In the northern half they are specially numerous, and in the central part they form a sort of watery maze like that of North Uist. There are only a few of the narrow, straight, valley lochs, so familiar on the mainland of Scotland, and those are in the southern mountainous part of the island; the majority are small, roundish, or relatively broad, and the larger ones of extremely irregular form. It was only possible to survey a small proportion of the numerous lochs, thirty altogether being sounded.

Five of the lochs exceed 2 miles in length. Loch Langavat is by far the longest, exceeding 7 miles, and in superficial area is about four times as great as any other loch. It is, however, exceeded in volume by Loch Suainaval, which contains 2843 millions of cubic feet. Loch Suainaval is also by far the deepest loch, exceeding 200 feet in maximum depth, while no other loch exceeds 100 feet. Five lochs, Langavat, Scaslavat, Grunavat, Benisval, and Raonasgail, approach 100 feet in depth. The mean depth of Loch Suainaval is 108 feet, no other loch exceeding 35 feet. Combining the areas of all the lochs, the extent of fresh water surveyed amounts to nearly 10 square miles, the volume of water to 7400 millions of cubic feet.

The thirty lochs of Lewis surveyed are contained in seventeen distinct basins, draining independently into the sea. Twelve of these basins contain only one loch which was surveyed; three contain two lochs; the Thamanabhaidh basin contains four lochs; the most extensive basin surveyed is the Laxey basin, with its eight lochs. Many extensive basins were not visited at all.

There follows a table of the seventeen basins and the lochs contained in them:—

<i>Basins.</i>	<i>Lochs.</i>
1 Seaforth	Skebacleit.
2 Amhuinn Mhor	Strandavat.
3 Laxey	Valtos, nam Faioleag, Trealaval, Fadagoa, Cuil Airidh a' Flod, Airidh na Ceardaich, nan Deaspoirt, Dhomhnuill Bhig.
4 Creed	a' Chlachain, Vatandip.
5 Bayhead	Airidh na Lic.
6 Barvas	More Barvas.
7 Ereray	Urrahag, Bruadale.
8 Bragor	an Duna.
9 Shawbost	Raoinavat.
10 Langavat	Langavat.
11 Gisla	Grunavat.
12 Amhuinn a' Chla- chain Mòire	Morsgail.
13 Forsa	Stacsavat, Suainaval.
14 Caslavat	Raonasgail.
15 Scaslavat	Scaslavat.
16 Thamanabhaidh	Dibadale, na Craobhaig, Crò Criosdaig, Benisval.
17 Bodavat	Bòdavát.

*Loch Skebacleit* (see Plate LXXVIII.) is a very narrow loch, in shape like the letter T, in the district of Paire, and a short distance east of the head of Loch Seaforth. The surrounding land is low, except on the south, where the hill rises to over 1000 feet. The body of the inverted  $\perp$  runs north and south, the cross-stroke east and west. The length, measured in a straight line, is nearly  $1\frac{1}{2}$  miles. The portion of the lake running east and west is  $1\frac{1}{4}$  miles long by one-fifth of a mile broad in the centre; the portion running north and south is 1 mile long and a quarter of a mile broad near the north end. The southern portion forms a simple basin with sides sloping gently to a depth of 26 feet opposite the northern branch. Where this branch goes off is a marked constriction, with a depth of only 3 feet. For half a mile northwards the bottom is uneven, and the greatest depth 15 feet. The expanded north end is a small basin of greater depth, deepest along the west side, where the maximum of 43 feet is found in a narrow arm running to the north-west. The area is about 194 acres, the mean depth 15 feet, and the volume 128 millions of cubic feet. The area draining into the loch measures 7 square miles. Glen Ouirn river enters the east end of the loch. The Seaforth river issues from the west end, and, after a winding course of half a mile, enters the head of Loch Seaforth. The level on the date of the survey (August 12, 1903) was 35.05 feet above sea-level.

The temperature at the surface was  $59^{\circ}0$  Fahr., at 25 feet  $59^{\circ}0$ , and at 40 feet  $58^{\circ}9$ .



a straight line from north to south, is  $1\frac{1}{3}$  miles, and the greatest breadth scarcely half a mile. The loch is shallow throughout, slightly deeper near the two expanded ends, in the southern of which is a depth of 20 feet, and in the northern the maximum of 25 feet. The mean depth is nearly 9 feet, the area about 131 acres, and the volume 49 millions of cubic feet. The drainage area is nearly 4 square miles in extent. Several large burns come down from the ridge to the west. The discharge is by the Amhuinn Mhor, a mile long, eastward into the head of Loch Erisort. On the date of the survey (August 5, 1903) the surface was 47·9 feet above sea-level.

The temperature varied 2° from surface to bottom: surface, 58°·0 Fahr.; 15 feet, 56°·4; and 23 feet, 56°·0.

*Loch Valtos* (see Plate LXXX.) is a small loch to the west of Laxey, on the north side of Loch Erisort. The surrounding land is low. In form it is narrow, with the axis curved and running south-west to north-east, while a narrow arm runs south-east from the middle of the loch. The length is two-thirds of a mile, and the greatest breadth, measured into the south-eastern branch, over a quarter of a mile. There is a constriction one-fifth of a mile from the west end of the loch, in which is the maximum depth, 27 feet. East of the constriction it is shallow, the greatest depth being 13 feet—the little round western basin is slightly deeper, 21 feet close to the north shore. The mean depth is over 7 feet, the area about 51 acres, and the volume 16 millions of cubic feet. The drainage area, which is that of the whole Laxey basin, is 22 square miles. The river Laxey just touches the northern extremity of the loch, and there are no other feeders of any size. On the date of the survey (August 15, 1903) the surface was 24·05 feet above sea-level.

The temperature at the surface was 59°·2 Fahr., at 15 feet 58°·0, and at 27 feet 57°·6:

*Loch nam Faoileag* (see Plate LXXX.) is a small but relatively broad loch immediately to the east of Loch Trealaval. It lies amid low moorland, at the same level as Loch Trealaval, and is commonly regarded as a portion of that loch. In form it is oblong, with very undulating shores, and measures two-thirds of a mile from east to west by one-third of a mile broad. The loch is shallow, in the central part almost flat and about 10 feet deep, the two small depressions of greater depth, 21 and 22 feet respectively, being close to the shore and at opposite ends of the loch. The mean depth is about 9 feet, the area about 100 acres, and the volume 38 millions of cubic feet. The drainage area of 17 square miles includes Loch Trealaval, Loch Fadagoa, and numerous smaller lochs. There is scarcely any inflow except through Loch Trealaval. The large river Laxey flows out from the north-east corner.

*Loch Trealaval* (see Plate LXXX.) is a large loch of very irregular form, lying about 2 miles north of Balallan on Loch Erisort. The sur-

rounding moor is low, with slight hills on the west and south-west. It is a maze of ramifying channels, promontories, and islands, similar to Loch Scadavay in North Uist, but much less extensive. After Loch Langavat it is the longest loch in the island, measuring nearly 3 miles, with a maximum breadth of half a mile. On the whole it is very shallow, having the low mean depth of 9 feet. There are many little depressions, separated by shallows, and many large and small islands and boulders further increase the irregularity of the contours. The two westernmost expansions of the loch have depths of 26 and 28 feet respectively. The maximum depth of 35 feet is close to the west shore, north-west from Eilean nan Uan. The superficial area, about 388 acres, is exceeded by only two lochs, Langavat and Suainaval; the volume, 156 millions of cubic feet, is equal to that of Loch Fadagoa, and is exceeded by four lochs, Langavat, Suainaval, Grunavat, and Benisval. The drainage area, which includes Loch Fadagoa and the two smaller lochs Airidh, amounts to  $16\frac{1}{2}$  square miles. The river Lag na Linne, which enters at the northern extremity of the loch, conveys the overflow of many lochs on the southern slope of the hills Beinn nan Surrag and Eitshal. A considerable, though very short, stream also enters from Loch Fadagoa, at the western extremity. The communication with Loch Faoileag is by a channel nearly 100 yards wide and only 1 foot deep. Loch Faoileag, from which the river Laxey issues, though here treated as a separate loch, might be regarded as a part of Loch Trealaval. On the date when surveyed (August 8, 1903) the surface was 88.5 feet above sea-level. The temperature at the surface was  $57^{\circ}3$  Fahr., and at 25 feet  $57^{\circ}4$ .

*Loch Fadagoa* (see Plate LXXX.) is a fairly large narrow loch between Lochs Trealaval and Langavat. The surroundings are low moorland, except on the south, where there is a hill of moderate elevation. The outline is extremely irregular, with many constrictions and expansions, and there are many small islands. The length, from north to south, is a little over 2 miles; the breadth, measured into the narrow prolongation which runs eastward towards Loch Trealaval, is nearly a mile. In correspondence with the irregular outline the bottom is very uneven, and there are five separate depressions over 20 feet in depth. The largest of these is in the southern triangular portion of the loch, and includes the maximum depth of 46 feet. A small hollow in the centre of the loch has a depth of 39 feet, and the northernmost depression a depth of 36 feet. The eastern extension is shallow, the greatest depth being 8 feet. The mean depth is over 11 feet, the area nearly half a square mile, and the volume 156 millions of cubic feet, exactly the same as that of Loch Trealaval. The drainage area exceeds 3 square miles. It includes many small lochs, the most important being a chain of three, leading westward to Loch nan Eilean. The outflow is by a stream only about 200 yards long, with a fall of 6 feet to Loch Trealaval. On the date of the survey

(August 11, 1903) the surface was 95.2 feet above sea-level. The temperature was uniform at 58°·0 Fahr., identical readings being recorded at the surface, 20 feet, and 40 feet.

*Loch Cuil Airidh a' Flod* (see Plate LXXX.) is a small narrow loch of irregular form, being really an inlet from Loch Trealaval on its south side. It is nearly a mile in length, and a quarter of a mile in maximum breadth. It is shallow, with a maximum depth of 9 feet and a mean depth of 4½ feet. The superficial area is about 61 acres, and the volume of water 12 millions of cubic feet. The drainage area, including Loch Airidh na Ceardaich, is scarcely 1 square mile. At the north end it joins Loch Trealaval by a broad channel, and is connected with Loch Airidh na Ceardaich, which is very slightly higher in level, at the south end.

*Loch Airidh na Ceardaich* (see Plate LXXX.) is a small loch to the south of Loch Trealaval, with which it communicates through Loch Cuil Airidh a' Flod. It is of very irregular shape. The length is scarcely two-thirds of a mile, and the greatest breadth a quarter of a mile. The maximum depth is 22 feet, and the mean depth 6 feet. The area is about 36 acres, and the volume 9 millions of cubic feet. The area drained measures one-fifth of a square mile. When surveyed, the surface was only an inch higher than Loch Cuil Airidh a' Flod, with which it is connected at the south-western extremity.

*Loch nan Deaspoirt* (see Plate LXXX.) is a small triangular loch between Balallan and Laxey, on the north shore of Loch Erisort. To north and south many little hills rise from 100 to 200 feet above the loch. The length from north-west to south-east is three-quarters of a mile, and the greatest breadth, at the extreme south end, a quarter of a mile. It is a simple basin, increasing in depth from north-west to south-east, to the maximum of 56 feet, a quarter of a mile from the lower end. The depth continues over 40 feet to close to the south end. The mean depth is 21 feet, the area about 55 acres, and the volume 50 millions of cubic feet. The drainage area, including Loch Dhomhnuill Bhig, is a little over a square mile. A small burn, a quarter of a mile long, comes from Loch Dhomhnuill Bhig, and a similar burn goes east to the head of Loch Valtos. The level was 59.2 feet on August 14, 1903. The temperature at the surface was 58°·0 Fahr., at 25 feet 58°·0, and at 48 feet 57°·0.

*Loch Dhomhnuill Bhig* (see Plate LXXX.) is a small narrowly triangular loch, about 1 mile to the north of Loch Erisort. The low hills bordering the loch rise to between 200 and 250 feet, or over 150 feet above the surface. The length from north-west to south-east is a little over half a mile, the maximum breadth, at the south end, a quarter of a mile. The loch is shallow, being 4 feet in the middle, and deepening to 8 feet near

the lower end, and 9 feet near the upper end. The mean depth is nearly 4 feet, the area 43 acres, and the volume, 7 millions of cubic feet, shows it to be the smallest loch surveyed in Lewis. A small burn flows east to Loch nan Deaspòirt. The height above sea-level was 82·9 feet on August 14, 1903.

*Loch a' Chlachain* (see Plate LXXXI.) is a narrow loch about 4 miles west of Stornoway, the land surface on which it lies rising gradually to the west. In form it is narrow and oblong, measuring fully half a mile in length from east to west, and one-fifth of a mile in breadth. It is shallow and nearly flat-bottomed, with only a very small area near the east end over 10 feet deep, and the maximum 11 feet. The mean depth is  $5\frac{1}{2}$  feet, the area 45 acres, and the volume 11 millions of cubic feet. The drainage area is extensive, including the whole upper waters of the Creed and several lochs, and measures 12 square miles. The loch is an expansion of the Creed, which flow in at the west end, and out at the east. The surface was 211·6 feet above sea-level on July 10, 1903. The temperature at the surface was  $56^{\circ}\cdot 9$  Fahr., and at 10 feet  $56^{\circ}\cdot 8$ .

*Loch Vatandip* (see Plate LXXXI.) is a small narrow loch 4 miles west of Stornoway. The hills to north and south rise about 100 feet above the loch. The length from east to west is exactly a mile, and the greatest breadth one-fifth of a mile. It is a simple, shallow, and even basin, the 10-foot contour closely following the shore, the bottom nearly flat, and the maximum depth of 17 feet near the east end. Very narrow for two-thirds of its length, it expands, one-third of a mile from the west end, into a triangular portion. The mean depth is 10 feet, the area about 64 acres, and the volume 27 millions of cubic feet. The drainage area is less than half a square mile. From the west end a small burn flows west into the river Creed. When surveyed on July 11, 1903, the surface was 275·9 feet above sea-level.

*Loch Airidh na Lic* (see Plate LXXXII.) is a small narrow loch,  $1\frac{1}{2}$  miles west of Stornoway. Low hills lie to north and south: on the south some 100 feet, on the north 150 feet, above the level of the water. It measures three-quarters of a mile from east to west, and one-sixth of a mile in greatest breadth, near the lower end. The bottom is regular and even, the sides sloping gently to the middle, and the depth gradually increasing from west to east, with the maximum of 19 feet near the outflow. The mean depth is 9 feet, the area about 47 acres, and the volume 19 millions of cubic feet. The area draining into the loch is nearly 3 square miles, a considerable stream, the Amhuinn a' Ghlinn Mhòir, flowing in at the west end. The Bayhead river flows out eastward through the town of Stornoway. The level of the loch on the date of the survey, July 9, 1903, was 178·7 feet. The surface temperature was  $55^{\circ}\cdot 8$  Fahr., at 15 feet  $55^{\circ}\cdot 7$ .

*Loch More Barvas* (see Plate LXXXII.) is a broad sheet of water, lying close to the sea-shore, near Barvas on the west coast, in a broad stretch of low country. It is a mile long from west to east, and half a mile broad. It is flat-bottomed, and very shallow, with a maximum depth of 8 feet, and a mean depth of  $4\frac{1}{3}$  feet. The superficial area is about 239 acres, and the volume of water 45 millions of cubic feet. It drains an area of 33 square miles, chiefly by Glen Barvas. It is separated from the sea by a mere sandbar, and when surveyed on August 22, 1903, was only 9·7 feet above sea-level. The surface temperature was  $53^{\circ}\cdot 1$  Fahr.

*Loch Urrahag* (see Plate LXXXIII.) is a loch of moderate size, between Barvas and Bragor, a little more than a mile from the shore. The surrounding land nowhere rises far above the loch. It is roughly hammer-shaped, with a narrow stem running north and south, and an expanded northern portion. It is  $1\frac{1}{4}$  miles long, and fully half a mile broad near the north end. It is a simple basin, shallow in the south, and gradually deepening northward to the maximum of 33 feet in the centre of the expanded portion. The mean depth is  $11\frac{1}{2}$  feet, the area about 211 acres, and the volume 105 millions of cubic feet. The drainage from  $7\frac{1}{2}$  square miles of country enters the loch chiefly from Glen Bruadale, through Loch Bruadale, which is only cut off from Loch Urrahag by a causeway. The outflow is by Glen Ereray, past several mills, into Loch Ereray.

The surface was 89·3 feet above sea-level on August 20, 1903. The temperature was  $55^{\circ}\cdot 4$  Fahr. throughout.

*Loch Bruadale* (see Plate LXXXIII.) is a small loch close to the south of Loch Urrahag, amid low country. It is half a mile long, one-third of a mile broad, flat-bottomed, and shallow—only 6 feet deep over the greater part of the area. The mean depth is  $4\frac{1}{2}$  feet, the area about 66 acres, and the volume 13 millions of cubic feet. It receives the drainage of 6 square miles of country, including the large Loch Breivat, chiefly brought by the Glen Bruadale river.

It is scarcely separated from Loch Urrahag, and the level was only 3 inches higher, or 89·5 feet above sea-level, on August 20, 1903.

*Loch an Dùna* (see Plate LXXXIV.) is a small broad loch in Bragor, about a mile from the coast. It is roughly rhomboid in shape, with a narrow arm running westward. It is half a mile long, by one-third of a mile broad. The basin is simple and deepens towards the east, where the maximum of 29 feet is found near the east shore. The mean depth is 13 feet, the area about 71 acres, and the volume 41 millions of cubic feet. The area drained is very limited, less than a square mile. The outflow is by the Allt na Muilne, flowing north past several mills into Loch Ordais. The surface was 97·6 feet above sea-level on August 22, 1903.

*Loch Raoinavat* (see Plate LXXXIV.) is a small loch about 3 miles north-east of Carloway, on the west coast, on a land surface gently rising towards the south. It is three-quarters of a mile long, from east to west, and a quarter of a mile broad at the extreme west end. It is narrow at the east end, and expands and deepens westward. A very small area, exceeding 50 feet in depth, with the maximum of 61 feet, lies close to the north shore and near the west end; the mean depth is  $20\frac{1}{2}$  feet, the area about 73 acres, and the volume 65 millions of cubic feet. The drainage area is barely half a square mile. The outflow is by a small stream, which, leaving the east end of the loch, flows north past several mills, into Loch na Muilne. The surface was 109.5 feet above sea-level on August 22, 1903. The temperature only varied one-fifth of a degree from surface to bottom—surface,  $55^{\circ}8$  Fahr.; 54 feet,  $55^{\circ}6$ .

*Loch Langavat* (see Plate LXXXV.).—Loch Langavat, the most extensive body of fresh water in the island of Lewis, is centrally situated in the broadest part of the island, between Lochs Seaforth and Erisort on the east, and Lochs Resort and Little Roag on the west. The upper end of the loch lies among hills of over 1500 feet in height. The land falls towards the lower end, which borders on a broad plain, studded with innumerable lochs, stretching for miles to the north and east. In form it is very irregular—long and narrow, with undulating shore-line and zigzag axis—several constrictions and bends dividing it into distinct basins. The length, in a straight line from south-west to north-east, is  $7\frac{1}{4}$  miles; if the centre line were followed it would be much greater. The maximum breadth is three-quarters of a mile. There are three large basins of over 25 feet in depth, besides some smaller depressions. The largest and deepest basin occupies the southern section of the loch, which is  $3\frac{1}{4}$  miles long, fully half a mile broad in the centre, and is almost straight. The 25-foot contour is parallel with the shore-line, and encloses an area nearly 3 miles long. The area enclosed by the 50-foot contour is fully a mile in length, and contains two small areas over 75 feet in depth, with maxima of 97 and 98 feet respectively, separated by an elevation on which the depth is 72 feet. This large basin is separated from the next by a very narrow strait where the depth is only 9 feet. The mid basin is deepest at the south-western end, where the depth of 90 feet occurs, and shallows and contracts towards the north-east. The next bend to the east leads to the third section of the loch, which is as long and broad as the first ( $3\frac{1}{4}$  miles long and three-quarters of a mile broad), but of much more complex form, the axis curving, the shore-line much broken up, the contours irregular and interrupted by numerous islands. The largest area of over 25 feet is at the south-west end, and has a maximum depth of 40 feet; smaller areas of greater depth are found further to the north-east. In the last large expansion near the lower end of the loch is a depth of 65 feet. The mean depth is 25 feet, the superficial area  $3\frac{1}{2}$  square miles, and the

volume of water 2388 millions of cubic feet. It is the only loch in Lewis the area of which exceeds a square mile. Though four times the area of Loch Suainaval, the next to it in size, the volume is less by 450 millions of cubic feet. The drainage area measures nearly 28 square miles. The feeders are all small local streams, the largest, Glen Langadale, at the upper end of the loch. From near the northern extremity of the loch two wide channels lead into Loch Airidh na h'Airde, whence a chain of lochs, with only very short connecting streams, extends some 4 miles northward to the head of Loch Roag near Callernish. Loch Coirigerod,  $1\frac{1}{2}$  miles long, which stands at a higher level than Loch Langavat, was not surveyed.

The surface at the time of the survey (July 13 to 18, 1903) was 108·0 feet above sea-level.

*Temperature Observations.*—The following serials were taken during the survey:—

			July 16.		July 17.
Surface	...	...	56°·8	...	56°·1
20 feet	...	...	56°·2	...	56°·1
50 "	...	...	55°·4	...	56°·0
87 "	...	...	—	...	55°·1
92 "	...	...	55°·0	...	—

*Loch Grunavat* (see Plate LXXXVI.) is a fairly large loch, lying about 2 miles to the west of Little Loch Roag. Though of the narrow form of valley lochs, it does not occupy a well-marked valley. High land occurs at the ends of the loch, while the sides are comparatively low. The length is  $2\frac{1}{4}$  miles, and the greatest breadth, about the middle of the loch, half a mile. The shore-line is irregular, with several promontories and deep inlets. A large island occupies almost the exact centre of the loch. South of the island the loch is almost everywhere shallow; north of it is a simple and comparatively deep basin. The 25-foot and 50-foot contours extend a short distance south of the island, the deep channel passing between the island and the west shore. Halfway between the island and the north end is a small area over 75 feet in depth, with the maximum of 90 feet. The mean depth is 28 feet, the area about 387 acres, and the volume of water 478 millions of cubic feet. The area draining into the loch is 3 square miles; there are no inflowing streams of any size. The outflow, near the southern end of the loch, through the inlet called Loch na Ciste, which could not be entered, is by the Gisla river, flowing 2 miles eastward into Little Loch Roag. The surface was 365·4 feet above sea-level on July 28, 1903.

The temperature had a range of 6° Fahr. from surface to bottom, the readings being:—

Surface	...	...	...	...	61°·5 Fahr.
15 feet	...	...	...	...	59°·2 "
25 "	...	...	...	...	58°·0 "
50 "	...	...	...	...	56°·1 "
80 "	...	...	...	...	55°·6 "

*Loch Morsgail* (see Plate LXXXVII.) is a small broad loch near the head of Little Loch Roag. The neighbouring hills are somewhat distant, the immediate surroundings low, except southward, where Scalaval Mula rises to 850 feet. The outline is roughly rhomboid, the length a little more than half a mile from south to north, the greatest breadth one-third of a mile. The basin is simple, of moderate depth, a narrow strip of over 25 feet in depth lying west of the centre, with a maximum depth of 31 feet. The mean depth is 12 feet, the area about 65 acres, and the volume of water 35 millions of cubic feet. The drainage area is extensive, extending to 10 square miles. The principal stream entering the loch is the Amhuinn a' Lòin, conveying the drainage of the south side of Beinn Mheadhonach. The Amhuinn a' Chlachain Mhòire flows out northwards. The height of the surface above sea-level could not be measured, but is estimated at about 70 feet.

The temperature at the surface on August 3, 1903, was 60°·1 Fahr., at 15 feet 59°·1, and at 29 feet 58°·9.

*Loch Stacsavat* (see Plate LXXXVI.) is a small triangular loch intervening between Loch Suainaval and the sea at Uig. The hills on the west rise only about 100 feet above the loch; on the east they are higher, and rise steeply from the shore to 450 feet. It is three-quarters of a mile long by one-third of a mile in greatest breadth. It is a simple basin, with the 25-foot contour roughly parallel to the shore, and the maximum depth of 40 feet about the centre. The mean depth is 17½ feet, the area about 87 acres, and the volume 66 millions of cubic feet. The area drained, including Loch Suainaval, is nearly 11 square miles. On the south the river Eysleit enters from Loch Suainaval; the river Forsa, a quarter of a mile long, passes northward by a series of small waterfalls into Lòin Erista, the head of Camus Uig. The surface on the date of the survey, July 25, 1903, was 35·9 feet above sea-level.

The temperature varied more than 5° Fahr. from surface to bottom, thus:—

Surface ... ..	61°·8 Fahr.
10 feet ... ..	61°·4 „
20 „ ... ..	59°·0 „
30 „ ... ..	57°·0 „
37 „ ... ..	56°·4 „

Considering the water-supply derived from Loch Suainaval, it is remarkable that the whole series should be so much higher than that taken in Loch Suainaval on the previous day.

*Loch Suainaval* (see Plate LXXXVI.), called locally Suainavat, is a large and somewhat broad loch, situated a mile or two south-east of Uig. It occupies a narrow steep-sided valley, the hills bounding which are highest on the west, while a comparatively low ridge separates it on the

east from Loch Grunavat. An isolated hill, Suainaval, 1403 feet in height, stands at the lower end of the loch on the east side. It is one of the longest lochs in Lewis, measuring  $2\frac{2}{3}$  miles in a straight line from north to south. The greatest breadth towards the north end is a little more than half a mile.

Loch Suainaval is a simple basin, with the slope of the bottom steepest from the shore to the depth of 100 feet. The 100-foot contour closely follows the shore-line except at the ends, and the area enclosed by it is  $2\frac{1}{4}$  miles in length. From the 100-foot contour to the centre the slope is more gradual, and only two small areas exceed 200 feet in depth. The larger of these areas, in the broadest part of the loch, is one-third of a mile long by one-fifth of a mile broad, and is flat-bottomed, with a greatest depth of 212 feet. The lesser 200-foot area is a little south of the centre, is very narrow, and includes the maximum depth of 219 feet. A study of the contours shows that the loch has the U-shaped cross-section characteristic of lochs formed in valleys which have been occupied by glaciers.\* The mean depth,  $108\frac{1}{2}$  feet, is very great, more than three times that of any other loch in Lewis.

The superficial area is nearly a square mile, or about one-fourth that of Loch Langavat. The volume of water, 2843 millions of cubic feet, shows that Loch Suainaval is the greatest lake in Lewis, being 450 millions of cubic feet more than that of Loch Langavat, six times that of Loch Grunavat, and eighteen times that of Loch Trealaval or Loch Fadagoa. The drainage area amounts to nearly 10 square miles. The outflow northward to Loch Stacsavat is by the short river Eysleit, with a fall of about  $1\frac{1}{2}$  feet. The surface was 37.4 feet above sea-level on July 24, 1903, which is about a foot lower than the level found by the Ordnance Survey on October 2, 1895.

A series of temperatures taken on July 24, 1903, showed, consistently with the great depth of the loch, a greater range than was observed in any other loch in Lewis. The range from surface to bottom was  $11^{\circ}2$  Fahr., and the distribution as shown in the following table:—

Surface ... ..	57°0 Fahr.
25 feet ... ..	55°2 "
50 " ... ..	53°0 "
75 " ... ..	50°4 "
100 " ... ..	47°7 "
200 " ... ..	45°8 "

*Loch Raonagail* (see Plate LXXXVIII.) is a small loch among the high hills which lie between the south end of Loch Suainaval and the west coast. It occupies a narrow valley between Tahaval, 1688 feet, on the east, and Mealasval, 1885 feet, on the west, which rise in steep crags covered with large and small stones on either side. The loch is of oblong

\* See Collet and Johnston, "On the Formation of Certain Lakes in the Highlands," *Proc. Roy. Soc. Edin.*, vol. 26, p. 108 (1906).

form, two-thirds of a mile long from north to south, and one-fifth of a mile broad. It is a simple basin, the slope of the bottom steeper on the east side, so that the narrow area of over 75 feet in depth lies near the east shore. The maximum depth of 95 feet lies north of the centre. The mean depth is 32 feet, the area about 66 acres, and the volume 94 millions of cubic feet. The drainage area measures 2 square miles. The Amhuinn Ehid enters at the south end, and the Amhuinn Caslavat, issuing from the north end, flows some 3 miles northward into a branch of Camus Uig. The surface of the loch was 288.0 feet above sea-level on July 29, 1903.

The temperature had a range of 6° Fahr. from surface to bottom :—

Surface ...	...	...	...	...	...	59°.0 Fahr.
25 feet ...	...	...	...	...	...	56°.9 „
50 „ ...	...	...	...	...	...	53°.6 „
93 „ ...	...	...	...	...	...	53°.0 „

*Loch Seaslavat* (see Plate LXXXVIII.) is a small triangular loch close to the shore of Camus Uig at Carnis, surrounded by low hills, rising 100 to 200 feet above the loch. The length, from south-west to north-east, is over half a mile, the greatest breadth one-fifth of a mile. The basin is simple, the bottom sloping gently, except on the north-east side which is very steep, to the maximum depth of 82 feet, close to the north-east shore. The mean depth is  $34\frac{1}{2}$  feet, the area about 48 acres, and the volume 73 millions of cubic feet. The drainage area is less than half a square mile. The outflow is by an insignificant stream, which flows for a quarter of a mile northward into a branch of Camus Uig. The surface was 122.9 feet above sea-level on July 29, 1903.

*Loch Dibadale* (see Plate LXXXVII.) is a small narrow loch lying between Loch Suainaval and Loch Resort. It is situated in a corrie between the two hills, Mula Chaolartan and Tamanaival (1530 feet). It measures two-thirds of a mile from north-west to south-east, and one-sixth of a mile in greatest breadth. It is a simple basin and relatively deep, deepest in the southern half, with the maximum, 61 feet, somewhat south of the centre. The mean depth is 28 feet, the area about 42 acres, and the volume 51 millions of cubic feet. The drainage area is  $1\frac{1}{2}$  square miles in extent. The Amhuinn Ghlasleit flows out from the south end and joins the Amhuinn Thamanabhaidh. Loch Dibadale lies at a considerable elevation, 416.8 feet above sea-level on July 31, 1903.

Temperatures in the deepest part gave :—

Surface ...	...	...	...	...	...	56°.5 Fahr.
25 feet ...	...	...	...	...	...	56°.3 „
55 „ ...	...	...	...	...	...	53°.0 „

*Loch na Craobhaig* (see Plate LXXXIX.) is a loch of moderate size, forming the lowest of the chain of lochs draining into Loch Thamanabhaidh, to the north of Loch Resort. The hills bounding the valley in which it

lies are much higher on the north side. On the flat southward towards Loch Bodavat are numerous small lochans. The length from west to east is a mile, the greatest breadth, at the west end, nearly half a mile. The main part of the loch is a simple basin, with the maximum depth, 50 feet, near the west shore. A narrow shallow arm, 13 feet deep at the mouth (greatest depth within 8 feet), runs one-third of a mile eastward and receives the burn from Loch Cro Criosdaig. The mean depth is nearly 17 feet, the area about 128 acres, and the volume 93 millions of cubic feet. It drains an area of 6 square miles, including Lochs Cro Criosdaig and Benisval, from which its water is chiefly derived. It discharges by Amhuinn Thamabhaidh westward into the sea-loch of the same name. The surface was 199·4 feet above sea-level on August 4, 1903. The temperature varied nearly 4° Fahr. from surface to bottom :—

Surface ...	...	...	...	...	...	59°·0 Fahr.
25 feet ...	...	...	...	...	...	59°·0 „
35 „ ...	...	...	...	...	...	58°·6 „
40 „ ...	...	...	...	...	...	58°·0 „
45 „ ...	...	...	...	...	...	57°·2 „
49 „ ...	...	...	...	...	...	55°·2 „

*Loch Cro Criosdaig* (see Plate LXXXIX.) is a small loch on the stream connecting Loch Benisval with Loch na Craobhaig, to the north of Loch Resort. To the south the hills rise 100 feet above the surface, towards Loch Benisval, northward they rise more gradually to Beinn Mheadhonach, 1303 feet. In form it is irregular, measuring four-fifths of a mile from west to east, with a maximum breadth of one-third of a mile. It is a shallow basin, nearly two-thirds of the area being covered by less than 10 feet of water, and deeper towards the east, where there are two little holes 20 and 21 feet in depth. The mean depth is 9 feet, the area about 80 acres, and the volume 31 millions of cubic feet. It drains an area of 3 square miles, including Loch Benisval, and overflows by the Amhuinn Uidh Phail, 300 yards long, westward to Loch na Craobhaig. The surface was 229·8 feet above sea-level on August 1, 1903.

*Loch Benisval* (see Plate LXXXIX.) is a broad sheet of water about half a mile north of Loch Resort, near the head of that loch. Low hills surround the loch, rising from 50 to 300 feet above the surface, the highest being Benisval, to the south-east, 624 feet in height, or 350 feet above the loch. The main loch is of oblong form, with a narrow prolongation to the south-east. It is three-quarters of a mile long, measured in a straight line from north to south, and half a mile broad. It is a simple and relatively deep basin, with sides most steeply sloping along the base of Benisval, and the maximum depth, 95 feet, near the east shore. The northern end, where are many small islands, is shallow. Only two lochs, Langavat and Suainaval, are deeper, and Loch Raonagail is of the same depth. The mean depth of nearly 35 feet is exceeded only by Loch Suainaval and equalled

by Loch Scaslavat. The area is about 172 acres, and the volume 260 millions of cubic feet. It receives only local drainage from an area of scarcely 1 mile square, and discharges northward by the Amhuinn Benisval, a quarter of a mile long, into Loch Cro Criostaig. The height above sea-level was 278·0 feet on August 3, 1903.

A series of temperatures showed a range of  $3\frac{1}{2}^{\circ}$  Fahr. from surface to bottom :—

Surface ... ..	58°·2 Fahr.
25 feet ... ..	58°·0 „
50 „ ... ..	55°·2 „
90 „ ... ..	54°·8 „

*Loch Bodavat* (see Plate LXXXIX.) is a small loch to the north of Loch Resort, into which it drains by a stream about a mile long. The hills to the north-west rise some 300 feet, those on the south-east 200 feet, above the loch. In form it is narrow, with a sigmoid curvature, and measures nearly a mile from north-east to south-west in a straight line between the ends. The greatest breadth near the centre is a quarter of a mile. The basin is simple, deepest in the middle, with the maximum of 46 feet a little east of the centre. The mean depth is 13 feet, the area about 91 acres, and the volume 50 millions of cubic feet. It receives the drainage of an area of  $1\frac{1}{3}$  square miles. The outflow is from the south-west corner of the loch. The surface was 179·6 feet above sea-level on August 1, 1903.

The range of temperature from surface to bottom was  $5^{\circ}$  Fahr. :—

Surface ... ..	60°·0 Fahr.
20 feet ... ..	59°·0 „
30 „ ... ..	58°·6 „
35 „ ... ..	55°·7 „
40 „ ... ..	55°·0 „

From the following table it will be seen that in the thirty lochs under consideration 2896 soundings were taken, and that the aggregate area of the water-surface is  $9\frac{2}{3}$  square miles, so that the average number of soundings per square mile of surface is 300. The aggregate volume of water contained in the lochs is estimated at 7409 millions of cubic feet. The area drained by these lochs is 152 square miles, or nearly sixteen times the area of the lochs.

## SUMMARY TABLE.

Giving Details concerning the Lochs in Lewis.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. Feet.	Mean. Feet.	Mean per cent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
Skebacleit	35.05	138	2.00	0.26	0.15	7.5	43	15.21	35.40	246	694	128	0.30	7.20	24.0
Strandavat	47.90	99	1.36	0.46	0.15	11.0	25	8.61	34.40	287	834	49	0.21	3.78	18.0
Valtos	24.05	48	0.64	0.30	0.12	19.4	27	7.40	27.40	125	457	16	0.08	21.93	274.1
nam Faoilcag	88.50	48	0.62	0.44	0.25	40.8	22	8.69	39.50	377	377	38	0.16	17.02	106.4
Trealaval	88.50	217	2.90	0.50	0.21	7.2	35	9.22	26.30	437	1662	156	0.61	16.54	27.1
Fadsgoa	95.20	150	2.60	0.40	0.18	7.1	46	11.70	25.43	298	1173	156	0.48	8.17	6.6
Cuil Airidh a' Flod	88.50	36	0.94	0.23	0.10	10.6	9	4.50	50.00	551	1102	12	0.10	0.81	8.1
Airidh na Ceardaich	88.50	25	0.60	0.22	0.10	16.7	22	5.86	26.20	144	541	9	0.06	0.21	3.5
nan Deaspoirt	59.20	53	0.74	0.26	0.12	15.6	56	20.82	37.20	70	188	50	0.09	1.15	12.8
Dhombhnuill Bhig	82.90	36	0.60	0.26	0.11	18.7	9	3.90	43.30	458	812	7	0.07	0.59	8.4
a' Chlachain	211.60	65	0.62	0.18	0.11	17.7	11	5.52	50.20	298	593	11	0.07	11.92	170.3
Vatandip	275.90	80	1.00	0.21	0.10	10.0	17	9.85	57.90	311	586	27	0.10	0.43	4.3
Airidh na Lic	178.70	78	0.76	0.16	0.10	12.6	19	9.21	48.50	211	436	19	0.07	2.84	40.6
More Barvas	9.70	58	1.04	0.52	0.36	34.6	8	4.33	54.10	686	1268	45	0.37	32.79	88.6
Urrahag	89.30	89	1.24	0.56	0.26	21.0	33	11.49	34.80	198	570	105	0.33	7.50	22.7
Bruadale	89.50	33	0.54	0.32	0.19	35.2	6	4.46	74.30	475	901	13	0.10	6.20	62.0

an Dùna	...	97.60	51	0.44	0.32	0.25	56.8	29	13.12	45.20	80	177	41	0.11	0.73	6.6
Raoinavat	...	109.50	56	0.76	0.26	0.15	19.7	61	20.56	33.70	66	195	65	0.11	0.44	4.0
Langavat	...	108.00	565	7.86	0.75	0.44	5.6	98	24.79	25.90	423	1674	2388	3.45	27.59	8.0
Grunavat	...	365.40	124	2.26	0.50	0.27	11.9	90	28.86	31.50	133	421	478	0.60	3.05	5.1
Morsgail	...	[about 70]	66	0.66	0.32	0.15	22.7	31	12.83	39.80	122	283	35	0.10	10.31	103.1
Stacsavat	...	35.90	84	0.72	0.38	0.19	96.2	40	17.43	43.60	95	218	66	0.14	10.90	77.8
Suainaval	...	37.40	127	2.68	0.56	0.35	13.1	219	108.60	49.60	65	130	2843	0.94	9.65	10.3
Raonasgail	...	288.00	53	0.64	0.22	0.16	25.0	95	32.37	34.10	35	104	94	0.10	2.07	20.7
Scaslavat	...	122.90	46	0.62	0.22	0.12	19.4	82	34.65	42.30	40	95	73	0.08	0.43	5.4
Dibadale	...	416.80	77	0.66	0.16	0.11	16.7	61	27.77	45.50	57	122	51	0.07	1.28	18.3
na Craobhaig...	...	199.40	84	1.00	0.40	0.20	20.0	50	16.63	33.30	106	317	93	0.20	5.92	29.6
Cro Criosdaig	...	229.80	78	0.80	0.30	0.15	18.7	21	8.80	41.90	201	480	31	0.13	2.97	22.8
Benisval	...	278.00	137	0.70	0.50	0.38	54.3	95	34.68	36.50	39	107	260	0.27	0.96	3.6
Bodavat	...	179.60	95	0.96	0.22	0.15	15.6	46	12.61	27.40	110	402	50	0.14	1.30	9.3
			2896										7409	9.64	151.98*	15.8

\* The drainage area of Loch Valtos includes those of Lochs nam Faoileag, Trealaval, Fadagaa, Cuil Airidh a' Flod, Airidh na Ceardaich, nan Deaspoirt, and Dhomhnull Bhig; that of Loch a' Chlachain includes that of Loch Vatandip; that of Loch Urrahag includes that of Loch Bruadale; that of Loch Stacsavat includes that of Loch Suainaval; and that of Loch na Craobhaig includes those of Lochs Cro Criosdaig and Benisval.

## THE LOCHS OF ORKNEY.

THE Mainland of Orkney possesses many fine lochs. The land surface consists of a series of low dark-topped hills, none reaching 1000 feet in height, between which are broad stretches of level or gently undulating moorland, now in great part under cultivation. In correspondence with this conformation of the land, and the absence of narrow valleys, the lochs occupying the hollows are all relatively broad, and they are without exception shallow and flat-bottomed. The two very large bodies of water, the Lochs of Stenness and Harray, which ramify into the very heart of the island, are subject to the influence of the tides, though their level is but slightly affected.

In the mountainous islands of Hoy and Rousay there are narrow valley lochs of greater depth than any on the Mainland. On the other islands of the group, which are quite low, there are only a few unimportant lochs, which were not surveyed. In the three islands visited (see Index Map, Fig. 24) fourteen lochs were surveyed. The largest, in every respect, is the Loch of Harray; the Loch of Stenness is little inferior in size, but all the others are much smaller. The deepest loch on the Mainland, the Loch of Stenness, 17 feet in depth, is slightly exceeded in depth by the Muckle Water in Rousay, but by far the deepest loch surveyed is the little Hoglinns Water in Hoy, which is 57 feet deep. The combined superficial areas of all the lochs surveyed amounts to 10 square miles, and the area draining into these lochs exceeds 90 square miles.

The Island of Hoy is the most mountainous of the Orkneys. With the exception of the Peninsula of South Walls, joined to the main island merely by a causeway, the island consists of one mountainous mass, rising from south to north, where it culminates in three peaks of over 1300 feet in height, separated by deep glens which cut right across the island. The central peak, the Ward hill, 1564 feet in height, is the highest point in Orkney, and even exceeds the highest hill in Shetland (Ronas hill, 1475 feet) by nearly 100 feet. On the southern slope of the island are several lochs, which, from their highland situation, might be expected to be deeper than the lochs in the plains of Pomona. That this is in fact the case can be definitely stated of one little loch, the Hoglinns Water, the survey of which, begun by the Lake Survey, was completed by Mr. William Marwick, who found a depth of 57 feet. The largest loch in Hoy, the Heldale Water, about a mile in length, was not surveyed.

The only extensive basin in the islands is the Harray basin, which drains 60 square miles of country, and includes five lochs which were surveyed. Lochs Hundland and Boardhouse are in one basin, the Muckle and Peerie Waters in Rousay are in another; all the other lochs drain independently into the sea. The lochs surveyed thus fall into eight distinct



FIG. 24.—INDEX MAP OF THE ORKNEY ISLANDS.

basins. The shores of all the lochs slope at a very low angle, and are paved with flat stones, so that approach to the shore in a boat was usually difficult, except at spots artificially deepened.

Though some of the lochs were partly overgrown with weeds, very commonly the bottom was free from weeds, and could be seen in the deepest parts. The paving of flat stones could be seen to continue all

over, and despite the great amount of organic *débris* resulting from the myriads of animals and plants living in the water, as well as sediment brought in by the streams, the stones were clean, or there was only a thin slimy film due to the growth of diatoms and other algæ. How is the clean paved bottom and the absence of peaty deposit so general at the bottoms of these lochs to be accounted for? Is all the sediment derived from every source carried off by the ordinary slow current of the loch, and is the paved bottom an original and permanent feature? It does not accord with experience of shallow lochs elsewhere to suppose this. Such lochs commonly silt up, and become overgrown with weeds, and are converted eventually into marshes. If these lochs of Orkney are silting up in the usual way, why the clean bottom and freedom from deposit? An explanation may be found in supposing that the lochs are violently agitated to the very bottom during gales, the stones re-arranged on the top of the latest formed mud, and the material in suspension in the water carried off during spates.

*Loch of Stenness* (see Plate XC).—The Loch of Stenness is a large sheet of salt water, measuring nearly 4 miles long and  $1\frac{1}{2}$  miles broad, and is about 2 miles north-east of the town of Stromness. The surrounding heather-clad moorland abounds in monuments of ancient peoples. In places the action of the waves has worn the shores into very low cliffs of rock or gravel, but in general the slope is gentle to the water's edge. The axis of the loch runs north-west to south-east, with a slight sigmoid curvature. The greatest breadth is in the centre, where a broad bay running to the south-west branches into arms running to north-west and south-east. In the southern bay the tide enters from the Bay of Ireland, under the Bridge of Waith. Though the channel is broad, and the access free, the level of the loch is but little affected by the tides, which indicates that the bar is but little below ordinary high-water level. At the eastern extremity the loch communicates with the Loch of Harray, under the Bridge of Brogar. During the whole of our stay in the islands the two lochs never differed measurably in level, though a current could be seen in one direction or the other. Marine algæ grow throughout the loch, and the fauna is marine.

The Loch of Stenness is flat-bottomed, and has a mean depth of  $10\frac{1}{2}$  feet, and a maximum depth of 17 feet, near the south-eastern extremity. The superficial area is  $2\frac{1}{2}$  square miles, and the volume of water 716 millions of cubic feet. The drainage area, including the Loch of Harray and many small lochs, measures 60 square miles. Apart from the inflow at the Bridge of Brogar, only a few small burns enter the loch. The surface at the date of the survey (August 19, 1903) was 3·6 feet above sea-level. Sir Walter Scott refers to both lochs (Stenness and Harray) as the Loch of Stenness.

The surface temperature on August 19, 1903, was  $58^{\circ}0$  Fahr., and on August 20,  $60^{\circ}2$ .

*Loch of Harray* (see Plate XC.).—The Loch of Harray, the largest in the islands, lies immediately to the north of the Loch of Stenness. The axis runs nearly north and south. The southern portion is elongate, with undulating shore-line; the northern part bifurcates into two broad inlets, giving the whole loch the approximate form of the letter Y. The surrounding land is undulating and everywhere low. The east side is principally farmland—there are extensive wet meadows (as at Kirk Ness)—moorland, and here and there low cliffs of gravel or rock. The Bridge of Brogar is built on the rocky barrier separating the Loch of Harray from the Loch of Stenness. The length, measured in a straight line, is  $4\frac{2}{3}$  miles, and the greatest breadth  $1\frac{3}{4}$  miles. The mean breadth is three-quarters of a mile. There are many islands, extensive shoals, and isolated stones. The bottom is flat, and the mean depth is about 9 feet. The greatest depth, 14 feet, occurs nearly in the narrowest part of the loch. The superficial area is  $3\frac{3}{4}$  square miles, and the volume of water 951 millions of cubic feet.

The area of country draining into the loch is about 45 square miles. The largest streams are the Burn of Hourston, draining several small lochs, and entering the Loch of Harray at the north end, and the Burn of Netherbrough, flowing in at the east side. The outflow at the Bridge of Brogar is, in certain states of the tide, converted into an inflow. There was always a current out or in during the survey, but there was never a measurable difference of level. The surface was 3·6 feet above sea-level on August 21, 1903. The temperature was 55°·0 Fahr. both at the surface and at a depth of 14 feet.

Though there is a free ingress of water from the Loch of Stenness, and the shores of that loch are overgrown by marine algæ close up to the Bridge of Brogar, the brackish water entering the Loch of Harray appears to be insufficient to have much effect on its biology. No sea-weeds were seen on the east side of the Bridge, the water was fresh to the taste, and the ordinary fresh-water plankton animals were present.

*Loch of Bosquoy* (see Plate XC.).—A small loch of rhomboid form near the north-east corner of the Loch of Harray, into which it drains by a short mill stream controlled by a sluice. It is surrounded by boggy meadowland. There are many islets of reeds in the western part of the loch. The length is two-thirds of a mile, and the breadth nearly one-third of a mile. The greatest depth is 5 feet near the north shore and east end. There is a considerable flat-bottomed area 4 feet deep. The mean depth is  $2\frac{1}{2}$  feet, the area about 65 acres, and the volume 7 millions of cubic feet. There is a considerable drainage area ( $3\frac{1}{4}$  miles) chiefly on the Hill of Milldoe (734 feet) on the east, from which the Corrigal burn flows. Where it enters the loch the stream is known as the Burn of Layaw. The level was estimated at 36 feet above sea-level.

*Loch of Sabiston* (see Plate XCI.).—This small loch in the Harray basin, also known as the Loch of Housby, lies  $1\frac{1}{2}$  miles north of the

Loch of Harray. It is surrounded by a boggy flat, except on the north, where the Hill of Greenay rises. Rock is seen at several points on the north-east shore. The length is fully half a mile, and the breadth fully a quarter of a mile. The bottom is flat, with a maximum depth of 3 feet, and a large area of this same depth. The north-west corner is filled with reeds. The mean depth is  $1\frac{1}{2}$  feet, the area about 77 acres, and the volume 5 millions of cubic feet. The drainage area measures fully 3 square miles. The outflow is westward by a small stream, utilized as a mill stream, into the Burn of Warth. The surface was 51.7 feet above sea-level on September 6, 1906.

*Loch of Isbister* (see Plate XCI.).—A small loch, square or somewhat cruciform in shape, near the Church of Twatt, and  $1\frac{1}{2}$  miles south of the Loch of Boardhouse. It is surrounded by extensive boggy flats, especially to the west, so that a rise of even a foot in level would greatly extend the area of the loch. It is extremely shallow, and much obstructed by stones. The length from north to south is nearly two-thirds of a mile; the breadth from east to west is a little less. The greatest depth, 3 feet, is at the east end. The mean depth is  $1\frac{1}{2}$  feet, the area about 80 acres, and the volume 5 millions of cubic feet. The drainage area is  $4\frac{1}{4}$  square miles. A drain with sluice leads to the Loch of Banks. The surface temperature was  $64^{\circ}6$  Fahr. on September 1, 1906, the highest observed in Orkney. The bottom is free from weeds, except in the southern corner, and covered with grey clayey mud. The level was estimated at about 40 feet above sea-level.

*Loch of Kirbister* (see Plate XCII.).—The Loch of Kirbister (or Loch of Orphir) is a loch of moderate size, and somewhat triangular shape, in the parish of Orphir, 5 miles south-west of Kirkwall. It lies amid cultivated land in a broad valley between hills of over 700 and 800 feet respectively. It is  $1\frac{1}{4}$  miles long, and fully half a mile broad. The bottom is almost perfectly flat, a great central area being uniformly 5 feet deep. The maximum depth is 6 feet, and the mean depth 4 feet. The area of the surface is about 227 acres, and the volume of water 41 millions of cubic feet. The drainage area measures 8 square miles. The largest burns are those entering at the two ends of the loch. The outflow is near the southern end, by a mill burn, about half a mile long, with a rocky channel, flowing into Waulkmill bay. The surface was 52.1 feet above sea-level on August 14, 1903. The surface temperature was  $57^{\circ}0$  Fahr.

*Loch of Tankerness* (see Plate XCII.) is a triangular loch of moderate size, near St. Andrew's church, 4 miles east of Kirkwall, surrounded by pasture and wet meadows. It is nearly a mile long by half a mile broad. It is shallow and flat-bottomed, very gradually deepening from

west to east, where the maximum depth of 7 feet is found. The mean depth is  $4\frac{1}{3}$  feet, the area about 149 acres, and the volume 28 millions of cubic feet. The drainage area is about a square mile. The outflow is by Mill burn, a quarter of a mile long, issuing from the south-west corner of the loch. The surface was 13.9 feet above sea-level on August 17, 1903, and the surface temperature was  $58^{\circ}5$  Fahr.

*Loch of Swannay* (see Plate XCIII.).—The Loch of Swannay (or Swona, or Swanna) is a large loch of elliptical form, in the extreme north of Pomona, at Costa head. It is surrounded by moorland, in part cultivated. The shores are paved with flat stones. Under Costa hill are ranges of crags. The Muckle Holm island is stony, and there are many stony shoals, especially south of the island, and along the west shore. The length is 2 miles, and the greatest breadth two-thirds of a mile. Around the Muckle Holm the bottom is irregular and shoaly. South of the island is a considerable flat of 8 feet deep. North of the island is a large flat-bottomed basin, gradually deepening from 12 feet to 16 feet near the north end. The mean depth is  $9\frac{1}{4}$  feet, the area about 603 acres, or nearly one square mile, and the volume 242 millions of cubic feet. The drainage area is fully 5 square miles. A small burn enters at the southern end, and the Swannay burn flows out at the north-west corner, over a dam with a sluice, which is now disused. There is rock in the stream at the outflow. The bottom is visible to a depth of 8 or 10 feet, and is stony, with little or no deposit of mud. The surface was 134.55 feet above sea-level on August 31, 1906. The temperature at the surface was  $57^{\circ}7$  Fahr., at 15 feet  $57^{\circ}0$ .

*Loch of Boardhouse* (see Plate XCIII.).—The Loch of Boardhouse, which, in accordance with the Orcadian custom of naming a loch indifferently from any conspicuous feature in its neighbourhood, also receives the appellations Loch of Birsay, Loch of Twatt, Loch of Kirbuster, Barony Loch, and perhaps yet others, is a large and broad loch in the parish of Birsay, about half a mile east of the village of that name. It lies amid fields gently sloping up from the shore, with patches of moorland. Ravie hill, on the south-west, and Kirbuster hill on the north-east, are heather-topped hills of no great elevation. The shores are stony, and so shallow that they are difficult to approach in a boat—the grass slopes come quite to the water's edge, with hardly any beach. The only rock seen was at the original outflow. The length is 2 miles, and the greatest breadth near the eastern end two-thirds of a mile. The bottom is flat, and gradually deepens from 5 feet at the north-west end to the maximum depth of 9 feet close to the east end. The mean depth is 6 feet, the area nearly a square mile, and the volume 150 millions of cubic feet. The drainage area is  $13\frac{1}{2}$  square miles. The Kirbuster burn, a fair-sized river, enters at the east end. From the north-west corner the Birsay burn flows

somewhat more than half a mile westward, and enters the sea at the village of Birsay. On August 30, 1906, the surface was 50·85 feet above the sea. The temperature was 57°·3 Fahr. throughout.

*Loch of Hundland* (see Plate XCIII.) is a triangular loch of moderate size, lying between the larger Lochs Swannay and Boardhouse. The land is higher on the east, where Hundland hill rises to 150 feet above the surface. The west side is low moor. The shores are stony, and there are many stony islands and shoals. The bottom, paved with flat stones, is visible at depths of 4 to 5 feet. In the deepest part of the loch are large beds of *Potamogeton*, reaching the surface from a depth of 7 feet. The length from north to south is  $1\frac{1}{3}$  miles, and the greatest breadth slightly exceeds half a mile. The bottom is flat, and in the great central portion varies between 5 and 7 feet in depth. The maximum of 7 feet occurs in a narrow strip near the eastern shore, in the widest part of the loch. The mean depth is about 4 feet, the superficial area nearly half a square mile, and the volume 51 millions of cubic feet. The drainage area is large, including the Durka dale, a glen about 5 miles long, and measures  $9\frac{1}{4}$  square miles. The Kirbuster burn flows from the south-east corner to the Loch of Boardhouse through a grassy flat. Rock is seen in the bed of the stream at the bridge carrying the public road. On September 1, 1906, the surface was 89·7 feet above sea-level. The temperature was 62°·0 Fahr. throughout.

*Loch of Skail* (see Plate XCIV.) is a small loch on the west coast of Pomona, half a mile south-east of the Bay of Skail. It is of triangular form, and broadest at the west end. It lies amid stony fields, and a boggy flat intervenes between the loch and the Bay of Skail. Through this the outflow goes by a small burn, utilized as a mill stream. Some rock is seen on the northern shore and close to the outflow. The island in the centre is artificial, formed of flat stones, and measures about 20 yards across. The length is nearly one mile, and the maximum breadth half a mile. The bottom is flat and covered by a yellowish mud. The western bay is filled with reeds. The maximum depth is 4 feet, the mean depth 2 feet, the area a quarter of a square mile, and the volume 14 millions of cubic feet. The loch drains an area of one square mile.

On August 29, 1906, the surface was 26·9 feet above sea-level, and the temperature was 58°·6 Fahr.

*Muckle Water* (see Plate XCI.) is a narrow straight loch, lying at a considerable elevation (322 feet) among the hills, in the island of Rousay. The shores are rocky on the western side of the loch. The south shore in the eastern half is a high bank of peat. There is a broad stony beach. The length is  $1\frac{1}{4}$  miles, and the breadth nearly a quarter of a mile. It is a simple basin, gradually deepening from the west end

eastwards to the maximum of 20 feet, then shallow at the east end. The mean depth is 11 feet, the area 119 acres, and the volume 58 millions of cubic feet. The drainage area, which includes that of the Peerie Water, measures  $1\frac{1}{2}$  square miles. The outflow is eastward, by the Suso burn, into the Sound of Rousay.

On September 18, 1906, the surface was 321·5 feet above sea-level. The temperature at the surface was 54°·6 Fahr., and at 18 feet 54°·0.

*Peerie Water* (see Plate XCI.) is a very small, narrow, oblong loch, close to the Muckle Water, in the island of Rousay. On the south rises a heather-clad hill, on the north a flat rugged moor intervenes between Peerie Water and Muckle Water. Rock was seen only at the west end. The bottom is stony and free from mud, moss growing in the deepest parts. The length is half a mile, and the breadth one-sixth of a mile. The bottom is nearly flat, the mean depth 6 feet, and the maximum 10 feet. The area is about 38 acres, and the volume 11 millions of cubic feet. The drainage area measures one-third of a square mile. The outflow is by a small burn flowing north into the Muckle Water. The level measured from Muckle Water was 328·25 feet above sea-level.

The temperature at the surface was 53°·5 Fahr., and at 9 feet half a degree less.

*Hoglinns Water* (see Plate XCIV.) is a small loch in the southern part of the island of Hoy, lying among heather-covered hills of about 600 feet in height. It is a little more than a third of a mile long, and a fifth of a mile broad, but is by far the deepest loch in Orkney, having a maximum depth of 57 feet, somewhat west of the centre. It is a simple basin, deeper towards the west end, and has a mean depth of 26 feet. The superficial area is about 39 acres, and the volume of water 44 millions of cubic feet. The drainage area measures scarcely half a square mile. The outflow is westward by the Hoglinns burn.

From the following table it will be seen that in the fourteen lochs under consideration 932 soundings were taken, and that the aggregate area of the water surface is nearly 10 square miles, so that the average number of soundings per square mile of surface is 93. The aggregate volume of water contained in the lochs is estimated at 2321 millions of cubic feet. The area drained by these lochs is  $90\frac{1}{3}$  square miles, or about nine times the area of the lochs.

## SUMMARY TABLE.

Giving Details concerning the Locks in Orkney.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.		Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. Feet.	Mean Feet.	Max.	Mean.			Total in square miles.	Ratio to area of loch.
Stenness	3-60	181	3-79	1-30	0-65	17-1	17	10-43	61-4	1177	716	2-46	59-43	24-2
Harray	3-60	224	4-84	1-70	0-78	16-1	14	9-02	64-4	1825	951	3-78	44-83	11-9
Bosquoy	[about 36]	23	0-64	0-30	0-16	25-0	5	2-50	50-0	676	7	0-10	3-25	32-5
Sabiston	51-70	27	0-60	0-28	0-20	33-3	3	1-50	50-0	1056	5	0-12	3-33	27-8
Isbister	[about 40]	33	0-60	0-45	0-21	35-0	3	1-50	50-0	1056	5	0-13	4-23	32-6
Kirbister	52-10	61	1-26	0-52	0-28	22-2	6	4-15	69-2	1109	41	0-35	7-89	22-5
Tankerness	13-90	58	0-86	0-52	0-27	32-6	7	4-35	62-1	649	28	0-23	1-20	5-2
Swarray	134-55	78	2-00	0-64	0-47	23-5	16	9-22	57-6	660	242	0-94	5-27	5-6
Boardhouse	50-85	70	2-03	0-72	0-44	21-7	9	6-06	67-3	1191	150	0-89	13-59	15-3
Hundland	89-70	68	1-30	0-54	0-33	25-4	7	4-32	61-7	981	51	0-43	9-27	21-6
Skail	26-90	23	0-98	0-51	0-24	24-5	4	2-00	50-0	1293	13	0-24	1-09	4-6
Muckle Water	321-50	33	1-21	0-23	0-15	12-4	20	11-08	55-4	319	57	0-19	1-48	2-5
Peerie Water	323-25	20	0-48	0-16	0-13	26-0	10	6-34	63-4	253	11	0-06	0-32	53-7
Hoglinns Water	—	23	0-38	0-20	0-16	42-1	57	26-09	45-8	35	44	0-06	0-41	6-8
		932									2321	9-98	90-36*	9-1

\* The drainage area of Loch Stenness includes those of Lochs Harray, Bosquoy, Sabiston, and Isbister; that of Loch Boardhouse includes that of Loch Hundland; and that of the Muckle Water includes that of the Peerie Water.

## THE LOCHS OF SHETLAND.

THE Shetland Islands (see Index Map, Fig. 25) are very different in their physical features from the neighbouring group of the Orkneys. In place of the tame undulating surface of Orkney, the Shetlands, though not higher, are more rugged and more varied. High rocky ridges are separated by deep valleys, both running north and south. The more varied surface gives rise to a greater diversity in the lochs. Though many are very shallow, there is not the unvarying flat-bottomed character of the Orkney lochs, and some are relatively deep. In some parts of Shetland there are numerous lochs clustered together, as in North Uist, in other parts there are few lochs. Of the hundreds of lochs in the islands only thirty-one were surveyed. Though there are many basins in which there are numerous lochs, it never happened that we were able to survey more than two in the same basin, and in so many cases was there only one in the basin sounded that the thirty-one lochs surveyed occupy twenty-four separate basins. The area drained by all the lochs surveyed in the islands is just about 50 square miles, a very small proportion of the whole land surface. Only eighteen of the lochs have drainage areas of more than a square mile, eight drain more than 2 square miles, four drain more than 5 square miles, and the Loch of Cliff, with the most extensive drainage system in Shetland, drains an area of  $8\frac{1}{2}$  square miles. The combined superficial areas of all the lochs amount to no more than 4 square miles. The longest loch in Shetland, measured in a straight line between the extreme points, is Loch Strom, on the Mainland. Loch Strom has also the greatest superficial area, a little over half a square mile. The largest body of water is, however, Loch Girlsta, which, though inferior both in length and in area to the two lochs, Strom and Cliff, has nearly three times the volume of water of any other loch in Shetland. The volume of water contained in all the lochs of Shetland which were surveyed, amounts to about 1400 millions of cubic feet, which is but little over the volume of Loch Tummel alone, though that loch is scarcely longer than Loch Strom, or broader than Loch Spiggie.

The lochs of the Mainland of Shetland number probably some hundreds of various sizes. The great majority are insignificant in size, and there is no really large lake in the island. The largest is not 3 miles in length, the deepest is only 74 feet in maximum depth, and none has a superficial



area of more than half a square mile. It was only possible to survey a small proportion of the lochs, as a great many had no boats on them. Among those surveyed there are some half-dozen somewhat larger lochs (Lochs Spiggie, Tingwall, Strom, Girlsta, Vaara, and Eela). Lochs in twenty distinct basins were surveyed, and in six of the basins there were two lochs surveyed.

The portion of the mainland called North Roe is like North Uist or Benbecula. The tract containing the lochs is situated to the north of Ronas hill and towards the west coast. Seen from the top of Black Butten, one of the summits of Ronas hill, the scene is like that viewed from Lee in Uist, but of less extent. The lochs are seen thickly studded over a stretch of rugged, dark moorland some 4 miles long by 3 miles broad. The moor undulates a good deal between 350 and 500 feet, and most of the larger lochs are near the latter level. All the lochs in this part which were surveyed drain independently into the sea, either to north or west, except Clubbi Shuns and Roer Water, which discharge into Colla firth on the south-east. The lochs surveyed in this district were Roer Water, Clubbi Shuns, Flugarth, Muckle Lunga, and Birka.

The two little lochs in the island of Bressay (Brough and Setter) are the smallest which were surveyed in Shetland. Both lochs are in the same basin—the Setter basin.

The island of Yell, the second largest island of the archipelago, is nearly cut in two by the opposite inlets of Whale Firth and Mid Yell Voe. There are in the northern half several fairly large lochs, and in the southern half only a number of smaller lochs. There were no means of surveying any of these lochs except one very small one, the Loch of Littlester, at the south end of the island.

The island of Unst is traversed from end to end by a central valley, in which there are two lochs—the Loch of Watlee (not surveyed), and the Loch of Cliff, one of the largest lochs in Shetland. There are a good many smaller lochs, of which one only, the Loch of Snaravoe, was surveyed.

*Sandy Loch* (see Plate XCV.) is a small loch on the hill which rises south-west from Lerwick, and about 2 miles from the town. A steep heather-clad hill rises on the west; to the east is a stretch of deep black peat. Rock was seen on the north and west. The loch is dammed up, and gives the water-supply to the town of Lerwick. The length is a little less than half a mile, the breadth a quarter of a mile, the greatest depth 7 feet. The area is about 46 acres, the drainage area barely one square mile, and the volume of water 9 millions of cubic feet. The chief feeder is a burn from the hill of Fitch, and the outflow by a stream half a mile long into the Voe of Sound. The level at the date of survey, August 11, 1903, was 219·85 feet.

The surface temperature was 57°·9 Fahr.

*Loch of Clickhimin* (see Plate XCV.) is a very small tidal loch lying close to the west of the town of Lerwick. The channel to the sea is cut through a low bar of gravel; on the west rises a steep hill. The east and south shores are strewn with boulders, and there are many also in the loch. A brough or Dùn stands on a promontory strewn with stones.

Loch Clickhimin is barely half a mile long, fully a quarter of a mile wide, and 10 feet in maximum depth, with a mean depth of between 5 and 6 feet. The superficial area is about 46 acres, and the loch drains an area of half a square mile. The volume is 11 millions of cubic feet. The bottom is covered with mud, sand, and boulders, and is in parts weedy. It is said that only high tides enter, and that there are no fish in the loch except eels.

The surface temperature was 52°·0 Fahr. on July 7, 1903.

*Loch of Girsta* (see Plate XCVI.) is a fine large loch of oblong form situated 6 miles to the north of Lerwick. Its long axis runs north and south. The shores are desolate heather-covered hills rising on east and west, higher on the west. There is a broad beach of small grey stones on east and west, and a sandy beach at the north end. The island in the loch is low and heather covered. Rock is exposed on the island and at several spots on the east shore. Near the outflow there is rock in vertical strata worn to the level of the beach. The outflow, controlled by a dam and sluice, is through a stony flat southward into Wadbister Voe.

Loch Girsta is  $1\frac{1}{2}$  miles long, and fully one-third of a mile broad in the middle. Its depth, 74 feet, is the greatest among the lochs surveyed in Shetland, though it only exceeds Clings Water by one foot. The mean depth, 31 feet, is the greatest in Shetland. The superficial area, one-third of a square mile, is exceeded only by Lochs Strom and Cliff, and is about the same as that of Loch Spiggie. The volume of water, 308 millions of cubic feet, is nearly three times as great as that of any other loch in Shetland, the four next largest, Lochs Cliff, Eela, Strom, and Clings Water, each slightly exceeding 100 millions. Only small burns enter Loch Girsta, the largest being the Bretto burn, which drains four small lochs on the west, and flows into the loch opposite the island. The outflow is on the south by a mill lead, one-third of a mile long, to the mill of Girsta. The area drained is nearly 2 square miles. When surveyed on July 8, 1903, the loch was 87·6 feet above sea-level. Except for the slight interference by the shallow water around the island, the basin is very simple, with approximately parallel contours and even slopes on all sides to the deepest water in the middle.

The temperature only varied 0·3 degree from surface to bottom; the surface temperature being 54°·1 Fahr., and at 75 feet 53°·8.

*Loch of Burraland* (see Plate XCVII.) is situated 4 miles south from Ollaberry and a little to the east of the main road. There is a farm

on the north shore, and all around rough peat, rugged hills to the west, gently sloping moor to the south, and low land to the east, through which the Scali burn flows to the Houb, a branch of the Sullom Voe. The loch measures half a mile in length, from east to west, and is a fifth of a mile broad. It is very shallow, with a mean depth of 5 feet, and the maximum of 10 feet in the centre. The area is about 53 acres, and the volume of water about 11 millions of cubic feet. The area drained slightly exceeds a square mile. The level was not ascertained, but is estimated at nearly 100 feet above sea-level. There are many boulders in the loch, along the east and north shores.

The surface temperature on July 24, 1903, was 55°·5 Fahr.

*Roer Water* (see Plate XCVIII.) is the largest of the lochs of North Roe. It is nearly in the centre of North Roe, and close to the foot of Ronas hill on its north-east side. It is of roughly oblong form, and measures nearly two-thirds of a mile in length, from east to west, and one-third of a mile in maximum breadth. It is a very shallow flat basin, with a mean depth of only 10 feet, and all, except two very small holes, less than 16 feet deep. In one of these holes, towards the west end, is the maximum depth of 32 feet; in the more easterly hollow is a solitary sounding of 27 feet, with shallow water all round. There is an island near the south-east shore.

Roer Water has a superficial area of about 91 acres, and contains 43 million cubic feet of water. The Burn of Roerwater flows from the east end of the loch some 2 miles south-eastward into Colla firth. The drainage area extends to 2½ square miles, and includes many small lochs. The level at the date of the survey could not be ascertained; when visited by the Ordnance Survey on September 28, 1876, the surface was 349·4 feet above sea-level.

The surface temperature on August 7, 1903, was 54°·8 Fahr.

*Clubbi Shuns* (see Plate XCVIII.) is a very small loch lying immediately to the west of Roer Water, into which it overflows by a short stream. It is of irregular form, and measures a little over a quarter of a mile in length, from east to west, by one-sixth of a mile in greatest breadth. In area, which is about 16 acres, and in volume, 7 millions of cubic feet, it is the smallest of the lochs of North Roe. The loch is very shallow, the greater part of it less than 10 feet deep, only a very small area, somewhat east of the centre, exceeding 20 feet in depth, with a maximum of 28 feet. The drainage area, of rather more than a square mile, includes many very small lochs and the larger Longa Water, which were not surveyed. The outflow is to the east, the burn passing through a lower loch of Clubbi Shuns (not surveyed) into Roer Water. The level could not be ascertained, but would be somewhat over 350 feet.

The surface temperature on August 6, 1903, was 56°·4 Fahr.

*Loch of Flugarth* (see Plate XCIX.) is a small, narrow oblong loch, running due north and south, and close to the Sand Voe, on the north coast of the Mainland. It lies amid low country, cultivated to north and south, at only a few feet above sea-level (determined by the Ordnance Survey to be 6.4 feet on October 23, 1876). The axis is slightly curved. It is half a mile long, by fully one-eighth of a mile in maximum breadth. The basin is flat-bottomed, with a maximum depth of 8 feet, and a mean depth of 5 feet. The superficial area is 40 acres, and the volume of water 8 millions of cubic feet. A considerable stream from the Bergs of Skelberry (648 feet) enters the south end of the loch, and the outflow, through Vats meadow, is barely 100 yards long. It drains fully a square mile of country.

The surface temperature was 58°.0 Fahr. on August 8, 1903.

*Muckle Lunga Water* (see Plate XCVIII.) is a fairly large loch, of very irregular form, about a mile to the north of Roer Water, and draining through a chain of lochs which were not surveyed, into South Wick, on the west coast of the Mainland. It is longer than Roer Water, measuring three-quarters of a mile from south to north, but is narrower (a quarter of a mile in greatest breadth), and of smaller superficial area (about 58 acres) and volume (17 millions of cubic feet). It is very shallow, having a mean depth of about 7 feet, and only a very small area over 10 feet deep, and the maximum of 27 feet, to the east of the centre, in the broadest part of the loch.

Muckle Lunga is the uppermost of the chain of lochs, and drains a very small area of only a third of a square mile. The burn flowing out northward to Moosa Water, then westward, changes its name, as is so common in Shetland, being the Moosawater burn after passing the loch of that name, and finally the Brettoo burn when tumbling over the cliffs into the South Wick. The height of the surface above sea-level could not be measured, but is estimated at somewhere between 450 and 500 feet, being the most elevated of the lochs surveyed in Shetland.

The surface temperature on August 7, 1903, was 55°.8 Fahr.

*Birka Water* (see Plate XCVIII.) is a small triangular loch, a short distance to the north of Ronas hill. It is fully a third of a mile long from south to north, and a quarter of a mile broad at the extreme south end. It is a simple basin, the 10-foot contour being close to the shore except at the angles, the slope of the bottom being gradual to the 20-foot contour, then steeper to the centre, where the maximum depth of 45 feet occurs. The mean depth is 12 feet, the superficial area about 30 acres, and the volume of water 15 millions of cubic feet. It drains an area of 3 square miles, receiving most of the water collected on the north slope of Ronas hill, and the overflow of a large number of lochs. The burn flows out in the middle of the west side, and, after a course of about

half a mile, falls over the cliffs into the Lang Clodie Wick. The level is estimated at just over 400 feet.

The surface temperature on August 6, 1903, was 53°·8 Fahr.

*Eela Water* (see Plate XCIX.) is about halfway between Hillswick and Ollaberry, and close to the main road. It is one of the largest lochs in Shetland, and nearly square in outline. The loch lies at a considerable elevation, in the midst of rough moor and low heather-covered hills, highest to the east. Part of the east shore is rocky, but the shores are for the most part cumbered with stones and boulders. At the north-east corner the watershed is close to the loch, and very little above the level of the water, though the outflow is to the south-west, by the Eelawater burn, which flows into Hamar Voe on the west coast. The loch measures three-quarters of a mile diagonally from north-east to south-west, and is fully half a mile broad at two places—at the extreme east and a little west of the centre.

Eela Water is a simple basin, the greater part less than 20 feet deep (mean depth 16 feet), the bottom sloping gently on all sides, the slope being greatest on the west and south. A limited depression of over 50 feet, with the maximum depth of 54 feet, occurs somewhat north-east of the centre. The superficial area is not quite a quarter of a square mile, and the volume of water 103 millions of cubic feet. Only a few very small burns enter the loch, the area drained extending to scarcely a square mile. The outflow is through peat, over a channel of boulders, and no rock was seen near. When surveyed on July 23, 1903, the elevation was 217·9 feet above sea-level; at that time the water was low, and might rise 3 to 4 feet higher. On October 21, 1876, the Ordnance Survey officers found the elevation to be 218·7 feet above the sea.

A series of temperatures taken in the deepest part showed a range of scarcely 1°:—surface, 54°·9 Fahr.; 25 feet, 54°·6; 50 feet, 54°·0.

*Punds Water* (see Plate XCVII.) is a small loch, 1½ miles south of Eela Water, and on the west side of the road. It is surrounded on all sides by wild heather-covered hills, and peat comes close down to the stony beach. The islands are low and covered with heather. The loch is of rhomboid form, half a mile long by a third of a mile broad. The bottom is very uneven, with several depressions, the deepest of which lies just north of the largest island, and has a maximum depth of 30 feet. The mean depth is 10 feet, the superficial area about 40 acres, and the volume of water 26 millions of cubic feet. It has a small drainage area, about half a square mile, and receives no considerable stream. The Pundswater burn flows north-west into Hamar Voe. On July 25, 1903, the surface was 149·3 feet above sea-level, which is almost identical with the elevation determined by the Ordnance Survey officers on August 17,

1876, viz. 149·4 feet; the water was low at the time of the survey, and might rise about 3 feet.

The temperature at the surface was 56°·0 Fahr., and at 25 feet 55°·4.

*Loch of Aithness* (see Plate C.) is a small loch of triangular form, draining eastward into Aith Voe. The surrounding land is low, but on the north the hill rises steeply to 100 feet above the loch. The loch is half a mile long and a quarter of a mile broad. It forms a simple basin, with the bottom sloping evenly on all sides to the centre, and slightly steeper on the north. The maximum depth is 57 feet, and the mean depth 19 feet. The superficial area is about 58 acres, and the volume of water 46 millions of cubic feet. The area draining into the loch is about two-thirds of a square mile. The surface of the water was 33·7 feet above sea-level on August 29, 1900, when the loch was visited by the Ordnance Survey; when visited by the Lake Survey on July 13, 1903, it was fully 2 feet higher, viz. 35·9.

The temperature at the surface was 55°·0 Fahr., at 25 feet 54°·6, at 55 feet 54°·4, a total range of only 0°·6.

*Loch of Vaara* (see Plate C.) is a fairly large loch in Aithsting, of oblong form, with its long axis running east and west. The surrounding moorland rises to no considerable elevation; hills of a little over 200 feet lie to the west and south-east. The shores are in part stony, but rock is exposed at various parts, and at the outflow at the north-west corner, whence the Vaara burn runs for a quarter of a mile northward into Loch Clousta. The loch is nearly a mile long and half a mile in greatest breadth. It forms a shallow basin of flattish bottom, with gently sloping sides, and the maximum depth of 25 feet almost in the centre. Towards the shores at various parts many stones and some points of rock show above the surface. The mean depth is more than half the maximum depth (or 13½ feet). The superficial area is about 128 acres, and the volume of water 80 millions of cubic feet. The area drained is about 1½ square miles, the chief inflow coming from the south-east by the Mouldry burn. The surface level on the date of the survey, July 13, 1903, was 25·95 feet, identical with the level determined by the officers of the Ordnance Survey on August 22, 1900, viz. 26·0 feet above the sea. The water was low at the time of the survey, and might rise 3 to 4 feet.

The surface temperature was 54°·4 Fahr.

*Loch of Clousta* (see Plate C.) is a pretty large loch of rhomboid form, longest from north to south. The surroundings are moorland—the shores of the loch chiefly rock. There are many islands of stones or rock, and many boulders and points of rock, some of them just submerged. The loch is nearly a mile long, and half a mile broad at the north end. It is constricted in the middle, where it is only

one-eighth of a mile wide, and 7 to 9 feet deep. Of the two basins which lie north and south of the constriction, the northern one is mostly shallow, with one little hollow of 26 feet deep to the north of the largest island. The southern basin is triangular in form, and the bottom slopes most steeply off the promontory on the west, close to which is the maximum depth of 57 feet. The mean depth is 15 feet.

The area of the loch is about 107 acres, and the volume of water 71 millions of cubic feet, nearly as great as that of Loch Vaara. The drainage area, which includes Loch Vaara, measures  $2\frac{1}{3}$  square miles. Loch Clousta is fed chiefly by the overflow of Loch Vaara. At the outflow into the North Voe of Clousta is a dam and sluice. On July 11, 1903, the surface was 7·8 feet above sea-level, nearly identical with the level observed by the Ordnance Survey officers, on September 25, 1877, viz. 7·9 feet. The range of temperature was less than  $1^{\circ}$  from surface to bottom:—

Surface ... ..	55°·8 Fahr.
10 feet ... ..	55°·8 "
25 ,, ... ..	55°·5 "
55 ,, ... ..	55°·0 "

*Loch of Hostigates* (see Plate C.) is a very small loch in the extreme north of Aithsting, measuring fully a quarter of a mile long from west to east, by a fifth of a mile in greatest breadth. Relatively to its small size it is fairly deep, measuring 41 feet somewhat east of the centre. The mean depth is 16 feet, the surface area about 19 acres, and it contains 13 millions of cubic feet of water. The drainage area is only one-eighth of a square mile. A small burn flows out to the north, through another little loch into Uyea sound. The level could not be determined.

On July 16, 1903, there was a range of temperature of  $2^{\circ}\cdot 5$  throughout the body of water, the readings at 20 feet and at 35 feet being identical:—

Surface ... ..	57°·5 Fahr.
10 feet ... ..	56°·4 "
20 ,, ... ..	55°·0 "
35 ,, ... ..	55°·0 "

*Clings Water* (see Plate C.) is a loch of moderate size in Aithsting, draining through the small Loch of Setter (not surveyed) into the Voe of Clousta. The surrounding moorland rises to heights of from 100 to fully 150 feet above the loch. In form Clings Water is nearly square, with a deep bay on the east, and a narrow arm on the west. Though but a small loch, measuring only two-thirds of a mile long, by fully one-third broad, it is one of the deepest lochs in Shetland, the maximum, 73 feet, being only 1 foot less than that of the Loch of Girlsta. The mean depth is  $26\frac{1}{2}$  feet, second only to the Loch of Girlsta. The superficial area is about 91 acres, and the contents 101 millions of cubic feet. It receives only surface drainage.

On July 14, 1903, the surface-level was 52·9 feet above the sea, almost identical with the elevation determined by the Ordnance Survey officers on August 24, 1900, viz. 53·0 feet. The basin is simple, the bottom sloping on all sides to the deepest water, a little north of the middle line. The variation of temperature from surface to bottom was only  $\frac{1}{2}^{\circ}$ :—

Surface ...	...	...	...	...	...	54°·8 Fahr.
25 feet ...	...	...	...	...	...	54°·6 „
70 „ ...	...	...	...	...	...	54°·3 „

*Grass Water* (see Plate CL.) is a narrow loch, to the west of Houllma Water in Aithsting. It lies amid low moorland, and measures two-thirds of a mile in length from north to south. The centre line of the loch is strongly curved. The greatest breadth, one-sixth of a mile, is at the north end, which is very shallow and obstructed by numerous boulders. At this end there are several small islands. The narrow southern portion is slightly deeper, with the maximum depth of 6 feet. The whole loch is filled with vegetable growth. The superficial area is 34 acres, and the contents 4 millions of cubic feet. The Yoxna burn, a considerable stream, conveying the overflow of Houllma Water and of several smaller lochs, enters at the southern extremity, and four or five smaller burns on the west shore. The outflowing stream passes northward through the little Loch Culeryn into the Vadills, at the head of Uni firth. The drainage area, including several fairly large lochs not surveyed, measures 3 square miles. The height of the loch above sea-level was not ascertained, but it may be estimated from a spot-level of 11 feet on the shore to be about 10 feet.

The surface temperature on July 15, 1903, was 58°·0 Fahr.

*Upper Loch of Brouster* (see Plate CL.) is a small loch about 5 miles south-east from Sandness. It is of oblong form, with the axis running north and south. It is the lowest of an extensive chain of lochs, stretching right across the peninsula, from near Sandness to the Browland Voe near Walls. The chain includes several fairly large lochs, of which only Burga Water was surveyed, there being no boat on the much larger Voxterby Loch. The loch is fully one-third of a mile long, one-eighth of a mile broad, with an uneven bottom, varying from 5 feet to 8 feet in the centre, and a very small part 11 feet deep near the south end. The mean depth is  $5\frac{1}{2}$  feet, the area about 22 acres, and the volume 5 millions of cubic feet.

The area draining into the loch is  $5\frac{1}{2}$  square miles. The Brace burn, from Voxterby Loch, comes in at the north end. A short stream flows south into the Loch of Brouster, a sea loch, and a branch of the Browland Voe. The level of the loch was not found, but it was stated that the water might fall a little lower, and might rise 5 to 6 feet higher than on the date of the survey (July 20, 1903). The surface temperature was 54°·2 Fahr.

*Burga Water* (see Plate CI.) lies about 3 miles south-east of Sandness. It is shaped roughly like the letter **T**, the stem of the letter running nearly north-west to south-east, the cross-stroke at right angles to it at the south end. There are low hills to the north-east, and higher hills south-westward. *Burga Water* is one of an extensive chain of lochs, forming one of the largest lake-systems in Shetland, of which, however, only two lochs could be surveyed. Its length is fully half a mile, and the greatest width, across the cross-piece of the **T**, is very little less, viz. five-twelfths of a mile. The contours of the bottom are somewhat irregular, the 10-foot contour only nearly following the shore line. The 20-foot contour zigzags from side to side of the loch, unless we regard the various soundings on which it depends as isolated. Near the south end is the maximum depth of 31 feet.

The superficial area is 78 acres, the mean depth nearly 13 feet, and the contents 42 millions of cubic feet. The chief sources of the loch are the Burn of Cattikismires from the west, and the burn from Mousavord Loch (not surveyed). Gibbie Laws burn flows from the east corner,  $1\frac{1}{2}$  miles south-eastward into Voxterby Loch. The area draining into the loch slightly exceeds 2 square miles. The islands at the south end are all of rock; there is rock exposed on the promontory on the west shore, and the channel leading to the little loch on the east is choked by rock and stones, so that it could not be entered.

On the date of the survey, July 21, 1903, the surface was 115.65 feet above sea-level, the water being low at the time, and liable to rise 3 feet higher. On August 27, 1877, the Ordnance Survey officers found the elevation to be 116.8 feet above the sea. The range of temperature was 2.4 Fahr. :—

Surface ...	...	...	...	...	...	56°·8 Fahr.
5 feet ...	...	...	...	...	...	56°·1 „
10 „ ...	...	...	...	...	...	54°·8 „
15 „ ...	...	...	...	...	...	54°·6 „
25 „ ...	...	...	...	...	...	54°·4 „

*Loch of North-house* (see Plate C.) is a loch of moderate size in Aithsting, about a mile north of Aithsting church. Its general form is peculiar. There is a main triangular body, with the apex to the south, from which a narrow arm runs to the north-west. The two portions are separated by a gravel bar, at the north end of which there is rock. There is also a bar of rocks near the outflow. The narrow portion west of the bar has a depth of 7 feet, and is almost flat-bottomed. In the main loch the maximum depth of 13 feet is at the north end, close to the gravel bar, and from there it gradually shoals to the south. The total length is five-sixths of a mile, the greatest breadth one-fifth of a mile. The mean depth is  $6\frac{1}{2}$  feet, the area about 58 acres, and the volume 16 millions of cubic feet. The drainage area measures about half a square

mile; there are no feeders of any importance, and the Twatt burn conveys the overflow into Bixter Voe.

On July 17, 1903, the surface was 77.9 feet above sea-level; on October 24, 1877, the Ordnance Survey officers found it to be 78.7 feet. The surface temperature was 54°.8 Fahr.

*Loch of Collaster* (see Plate C.) is a very small triangular loch, lying 1 mile north-west of Aithsting church. It measures fully one-third of a mile from north to south, by one-fifth of a mile broad at the north end. It is very shallow, the maximum depth of 10 feet being near the north end. It receives on the west the Burn of Shunalittle from Loch Shunalittle. The Twatt burn carries the overflow to Kirkhouse Water (not surveyed), whence the Burn of Quinigill issues, and, joining the Twatt burn from the Loch of North-house, enters Bixter Voe. The superficial area is about 25 acres, the mean depth nearly 6 feet, and the volume of water 7 millions of cubic feet; three soundings in the maximum depth of 10 feet were taken near the northern end. It drains an area of less than half a square mile. The height of the loch above sea-level could not be ascertained.

On July 14, 1903, the surface temperatures was 53°.0 Fahr.

*Loch of Strom* (see Plate CII.) lies 5 miles due north of Scalloway, and is one of the longest lochs in Shetland, but is very narrow. It is a tidal loch. Its axis runs nearly due north and south. The valley in which it lies is here very narrow, and the hills which bound it slope steeply into the loch. On the east the hills are higher and covered with heather, and rock shows at many points on the lake-shore; on the west the lower hills are rugged and covered with grass; rock shows at the promontory called Quoy ness, on the west shore, and at the extreme south end. South of the Strom bridge the west shore is a terrace of gravel with boulders. There is rock at the north end of Strom bridge, and at the sea end of the Strom on the south side. The tide appears to have little effect on the level of the loch, which was 0.5 foot above sea-level on the date of the survey (August 1, 1903), but it must renew the water with sufficient frequency to permit of the growth of fucoids and other marine organisms over the whole of the bottom, even to the extreme north. The northern part of the loch, rather more than half the length, is very narrow; south of Quoy ness is a broader portion. The length is a little over  $2\frac{1}{2}$  miles, which slightly exceeds that of the Loch of Cliff, unless the narrow eastern arm is included in the length of that loch. The greatest breadth, one-third of a mile, is just south of Quoy ness.

The Loch of Strom is very shallow. East of Quoy ness, on each side of the narrow island, the depth is only 6 feet, and there is deeper water both to the north and south. In the northern basin, the central part of

which is nearly flat-bottomed, but slightly deeper towards the east side, the greatest depth is 12 feet. In the southern basin the maximum depth of 13 feet is close to Quoy ness, and it gradually shoals to the south end of the loch. This basin is constricted in the middle by the Castle Holm and a number of other islands. In superficial area, which is 331 acres, or about half a square mile, the Loch of Strom is the largest, as it is also the longest, in Shetland. The low mean depth, 7 feet, gives a relatively small volume of only 101 millions of cubic feet, which is equalled by one loch (Clings Water), and exceeded by four lochs (Eela, Cliff, Spiggie, and Girlsta).

The Loch of Strom has an extensive drainage area, including Sand Water, and the whole central valley of the Mainland for almost 6 miles north, or almost as far as Voe. The upper part of this valley, where the stream flows south from Petta Water, is known as Tetta vale; after passing through Sand Water it becomes Sandwater burn, and flows into the north end of the Loch of Strom, under the name of Strom Firth burn. The drainage area extends to nearly 8 square miles, or about half a square mile less than that of the Loch of Cliff. The surface temperature varied from 56°·8 to 57°·2 Fahr. in different parts of the loch.

*Loch of Tingwall* (see Plate CIII.) is a fairly large loch of oblong form, 4 miles west of Lerwick, and 2 miles north of Scalloway. It occupies, with the Loch of Asta, a narrow valley running across the Mainland, nearly from north to south, between Tax firth and Cliff sound. The whole west side of the loch is cultivated, with high hills rising behind; on the east is moorland, with sparse heather. At the north end is a flat strip of meadow, liable to floods. On the western shore are a few large boulders and bosses of rock. The island in the centre is low and covered with heather. The length is just over a mile, and the greatest breadth nearly a quarter of a mile.

The loch is divided into two nearly equal portions by a constriction, where it is also very shallow, the depth in the centre of the narrows being only 9 feet. It is still shallower in the channels on either side of the island north of the narrows, where the depths are only 2 and 3 feet. The northern basin is the shallower. It is almost flat-bottomed over the greater part of the area, with depths of from 7 to 9 feet. In the centre is a very small and abrupt depression, in which there is a depth of 40 feet. The southern basin is of a different character; as shown by the contours, the sides slope fairly regularly to the centre, where there is the maximum depth of 60 feet. The mean depth is about 19 feet, the area nearly 107 acres, and the volume of water 87 millions of cubic feet. No large streams enter the loch; its outflow is to the south, by a stream about 100 yards long, into the Loch of Asta. There is rock close to the outflow, on the west side, and the burn flows among stones, with rock in the channel a few yards from the loch.

On July 2, 1903, the surface was 28·4 feet above sea-level, which is identical with the level found by the Ordnance Survey officers on July 19, 1876. The temperature varied less than half a degree from surface to bottom.

Surface ...	...	...	...	...	...	55°·3 Fahr.
10 feet ...	...	...	...	...	...	55°·0 „
25 „ ...	...	...	...	...	...	55°·0 „
55 „ ...	...	...	...	...	...	54°·9 „

*Loch of Asta* (see Plate CIII.) is a small loch just south of the Loch of Tingwall, and the surroundings are similar, but the hills are lower, and there is no marginal flat. There is rock on the west side, towards the north; on the east, where there is no beach, and the hill slopes steeply into the loch, no rock was seen. The burn flows southward about a mile into Cliff sound, close by Scalloway. There is rock in the stream close below the loch.

The loch is narrow and elongate from north to south, with a length of half a mile, and greatest breadth of one-eighth of a mile. It is very shallow, the greater part less than 6 feet deep, and a single sounding of 13 feet near the north end. The mean depth is 5 feet, the area 32 acres, and the volume of water 7 millions of cubic feet. The level is barely 2 feet lower than the Loch of Tingwall, viz. 26·6 feet above sea-level on July 2, 1903, which is nearly identical with that (26·5 feet) determined by the Ordnance Survey on July 19, 1876. The drainage area, which includes the Loch of Tingwall, is nearly 2 square miles.

*Loch of Brow* (see Plate CIV.) is a small triangular loch in Dunrossness, close to the east end of the Loch of Spiggie. The surrounding country is low, rising highest on the north. The loch measures half a mile long, by one-ninth of a mile broad near the east end. It is very shallow and almost flat-bottomed, with a maximum depth of 6 feet and a mean depth of 2½ feet. It has an area of nearly 45 acres, and contains 5 millions of cubic feet of water. Two streams enter at the east end, the chief being the Burn of Hogarth, coming from the north, the area drained being a little over a square mile. The outflow to the Loch of Spiggie is across a flat boggy meadow, about one-eighth of a mile across. The level at the date of the survey (July 3, 1903) was the same as Loch Spiggie, viz. 4·0 feet above sea-level; the Ordnance Survey officers found the level on September 19, 1876, to be 3·5 feet above the sea.

The surface temperature was 58°·5 Fahr.

*Loch of Spiggie* (see Plate CIV.) is the only moderately large loch in the southern part of Mainland. It is approximately oblong in shape, and its long axis runs nearly north and south. The surrounding land is low, and there are a number of farms on the shores of the loch. At the north end are the Sands of Scousburgh. In length it is fourth among the lochs

of Shetland, measuring  $1\frac{1}{3}$  miles in a straight line between the extreme points. The maximum breadth, in the middle, is nearly half a mile.

The loch forms a simple basin, very shallow near the north end. The bottom slopes very gradually down to 20 feet, after which the slope is steeper. The area over 30 feet deep is very narrow, and includes a very small area of over 40 feet founded on a single sounding of 41 feet. The superficial area is 213 acres, or one-third of a square mile, and the volume of water, 111 millions of cubic feet, shows the loch to be the third largest in Shetland. The area drained, including the Loch of Brow, is nearly 6 square miles. The principal streams entering the loch are that from the Loch of Brow, the Burn of Hillwell near the south end, and the Burn of Scousburgh in the north. The outflow is through a narrow bar, the Beach of Spiggie. The surface was only 4.0 feet above the level of the sea on July 3, 1903, as compared with 3.8 found by the Ordnance Survey on October 24, 1900.

The temperature was uniform throughout, viz.  $56^{\circ}8$  Fahr.

*Loch of Brough* (see Plate XCV.) is a very small loch towards the west side of Bressay. It is the upper loch in the Setter basin, and lies at an elevation of 75.1 feet between two low hills. This elevation was determined on June 30, 1903, when the water was very low, and liable to rise 3 feet higher; when visited by the Ordnance Survey officers on June 14, 1876, the level was 77.6 feet above the sea. It is of oblong form, measuring nearly one-third of a mile from north to south, by one-eighth of a mile in greatest breadth, at the north end. It is flat-bottomed, with a mean depth of 2 feet, and a maximum of 4 feet. The area is 19 acres, the volume 2 millions of cubic feet, and the drainage area is half a square mile. A small burn flows a quarter of a mile north into the Loch of Setter. There is a deposit of peat and sand on the south-east end of the loch. The loch was lowered by a drain some years ago, in order to allow carts to pass along the shore. The surface temperature was  $55^{\circ}6$  Fahr.

*Loch of Setter* (see Plate XCV.) is a very small loch close to the shore of the Voe of Cullingsburgh, on the east side of Bressay, at a height of 43.2 feet above the sea. This elevation was found both by the Lake Survey on June 30, 1903, and by the Ordnance Survey on June 14, 1876; this is practically the lowest level, and the water may rise 3 feet higher. It is almost circular, measuring one-fifth of a mile in greatest diameter. It is in all respects by far the smallest loch in Shetland. Its greatest depth is 2 feet, and its mean depth 1 foot; the surface area is 14 acres, and the volume of water, half a million cubic feet, is one-third of that of the Loch of Brough, the nearest to it in size. The drainage area, which includes the Loch of Brough, is rather more than a square mile. When surveyed the loch was much overgrown with weeds. The surface temperature was  $56^{\circ}3$  Fahr.

*Loch of Littlester* (see Plate CV.) is of somewhat rhomboid form, longest from west to east, where a shallow arm goes off. It is surrounded by low heather-covered hills, except at the east end, where a stretch of flat meadow is covered by crofts. The length is half a mile, by fully a quarter of a mile broad. The basin is flat-bottomed, with a greatest depth of 9 feet, and a mean depth of 5 feet. The surface area is about 64 acres, and the volume 13 millions of cubic feet. The drainage area is barely one-third of a square mile. The burn flows east into the stream which also drains Loch Kettlester, and enters Burra Voe. The surface was 34.25 feet above sea-level on August 7, 1903; the Ordnance Survey determined the elevation on September 28, 1876, as being 34.7 feet above the sea. On the first-mentioned date the water was low, and might rise  $1\frac{1}{2}$  to 2 feet.

The temperature of the surface water was 56° 0 Fahr.

*Loch of Cliff* (see Plate CVI.) is in the northern part of the island of Unst, and is the most northerly loch in the British Islands. It is a long and narrow loch, running north and south in the long valley which occupies the whole central part of Unst from north to south. Near its northern end a long arm runs to the south-east. The valley in which the loch lies is at this part very narrow. The hills to the west are high, attaining to 558 feet in Libbers hill, heather-clad in the higher parts, with pasture below. On the east are lower grassy hills; in the bend formed by the eastern arm and the main loch is a domed heather-covered hill, the Ness of Queyhouse. The arm is filled with weeds in its eastern end, and the south end of the loch is also weedy. There is a pile of stones in the centre of the loch, opposite the opening into the eastern branch, and another heap, composed of large stones, at the broadest part of the loch. A bright green flat bars the northern end of the loch, and through this the Burn of Burrafirth cuts a zigzag course into Burra Firth. The length of the main loch, measured in a straight line between the extremities, is  $2\frac{1}{3}$  miles. This is just a little less than the Loch of Strom. The eastern arm measures over three-quarters of a mile, following the centre. The greatest width in the main loch is a little over a quarter of a mile.

The Loch of Cliff is relatively very shallow; the maximum depth of 21 feet is in the widest part, and to this the slope is on all sides gradual. In the narrowest part, towards the north end, the depth in the centre is only 13 feet, and north of this it deepens slightly to 16 feet. The eastern arm, except a small portion near the main loch, is less than 10 feet deep. The mean depth is fully 10 feet, the surface area about 256 acres, and the volume of water 118 millions of cubic feet, which is only exceeded by that of the Loch of Girlsta, and is a little greater than that of the Loch of Spiggie. The drainage area of  $8\frac{1}{2}$  square miles exceeds that of any other loch in Shetland and includes the Loch of Watlee, a fairly large loch

lying 3 miles to the south. The stream which brings the drainage of the whole central valley of Unst has various names—the Burn of Caldback where it leaves Loch Watlee, the Burn of Mailand in its middle course, and the Burn of Baliaster where it enters the loch. On the date of the survey (August 4, 1903) the surface-level was 5·75 feet above the sea.

The surface temperature in the main loch was 56°·4 Fahr., and in the eastern branch 56°·3.

*Loch of Snarravoe* (see Plate CV.) is in the southern part of Unst. It is a narrowly triangular loch, broadest in the south, its axis running north-east to south-west. Both shores of the loch are steep grassy slopes, the west lower and cultivated, the east rising nearly 200 feet above the loch, and strewn in its lower part with myriads of stones. The largest burn is that coming in at the north-east end from the Loch of Stourhoull, half a mile higher up the valley. Some torrents entering on the east have spread out wide deltas of stones. There is a sparse fringe of reeds along the west shore. The Burn of Snarravoe flows out at the south-west corner, and winds through a flat meadow a quarter of a mile north-westwards into Snarra Voe. There is hardly any beach, and no rock was seen at the margin of the loch. The upper end is sandy, with some large boulders. Loch Snarravoe is over half a mile long, and a quarter of a mile broad at the extreme south. The superficial area is about 53 acres, the volume of water 27 millions of cubic feet, and the drainage area three-quarters of a square mile. The basin is simple, the 10-foot contour closely following the shore. In the centre the depth is only 12 feet; northwards it deepens slightly to 15 feet; to the south, and close to the west shore, is a small area over 20 feet in depth, with the maximum of 29 feet. The surface is very little above sea-level; on the date of the survey (August 6, 1903) it was at its lowest, 5·3 feet; the Ordnance Survey found the level on November 10, 1876, to be 5·6 feet above the sea.

The temperature of the water was almost uniform throughout—

Surface ...	...	...	...	...	...	55°·2 Fahr.
10 feet ...	...	...	...	...	...	55°·1 „
25 „ ...	...	...	...	...	...	55°·1 „

From the following table it will be seen that in the thirty-one lochs under consideration 1707 soundings were taken, and that the aggregate area of the water surface is nearly  $5\frac{1}{2}$  square miles, so that the average number of soundings per square mile of surface is 318. The aggregate volume of water contained in the lochs is estimated at 1416 millions of cubic feet. The area drained by these lochs is nearly 52 square miles, or about  $9\frac{1}{2}$  times the area of the lochs.

## SUMMARY TABLE.

Giving Details concerning the Locks in Shetland.

Loch.	Height above sea. Feet.	Number of sound- ings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.	Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.		Max. Feet.	Mean. Feet.	Mean percent. of max.				Max.	Mean.
Sandy	219-85	38	0-40	0-24	0-17	42-5	7	4-73	68-0	302	444	0-07	0-85	12-1
Clickhimin	—	29	0-42	0-29	0-17	40-5	10	5-60	56-0	222	396	0-07	0-55	7-9
Girlsta	87-60	93	1-48	0-36	0-24	16-2	74	31-41	42-4	106	249	0-35	1-79	5-1
Burrland	[nearly 100]	39	0-60	0-23	0-14	23-5	10	4-67	46-7	317	679	0-08	1-15	14-4
Roer	349-40 [Sept. 23, 1876]	59	0-62	0-36	0-24	39-2	32	10-16	31-8	102	322	0-15	2-23	14-9
Clubbi Shuns	[somewhat over 350]	26	0-29	0-14	0-09	32-4	28	8-85	31-6	55	173	0-27	1-12	4-1
Flugarth	6-40 [Oct. 23, 1876]	48	0-52	0-14	0-11	21-2	8	5-23	65-4	343	525	0-06	1-13	19-0
Muckle Lunga	[between 450 & 500]	65	0-74	0-26	0-12	16-1	27	6-88	25-5	145	568	0-09	0-34	3-8
Birka	[just over 400]	47	0-36	0-20	0-13	36-4	45	11-81	26-2	42	161	0-05	2-96	59-2
Eela	217-90	77	0-79	0-63	0-28	35-4	54	16-59	30-7	77	251	0-22	0-90	4-1
Punds	149-30	84	0-48	0-32	0-19	39-6	30	10-20	34-0	84	248	0-09	0-51	5-7
Aithness	35-90	38	0-50	0-28	0-18	35-4	57	18-84	33-1	46	140	0-09	0-60	6-7
Vaara	25-95	67	0-84	0-45	0-25	29-8	25	13-44	33-8	177	390	0-21	1-53	7-3
Clounsta	7-80	111	0-92	0-42	0-18	19-6	57	15-27	26-8	88	318	0-17	2-35	13-8
Hostigates	—	30	0-28	0-20	0-10	36-1	41	16-26	39-7	36	91	0-03	0-12	4-0
Clings	52-90	44	0-68	0-38	0-25	36-8	73	26-55	36-4	49	135	0-14	0-61	4-4
Grass	[about 10]	35	0-64	0-16	0-08	13-0	6	2-99	49-8	563	1132	0-05	2-99	6-0





group of reservoirs, and Mr. Wm. Lockhart, C.E., of the Kirkcaldy and Dysart Waterworks for tracing of the new reservoir at Holl.

*Gladhouse Reservoir* (see Plate CVII.), the largest of the Forth reservoirs, lies at the base of the Moorfoot hills, about 13 miles south of Edinburgh. It is very irregular in outline, and  $1\frac{1}{2}$  miles in length from south-west to north-east, with a maximum breadth across the middle of nearly a mile. The superficial area is about 375 acres, or over half a square mile, and the drainage area about  $12\frac{1}{2}$  square miles. The reservoir is, on the whole, comparatively shallow, 84 per cent. of the floor being covered by less than 25 feet of water, and only one sounding was taken in depths exceeding 50 feet, viz. the maximum of 55 feet near the sluice at the northern end. Here deep water approaches close to the shore in places, but the bottom is very uneven. The volume of water is estimated at 269 million cubic feet, and the mean depth at  $16\frac{1}{2}$  feet.

When surveyed on July 2, 1903, the elevation was 888·6 feet above sea-level, and temperatures taken in the deepest part gave  $60^{\circ}\cdot9$  Fahr. at the surface, and identical readings of  $58^{\circ}\cdot0$  at depths of 30 and 45 feet.

*Rosebery Reservoir* (see Plate CVIII.) lies about a mile to the north of Gladhouse reservoir, and is extremely irregular in outline. The main body trends north and south, and is two-thirds of a mile in length; but its northern end sends off a branch in a south-easterly direction, so that a line drawn along the axis of maximum depth from end to end would be about a mile in length. The maximum breadth is less than a quarter of a mile, and the superficial area about 52 acres, whilst the area drained, including Gladhouse reservoir, is about 14 square miles. The maximum depth of 55 feet was recorded at the junction of the two arms of the reservoir near the outflow, where there is a small basin exceeding 50 feet in depth, equal to 11 per cent. of the total area, while 56 per cent. of the bottom is covered by less than 25 feet of water. The volume of water is estimated at 58 million cubic feet, and the mean depth at  $25\frac{1}{4}$  feet, which is much greater than the mean depth of Gladhouse reservoir, though the maximum depth is identical.

When surveyed on June 30, 1903, the elevation was 731·5 feet above the sea. Temperatures taken in the deepest part showed a range from surface to bottom of  $9^{\circ}\cdot2$  Fahr., and the decrease occurred mostly between 30 and 35 feet, for within this interval of 5 feet of depth a fall of no less than  $7\frac{1}{2}^{\circ}$  was recorded—equal to a fall of  $1\frac{1}{2}^{\circ}$  per foot of depth; while between  $32\frac{1}{2}$  and 35 feet a fall of  $4\frac{1}{2}^{\circ}$  was recorded—equal to a fall of nearly  $2^{\circ}$  per foot of depth. The readings were as follows:—

Surface ... ..	57°·5 Fahr.
30 feet ... ..	57°·0 "
$32\frac{1}{2}$ " ... ..	54°·0 "
35 " ... ..	49°·5 "
40 " ... ..	48°·5 "
50 " ... ..	48°·3 "

*Portmore Loch* (see Plate CIX.) lies a little more than 2 miles to the south-west of Gladhouse reservoir, and is two-thirds of a mile in length from north to south, with a maximum breadth of one-third, and a mean breadth of a quarter, of a mile. The superficial area is about 105 acres, and the drainage area exceeds 3 square miles. It is a simple, flat-bottomed basin, the 10-foot contour closely hugging the shore all round, and the 20-foot contour enclosing an area in the northern half equal to one-fourth of the total area, the maximum depth of 41 feet being recorded about a quarter of a mile from the north end. The area covered by less than 10 feet of water is one-fifth of the total area, so that about 55 per cent. of the lake-floor is covered by water between 10 and 20 feet in depth. The volume of water is estimated at 76 million cubic feet, and the mean depth at nearly 17 feet. When surveyed on July 4, 1903, the elevation could not be determined; on December 23, 1892, the Ordnance Survey officers found it to be 999·0 feet above sea-level. The temperature of the water was practically uniform throughout, the readings at the surface and at 20 feet being identical, viz. 57°·5 Fahr., while a reading at 40 feet gave 57°·1.

*Edgelaw Reservoir* (see Plate CVIII.) lies about 5 miles to the north-east of Portmore Loch, and little more than half a mile to the north-west of Rosebery reservoir. It is elongated and irregular in outline, with curved axis, trending generally in a west-to-east direction, and is two-thirds of a mile in length by only one-sixth of a mile in maximum breadth. The superficial area is only 35 acres, while the drainage area, including Portmore Loch, exceeds 10 square miles. Though one of the smallest of the Forth reservoirs, it is the deepest, having a maximum depth near the outflow of 77 feet, while the mean depth is over 31 feet, the volume of water being estimated at 47 million cubic feet. The bottom is uneven, a small 50-foot basin occupying a central position, and being separated by shallower water from the main 50-foot basin at the east end, where deep water approaches very close to the shore.

When surveyed on July 7, 1903, the elevation was 650·9 feet above the sea. Temperatures in the deepest part showed a range of 11°·4 Fahr. from surface to bottom, but no very rapid fall of temperature is indicated by the readings:—

Surface ... ..	60°·0 Fahr.
15 feet ... ..	57°·3 "
30 " ... ..	52°·6 "
70 " ... ..	48°·6 "

*Duddingston and St. Margaret's Lochs* (see Plate CX.).—These two small shallow lochs, situated at the base of Arthur's seat in the immediate neighbourhood of Edinburgh, were sounded. Duddingston covers an area of about 20 acres and St. Margaret's about 4 acres, the maximum depths

being respectively 10 and 5 feet, the mean depth in each case being one-half of the maximum. The volume of water in Duddingston is about 4 million cubic feet, and in St. Margaret's about half a million cubic feet. They were surveyed on June 27, 1903, when the temperature of the water in Duddingston was  $61^{\circ}1$  Fahr., and in St. Margaret's  $60^{\circ}7$ .

*Harperrig Reservoir* (see Plate CXI.) is situated at the base of the Pentland hills, about 12 miles south-west of Edinburgh. It exceeds a mile in length from south-west to north-east, with a maximum breadth of half a mile, the superficial area being about 226 acres. It is, on the whole, comparatively shallow and flat-bottomed, with a small area of deep water near the outflow, the maximum depth of 30 feet being recorded close to the weir. More than one-half of the bottom is covered by water between 10 and 20 feet in depth, while only 4 per cent. is covered by more than 20 feet of water. The volume of water is estimated at 108 million cubic feet, and the mean depth at 11 feet. When surveyed on July 21, 1903, the elevation was 891.9 feet above sea-level.

*Threipmuir Reservoir* (see Plate CXII.) lies about 4 miles to the north-east of Harperrig reservoir, and is practically continuous with Harelaw reservoir, though standing about 25 feet higher. These two contiguous basins form a perfect contrast in conformation, Threipmuir covering an area six times greater than that of Harelaw, but being relatively shallow. Indeed, the south-western portion is merely a swamp. Threipmuir reservoir is  $1\frac{1}{2}$  miles in length from south-west to north-east, excluding a narrow arm branching off to the east; from the extremity of this arm to the extremity of the south-western swampy portion is fully 2 miles. The superficial area is about 192 acres, while the drainage area exceeds 6 square miles. The maximum depth of 17 feet occurs near the outflow, whence the water shallows gradually on proceeding to the south-west or along the narrow arm to the east. The volume of water is estimated at 66 million cubic feet, and the mean depth at 8 feet. When surveyed on July 1, 1903, the elevation was 831.5 feet above the sea, and the temperature of the water was uniform, the reading at the surface being  $59^{\circ}3$  Fahr., and at 10 feet  $59^{\circ}2$ .

*Harelaw Reservoir* (see Plate CXII.) is irregular in outline, and exceeds half a mile in length from south-west to north-east, covering an area of only 30 acres, and draining an area of 7 square miles, including Threipmuir. The depth increases gradually on proceeding from the inflow towards the outflow, where a maximum of 54 feet was recorded. The volume of water is estimated at 30 million cubic feet (nearly half that of Threipmuir), and the mean depth at 23 feet (nearly three times that of Threipmuir). When surveyed on July 1, 1903, the elevation was 806.0 feet above the sea. Temperatures taken in the deepest part gave some

interesting results, for from the surface down to 45 feet the temperature was found to be practically uniform, but between 45 and  $47\frac{1}{2}$  feet a fall of about  $5^{\circ}$  Fahr. was recorded—equal to  $2^{\circ}$  per foot of depth—the total range from surface to bottom being  $6^{\circ}\cdot 2$ . The readings were as follows:—

Surface ... ..	$58^{\circ}\cdot 5$ Fahr.
30 feet ... ..	$58^{\circ}\cdot 5$ „
40 „ ... ..	$58^{\circ}\cdot 0$ „
45 „ ... ..	$58^{\circ}\cdot 0$ „
$47\frac{1}{2}$ „ ... ..	$53^{\circ}\cdot 1$ „
50 „ ... ..	$52^{\circ}\cdot 3$ „

*Linlithgow Loch* (see Plate CXIII.) lies close to the town of Linlithgow, with the ruins of the historic palace standing on its southern shore. It is nearly a mile in length from north-east to south-west, with a maximum breadth of a quarter of a mile, the superficial area being about 103 acres. The promontory on which the palace stands cuts the loch into two halves, the north-eastern half being flat-bottomed and shallow (maximum 10 feet), the south-western half deepening from the outflow towards the central promontory, off which the maximum depth of 29 feet was recorded. The volume of water is estimated at 34 million cubic feet, and the mean depth at  $7\frac{1}{2}$  feet. When surveyed on June 25, 1903, the surface was 149·8 feet above the sea, practically identical with the elevation (149·9 feet) recorded by the Ordnance Survey on May 6, 1896. The following temperatures taken in the deepest part show a range from surface to bottom of  $7^{\circ}$  Fahr., the greatest fall being one of  $3^{\circ}$  between 10 and 15 feet:—

Surface ... ..	$62^{\circ}\cdot 2$ Fahr.
5 feet ... ..	$61^{\circ}\cdot 2$ „
10 „ ... ..	$58^{\circ}\cdot 8$ „
15 „ ... ..	$55^{\circ}\cdot 8$ „
25 „ ... ..	$55^{\circ}\cdot 2$ „

*Gartmorn Dam* (see Plate CXIV.) lies less than 2 miles from the town of Alloa on the northern shore of the Firth of Forth, and is used in connection with the water-supply to that town. It exceeds a mile in length from east to west, with a maximum breadth of one-third of a mile, the superficial area being about 140 acres, and the drainage area nearly 3 square miles. The water deepens gradually on proceeding from the east end towards the outflow at the west end, where the maximum depth of 21 feet was recorded; nearly half the bottom is covered by less than 10 feet of water, while nearly 10 per cent. is covered by more than 20 feet of water. The volume is estimated at 65 million cubic feet, and the mean depth at  $10\frac{3}{4}$  feet. When surveyed on May 17, 1905, the elevation could not be determined from bench-mark, but the scale at the weir showed 17 feet of water. The following temperatures taken in the deepest part show a range of  $4^{\circ}$  Fahr. from surface to bottom, there being a fall of no less than  $3^{\circ}$  between the surface and a depth of 5 feet:—

Surface ...	...	...	...	...	...	60°·0 Fahr.
5 feet ...	...	...	...	...	...	57°·0 "
10 ,, ...	...	...	...	...	...	56°·8 "
20 ,, ...	...	...	...	...	...	56°·0 "

*Peppermill Dam* (see Plate CXV.) lies little more than a mile from Kincardine, on the northern shore of the Firth of Forth, and about 2 miles from Gartmorn Dam. It is nearly a mile in length from east to west, with a maximum breadth of a quarter of a mile in the central part, whence it narrows towards both ends. The superficial area is about 90 acres, and the drainage area nearly 2 square miles. The eastern portion is shallow, the water deepening towards the west end, where the maximum of 17 feet was recorded. The volume of water is estimated at 34 million cubic feet, and the mean depth at  $8\frac{1}{2}$  feet. When surveyed on May 17, 1905, the elevation was 158·9 feet above the sea, as compared with 160·5 feet found by the Ordnance Survey officers on September 14, 1894. The following temperatures taken in the deepest part show a range of less than 3° Fahr. from surface to bottom, a fall of 1°·5 Fahr. being recorded between 5 and 10 feet:—

Surface ...	...	...	...	...	...	60°·0 Fahr.
5 feet ...	...	...	...	...	...	59°·5 "
10 ,, ...	...	...	...	...	...	58°·0 "
15 ,, ...	...	...	...	...	...	57°·3 "

*Moor Dam* (see Plate CXV.) is a little shallow basin lying between Peppermill Dam and the town of Kincardine. It is very irregular in outline, the maximum diameter from north to south being nearly half a mile, and the superficial area about 49 acres. Towards the western shore several soundings in 5 and 6 feet were taken, the northern and eastern parts, equal to three-fourths of the total area, being less than 5 feet in depth, the mean depth being estimated at  $3\frac{1}{4}$  feet, and the volume at 7 million cubic feet. When surveyed on May 17, 1905, the elevation was 145·4 feet above the sea, as compared with 146·8 feet determined by the Ordnance Survey on September 12, 1894. The temperature of the surface water was 60°·5 Fahr.

*Burttisland Reservoir* (see Plate CXVI.) lies about a mile from Aberdeen, and less than 3 miles from Burttisland, on the northern shore of the Firth of Forth. It is most irregular in outline, and about half a mile in maximum diameter, with a superficial area of about 43 acres. Very deep water occurs close to the sluice at the southern end, where the maximum of 39 feet was found, and a small area exceeding 20 feet in depth runs along the south-eastern shore, but more than half of the bottom is covered by less than 10 feet of water, the mean depth being estimated at nearly 12 feet, and the volume at 22 million cubic feet. When surveyed on May 19, 1905, the elevation was 290·0 feet above the sea. The following temperatures taken in the deepest part show a constant temperature down

to 20 feet, and then a fall of no less than 6° Fahr. between 20 and 30 feet:—

Surface ... ..	57°·0 Fahr.
10 feet ... ..	57°·0 „
20 „ ... ..	57°·0 „
30 „ ... ..	51°·0 „

*Kinghorn Loch* (see Plate CXVI.) is a small deep basin about half a mile from Kinghorn on the northern shore of the Firth of Forth. It is sub-circular in outline, and about one-third of a mile in maximum diameter, covering an area of about 30 acres. The basin is simple, with the maximum depth of 38 feet centrally placed, but towards the southern shore. The volume of water is estimated at 20 million cubic feet, and the mean depth at over 15 feet. When surveyed on May 19, 1905, the elevation was 203·4 feet above the sea, as compared with 205·2 feet found by the Ordnance Survey on May 4, 1893. The following temperatures taken in the deepest part show a constant temperature from the surface down to 20 feet, and then a fall of 4° Fahr. between 20 and 30 feet:—

Surface ... ..	55°·0 Fahr.
10 feet ... ..	55°·0 „
20 „ ... ..	55°·0 „
30 „ ... ..	51°·0 „

*Loch Fitty* (see Plate CXVI.) lies about 3 miles north of the town of Dumfermline in Fife, and 5 miles south of Loch Leven. It trends nearly east and west, and is nearly a mile in length, and practically uniform in width, the maximum breadth being about one-third, and the mean breadth a quarter, of a mile. The superficial area is about 143 acres, and the drainage area about 9 square miles. The loch forms a simple basin, with the deeper water lying along the southern shore, where an artificial bank has been built across, off which the maximum depth of 16 feet was found; the small part of the loch cut off by the embankment has a maximum depth of 12 feet. The volume of water is estimated at 46 million cubic feet, and the mean depth at 7½ feet, fully two-thirds of the bottom being covered by less than 10 feet of water. The loch was surveyed on May 12, 1905, when the elevation was 412·8 feet above the sea, as compared with 413·0 feet determined by the Ordnance Survey officers on March 22, 1894. The temperature at the surface was 53°·0 Fahr., and at a depth of 15 feet 52°·0.

*Loch Gelly* (see Plate CXVI.) lies about 4 miles to the east of Loch Fitty and about the same distance south-east of Loch Leven. It is a broad, shallow, flat-bottomed basin, three-quarters of a mile in length from east to west, by nearly half a mile in maximum breadth. The superficial area is about 148 acres, and the drainage area about 2½ square miles. The maximum depth is 9 feet, and the mean depth 5 feet, the volume of water being estimated at 32 million cubic feet. When surveyed on May 11, 1905, the elevation was 351·2 feet above the sea, almost identical with

that determined by the Ordnance Survey on July 8, 1893, viz. 351·1 feet. The temperature at the surface was 51°·0 Fahr., and at 8 feet 50°·5.

*Harperleas Reservoir* (see Plate CXVI.) lies about 3 miles north-east of Loch Leven, on the boundary between Fifeshire and Kinross-shire, and is used by the Kirkcaldy and Dysart Waterworks. It is a small artificial basin covering an area of about 40 acres, but relatively very deep, the maximum depth of 41 feet being found close to the eastern shore, while one-third of the bottom is covered by more than 25 feet of water. The mean depth is estimated at 18 feet, and the volume of water at 31 million cubic feet. When surveyed on May 16, 1905, the elevation was 848·35 feet above the sea. The temperature of the water varied little, the following readings being recorded :—

Surface ...	...	...	...	...	...	51°·0 Fahr.
10 feet ...	...	...	...	...	...	50°·0 "
20 "	...	...	...	...	...	49°·0 "
36 "	...	...	...	...	...	48°·7 "

*Holl Reservoir* (see Plate CXVII.) lies about a mile to the south-east of Harperleas, and has been recently made for the further supply of water to Kirkcaldy. Ballo reservoir lying between them had been emptied for repairs in February, 1905, and had very little water in it when visited in May, 1905. Holl reservoir covers an area of about 45 acres and is relatively deep, the maximum being 38 feet and the mean 17 feet, while nearly one-half of the bottom is covered by more than 20 feet of water. On May 16, 1905, the following temperatures were taken, showing a range throughout the body of water of 4° Fahr. :—

Surface ...	...	...	...	...	...	53°·0 Fahr.
10 feet ...	...	...	...	...	...	52°·2 "
20 "	...	...	...	...	...	49°·5 "
30 "	...	...	...	...	...	49°·0 "

*Kilconquhar Loch* (see Plate CXVIII.) lies close to the town of Kilconquhar, and about a mile north of Elie on the northern shore of the Firth of Forth. It is sub-circular in outline, and over half a mile in maximum diameter, covering an area of about 95 acres. It is a shallow flat-bottomed basin, the maximum depth being 6 feet and the mean depth 4 feet, the volume of water being estimated at 16 million cubic feet. When surveyed on May 18, 1905, the elevation was 48·6 feet above the sea, as compared with 49·4 feet determined by the Ordnance Survey on March 19, 1894. The temperature at the surface was 61°·5 Fahr., and at 5 feet 61°·0.

## SUMMARY TABLE.

Giving Details concerning the Reservoirs in the Forth Basin.

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.		
				Max.	Mean.	Max. Feet.	Mean. Feet.	Mean per cent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.	
Gladhouse	888-60	136	1.56	0.94	0.37	55	16.46	29.9	150	500	269.0	0.59	12.54	21.2	
Rosebery	731.50	73	0.68	0.22	0.12	55	25.20	45.8	65	142	58.0	0.08	13.97	—	
Portmore	999.00	60	0.66	0.36	0.25	41	16.79	40.9	85	208	76.0	0.16	3.28	20.5	
	[Dec. 23, 1892]														
Edgelaw	650.90	65	0.62	0.16	0.09	77	31.10	40.4	43	105	47.0	0.05	10.16	203.2	
Duddingston	130.45	38	0.34	0.16	0.08	10	5.14	51.4	180	349	4.0	0.01	0.10	3.3	
St. Margaret's	121.20	19	0.13	0.06	0.05	5	2.50	50.0	137	275	0.4	0.03	0.02	2.0	
Harperrig	891.90	53	1.27	0.51	0.28	30	10.96	36.5	233	597	108.0	0.35	2.55	7.3	
Threipmuir	831.50	105	1.50	0.32	0.20	17	7.90	46.5	466	1002	66.0	0.30	6.34	21.1	
Harelaw	806.00	60	0.60	0.13	0.08	54	22.83	42.3	59	139	30.0	0.05	6.96	139.2	
Linlithgow	149.80	78	0.80	0.26	0.20	29	7.55	—	—	559	34.0	0.16	0.77	4.8	
Gartnorn	—	62	1.04	0.34	0.21	21	10.75	51.2	261	511	65.0	0.22	2.72	12.4	
Peppermill	158.90	35	0.90	0.26	0.16	17	8.60	50.8	280	550	34.0	0.14	1.90	13.6	
Moor	145.40	26	0.47	0.35	0.16	34.7	3.27	54.5	413	758	7.0	0.07	0.33	4.1	
Burntisland	290.00	39	0.50	0.29	0.13	26.9	11.85	30.4	68	223	22.0	0.07	1.14	16.3	
Kinghorn	203.40	28	0.31	0.25	0.15	38	15.33	40.3	43	107	20.0	0.05	0.26	5.2	
Fitty	412.80	44	0.90	0.31	0.25	16	7.40	46.2	237	642	46.0	0.22	9.03	41.0	
Gally	351.20	47	0.76	0.46	0.30	9	5.03	55.9	446	798	32.0	0.33	2.52	11.0	
Harperleas	848.35	27	0.50	0.25	0.13	41	17.88	43.6	64	148	31.0	0.06	1.18	19.7	
Holl	—	19	0.44	0.34	0.16	36.3	17.04	46.8	61	136	33.0	0.07	2.85	40.7	
Kilconquhar	48.60	33	0.54	0.42	0.27	6	3.90	64.7	475	734	16.0	0.15	0.95	6.3	
		1065									998.4	3.07	43.69	14.2	

\* The drainage area of Rosebery reservoir includes that of Gladhouse; that of Edgelaw reservoir includes that of Portmore Loch; that of Harelaw reservoir includes that of Threipmuir reservoir; and that of Holl reservoir includes that of Harperleas reservoir.

From the table on page 258 it will be seen that in the twenty reservoirs under consideration 1065 soundings were taken, and that the aggregate area of the water-surface is about 3 square miles, so that the average number of soundings per square mile of surface is 355. The aggregate volume of water contained in the reservoirs is estimated at about 998½ millions of cubic feet. The area drained by these reservoirs is 43½ square miles, or about 14 times the area of the lochs.

## LOCHS OF THE TAY BASIN.

THE lochs of the Tay basin were dealt with in papers published in the *Geographical Journal* in March, 1901, September and November, 1903, and January, 1904. Subsequently the Loch of Lindores was sounded.

*Loch of Lindores* (see Plate CXIX.).—The Loch of Lindores lies 2 miles south of the Firth of Tay at Newburgh, and is nearly a mile in length from south-east to north-west, with a maximum breadth of nearly half a mile. The superficial area is about 110 acres, and the drainage area over 2 square miles. It is a shallow loch with a maximum depth of only 10 feet, observed in two places, a mean depth of 5 feet, the volume of water being estimated at 24 million cubic feet. The loch was surveyed on April 15, 1904, when the elevation was 221·09 feet above sea-level, as compared with 223·8 feet recorded by the Ordnance Survey officers on April 18, 1893.

## LOCHS OF THE LINNHE BASIN.

In the paper dealing with the lochs of the Lochy basin published in the *Geographical Journal* in December, 1906, two lochs on the shores of Loch Linnhe, Loch Lùn dà Bhrà and Loch nan Gabhar, were included. When sounding Loch nan Gabhar the surveyor was enabled to sound two little lochans lying about 2 miles to the east, near the Corran narrows at Ardour, which proved to be relatively very deep.

*Lochan na h-Eaglais* (see Plate CXX.).—Lochan na h-Eaglais (or Church Loch) is the smaller and shallower of the two, and sub-circular in outline, about one-sixth of a mile in maximum diameter, and covering an area of about 10 acres. It forms a simple deep basin, with a maximum depth of 43 feet, the mean depth being estimated at 23 feet, or more than half the maximum depth, and the volume of water at 10 million cubic feet. The loch was surveyed on May 12, 1903, but the elevation could not be determined. The following temperatures taken in the deepest part show a range of only 2<sup>o</sup>.5 Fahr. :—

Surface ...	...	...	...	...	...	50 <sup>o</sup> .0 Fahr.
10 feet ...	...	...	...	...	...	48 <sup>o</sup> .5 „
20 „ ...	...	...	...	...	...	47 <sup>o</sup> .8 „
40 „ ...	...	...	...	...	...	47 <sup>o</sup> .5 „

*Lochan Eion Mhic Alastair* (see Plate CXX.) is also sub-circular in outline, and a quarter of a mile in maximum diameter. There is a deep central basin with a maximum depth of 74 feet near the south-eastern end, where the slope is steep. The volume of water is estimated at 45 million cubic feet, and the mean depth at nearly 40 feet, or more than half the maximum. Considering its small area the loch is very deep, about 57 per cent. of the lake-floor being covered by more than 40 feet of water. The loch was surveyed on May 12, 1903, but the elevation could not be determined. The floods of the previous February had left a drift-mark 5½ feet above the level at the time of the survey, when the water was near its lowest level. The following temperatures taken in the deepest part of the loch show a range from surface to bottom of 3<sup>o</sup>.5 Fahr. :—

Surface ...	...	...	...	...	...	47 <sup>o</sup> .0 Fahr.
10 feet ...	...	...	...	...	...	46 <sup>o</sup> .8 „
25 „ ...	...	...	...	...	...	46 <sup>o</sup> .3 „
50 „ ...	...	...	...	...	...	45 <sup>o</sup> .0 „
65 „ ...	...	...	...	...	...	43 <sup>o</sup> .5 „

It is said to freeze over very seldom, and then only in extremely frosty weather.

## LOCHS OF THE CLYDE BASIN.

WITHIN this basin (see Index Map, Fig. 27) seven lochs were sounded by the Lake Survey staff, including one of the largest and most important of Scottish fresh-water lochs (Loch Lomond), which is interesting as being one of the two Scottish inland bodies of water surveyed "in the interests of navigation" by officers of the British navy so long ago as 1861. The other loch surveyed at that time was Loch Awe in the Etive basin, to be dealt with later. With the object of determining what changes in conformation, if any, had taken place in the interval of over forty years, Loch Lomond and Loch Awe were sounded in 1903, and the results were carefully compared with those obtained in 1861, as shown in the Admiralty charts published in 1862 and 1863 respectively. Generally speaking, the depths recorded by the two surveys, both in Loch Lomond and in Loch Awe, agree very closely, and it was at first considered that it would be unnecessary to publish the soundings in these lochs, but ultimately the Directors decided, in order to render the account of the work of the Lake Survey complete, to issue the maps of these lochs in the same form as the other maps accompanying this volume.

To the north of the Firth of Clyde, besides Loch Lomond, two neighbouring small lochs (Geal and Sloy) were sounded, and to the south of the Firth of Clyde, four lochs were sounded, viz. Kilbirnie Loch, Castle Semple Loch, Loch Thom, and Gryfe reservoir, the two last mentioned being artificial, and connected with the supply of water to the town of Greenock.

*Loch Lomond* (see Plates CXXIV. and CXXV.).—Loch Lomond is so well known that there is no necessity to enter here into a detailed topographic description; the beauty of its surroundings, which is enhanced by the many large islands occupying the wide southern portion, has been referred to by many writers, and has earned for it the title of "Queen of Scottish lakes" (see Fig. 35). Briefly, it may be stated that the loch trends nearly north and south, and in a straight line is about 21 miles in length, but following the sinuous axis of maximum depth, the length is nearly 23 miles, Loch Lomond being exceeded in this respect only by Loch Awe and Loch Ness. The upper northern portion for a distance of 12 or 13 miles from the head of the loch is narrow, mostly less than a mile across, but to the south of Ross point the loch opens out, and attains

a maximum breadth of 5 miles about 3 miles above the exit of the river Leven at Balloch; the mean breadth of the entire loch is about  $1\frac{1}{4}$  miles. In superficial area Loch Lomond is the largest of all the Scottish fresh-



FIG. 27.—INDEX MAP OF THE CLYDE BASIN.

water lochs, being estimated to cover  $27\frac{1}{2}$  square miles; its nearest rival in this respect is Loch Ness, with  $21\frac{3}{4}$  square miles, followed by Loch Awe with less than 15 square miles. The area draining into the loch

is about 270 square miles, or ten times the area of the loch. The maximum depth recorded by the Lake Survey was 623 feet, while on the Admiralty chart of Loch Lomond a maximum of 105 fathoms, equal to 630 feet, is shown, but there is no indication of the level of the water at the time of the Admiralty survey. The volume of water contained in the loch is estimated at 92,805 millions of cubic feet, or over one-half of a cubic mile; in this respect Loch Lomond ranks second among the Scottish lakes, being exceeded only by Loch Ness, the capacity of which is about three times greater. The mean depth of the entire loch is estimated at only  $121\frac{1}{4}$  feet, less than 20 per cent. of the maximum depth, which indicates that a large proportion of the lake-floor is covered by shallow water. As a matter of fact, more than two-thirds of the lake-floor is covered by less than 100 feet of water, as shown in the following table, giving the approximate areas between the consecutive contour-lines drawn in at equal intervals of 100 feet, and the percentages to the total area:—

Feet.			Acres.		Per cent.
0 to 100	...	...	11,881	...	67·6
100 „ 200	...	...	2,880	...	16·4
200 „ 300	...	...	974	...	5·5
300 „ 400	...	...	528	...	3·0
400 „ 500	...	...	450	...	2·6
500 „ 600	...	...	767	...	4·4
Over 600	...	...	85	...	0·5
			17,565		100·0

This table shows a gradually decreasing area with increasing depth down to the 500-foot contour, but then a striking increase in the area is indicated for the zone between 500 and 600 feet, compared with the two shallower zones, denoting that the deepest part of the loch partakes of a flat-bottomed character.

The bathymetrical conditions in Loch Lomond having been so long known, may be here referred to briefly. The conformation of the entire loch is complex, but especially so in the wide southern portion, where the contour lines of depth are sinuous in the extreme, but even the narrow northern portion, which might be looked upon as a characteristic elongated Highland loch, is to a certain extent irregular. There are three distinct 50-foot basins, separated by shallow water (1) at the entrance of the Douglas water, and (2) at the chain of islands consisting of Inchtavanach, Inchconnachan, Inchmoir, Inchcrum, Inchfad, and Inchcailloch, to the south of which chain the water is all less than 100 feet in depth. There are two 100-foot basins, one lying between the chain of islands mentioned and the entrance of the Douglas water, the other extending northwards uninterruptedly from the Douglas water delta to near the head of the loch. There are three 200-foot basins: a small one about a mile from the head of the loch having a maximum depth of 206 feet, a larger one south of the entrance of the Douglas water, circling round Ross point, having a

maximum depth of 217 feet, and the largest one extending from north of the Douglas water delta as far as Ardvorlich, about 2 miles from the head of the loch, enclosing all the deeper basins. The 300-foot and 400-foot contours are continuous, and enclose areas respectively over 8 and nearly 7 miles in length, lying to the north of the Douglas water delta. The 500-foot basin is cut in two portions by a ridge, on which the greatest depth is 483 feet, crossing the loch just south of Tarbet, the smaller southern portion being over a mile in length, and having a maximum depth of 564 feet, while the northern portion exceeds 3 miles in length and encloses the maximum depth of the loch. The 600-foot basin is a mile in length, and lies to the north of Tarbet, the maximum depth of 623 feet having been recorded little more than half a mile to the north-east of Tarbet island.

The survey of Loch Lomond occupied from May 30 to June 19, 1903. On commencing work the elevation of the surface of the water was determined by levelling from two bench-marks as being 23·9 feet above mean sea-level, and during the progress of the survey the water slowly fell to the extent of more than a foot, but all the soundings were reduced to that datum level; the elevation determined by the officers of the Ordnance Survey on October 12, 1896, was 26·9 feet above the sea, or 3 feet higher than on May 30, 1903. A drift-mark measured on June 9, 1903, was found to be  $7\frac{1}{2}$  feet above the water surface, so that the range in level is considerable.

*Temperature Observations.*—The temperature conditions in Loch Lomond have been studied by Mr. J. Y. Buchanan and others, and for purposes of comparison half a dozen serial observations taken during the survey are given here, arranged geographically from north to south.

SERIAL TEMPERATURES IN LOCH LOMOND.

Depth in feet.	June 2. Off Ardvorlich. Depth 205 feet.	June 11. Off Culness. Depth 622 feet.	June 18. Between the islands of Torrinch and Inchmoan. Depth 72 feet.	June 16. Between Creinch Island and Inchmurrin. Depth 60 feet.	June 19. Off eastern side of Inchmurrin. Depth 55 feet.	June 13. Southern end. Nearly a mile south of Inchmurrin. Depth 62 feet.
	° Fahr.	° Fahr.	° Fahr.	° Fahr.	° Fahr.	° Fahr.
0	46·0	58·1	57·4	56·6	57·2	59·5
10	45·8	—	—	56·6	—	—
15	—	—	—	56·6	—	58·3
20	45·2	57·8	—	—	57·2	—
25	45·2	—	55·3	—	—	—
30	—	52·7	—	56·0	57·0	56·8
35	—	—	52·0	—	—	—
40	—	46·3	—	—	53·5	52·9
50	44·5	45·8	50·5	—	51·2	—
60	—	—	—	55·8	—	49·6
70	—	—	49·4	—	—	—
100	44·0	43·8	—	—	—	—
200	42·8	42·7	—	—	—	—
300	—	42·2	—	—	—	—
400	—	42·2	—	—	—	—
500	—	42·2	—	—	—	—
600	—	42·2	—	—	—	—

*Geal Loch* (see Plate CXXIV.) is a small simple basin lying at the head of Loch Lomond, into which it drains. It is one-third of a mile in length in a north and south direction, and covers an area of about 28 acres. The maximum depth of 23 feet was recorded towards the northern end, the mean depth being estimated at nearly  $10\frac{1}{2}$  feet, and the volume of water at 12 million cubic feet.

*Loch Sloy* (see Plate CXXIV.) is situated about 3 miles south-west from Ardlui, and about 2 miles to the west of the upper part of Loch Lomond, the mighty Ben Vorlich rising between them; while to the west of Loch Sloy rises Beinn Dubh, and to the south-west Ben Voine and other lofty peaks. The floor of the loch is rocky, and the hollow in which it rests has probably been filled up to a large extent by boulders fallen from the steep slopes of Ben Vorlich and Beinn Dubh; the outflowing stream flows over solid rock, and the bed of the loch is undoubtedly a rock basin. The loch trends from north-west to south-east, and is extremely elongate in outline, being over a mile in length, but only one-eighth of a mile in maximum breadth. The superficial area is about 65 acres, of which about 73 per cent. is covered by less than 10 feet of water, and the drainage area is extensive, exceeding 6 square miles. The maximum depth of 31 feet was recorded near the southern end, the mean depth being estimated at over 8 feet, and the volume at 23 million cubic feet. The floor of the loch is irregular, there being two 10-foot basins, the larger, over half a mile in length, occupying the southern portion of the loch, separated from the smaller, a quarter of a mile in length, by a ridge covered by 1 and 2 feet of water. The loch was surveyed on June 11, 1903, but the elevation above the sea could not be determined; judging from spot-levels it appears to be about 810 feet above sea-level.

*Kilbirnie Loch* (see Plate CXXXII.) is a broad oblong sheet of water in the county of Ayr, between the villages of Kilbirnie and Beith, 16 miles from Glasgow. It lies entirely in cultivated land, the G. and S.W. Railway skirts its eastern shore, and the southern end is occupied by ironworks and chemical works, the *débris* from which encroaches upon the loch. The length is over  $1\frac{1}{4}$  miles, and the greatest breadth is fully one-third of a mile. The loch is shallow, more than half the area being covered by less than 10 feet of water, and the mean depth is  $9\frac{3}{4}$  feet. The west side is shallow, a depression running parallel to the east shore, in which there are two holes of 24 feet and 30 feet respectively. The area is about 247 acres, or nearly two-fifths of a square mile, and the volume of water 105 millions of cubic feet. The drainage area extends to about 2 square miles. The Maich burn is the chief feeder, entering at the north end. The outflow is by the Dubb's burn, which flows from the north-east corner of the loch northward by the bed of the Barr Loch (now drained) into Castle Semple Loch.

On the date of the survey (July 26, 1906) the surface was 100.3 feet above sea-level.

*Castle Semple Loch* (see Plate CXXXIII.) is a fairly large loch, in the county of Renfrew, about 15 miles west of the city of Glasgow. The north shore is wooded, and there is a sparse strip of trees on the south shore also, between the loch and the railway. The loch is of narrowly triangular form, broadest near the west end, and measures  $1\frac{3}{4}$  miles in length, and a little more than one-third of a mile in breadth. It is extremely shallow and flat-bottomed, 5 feet in maximum depth, and  $2\frac{1}{2}$  feet in mean depth. The area is about 203 acres, or one-third of a square mile, and the volume 22 millions of cubic feet. Castle Semple Loch receives the drainage of an extensive area (nearly 36 square miles), chiefly brought from the hills to the west by the river Calder, which enters the west end of the loch. The Black Cart water issues from the east end of the loch, and, after flowing 10 miles to the north-east, enters the Clyde 3 miles north of Paisley.

The level of the surface on May 7, 1896, was found by the Ordnance Survey to be 89·6 feet above the sea. The temperature was 60°·0 Fahr. throughout on July 21, 1906.

*Upper Gryfe Reservoir* (see Plate CXXXIV.)—The Gryfe reservoir, which lies 3 miles south of Greenock, and immediately to the east of Loch Thom, has been formed by draining the upper portion of the valley of the Gryfe, and is a part of the Greenock Waterworks. The surroundings are moorland and pasture. The north shore rises more steeply from the loch. When full the length is  $1\frac{1}{3}$  miles, but on the date of the survey (October 8, 1906) the loch was very low, and was only about a mile long. The greatest breadth at the east end was fully one-third of a mile. The maximum depth close to the dam was 34 feet, and the mean depth over 17 feet. The superficial area was about 115 acres, and the volume 87 millions of cubic feet. The drainage area is  $2\frac{1}{2}$  square miles. The river Gryfe flows eastward about 12 miles, and joins the Black Cart near Paisley. The elevation was 598·2 feet above sea-level.

*Loch Thom* (see Plate CXXXIV.) is a large artificial loch, the principal reservoir of the Greenock Waterworks, lying at an elevation of 632·4 feet above the sea among the hills some 3 miles south of Greenock. It is surrounded by moorland, and there are one or two farms on the shores.

The loch was very low at the time of the survey (August 16, 1906), and the large island near the east dam was joined to the shore. The length, measured in a straight line from north to south, is  $1\frac{1}{2}$  miles. The axis of the loch is strongly curved. The greatest breadth, about the middle of the loch, is half a mile. The depth is greatest in the northern part, and the maximum depth of 42 feet is near the northern end of the loch. The mean depth is  $19\frac{1}{4}$  feet, the area about 331 acres, or half a square mile, and the volume 277 millions of cubic feet. The drainage area is about  $5\frac{1}{2}$  square miles.

The temperature was identical (60°·0 Fahr.) at the surface and at 35 feet.

## SUMMARY TABLE.

*Giving Details concerning the Lochs in the Tay, Linnhe, and Clyde Basins.*

Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.	
				Max.	Mean.	Mean breadth per cent. of length.	Max. Feet.	Mean. Feet.	Mean per cent. of max.	Max.			Mean.	Total in square miles.
Lindores	221.09	48	0.84	0.40	0.21	25.0	10	5.06	44.4	877	24	0.17	2.12	12.5
na h-Eaglais	—	25	0.16	0.14	0.10	62.5	43	23.84	20	37	10	0.02	0.04	2.0
Eion Mhic Alastair	—	33	0.25	0.20	0.16	64.0	74	39.73	18	33	45	0.04	1.35	33.7
Lomond	23.9	2200	22.64	4.83	1.21	5.3	623	121.29	192	986	92,805	27.45	270.43	9.9
Geal	—	26	0.92	0.16	0.13	40.6	23	10.38	73	163	12	0.04	0.13	3.2
Sloy	[about 810]	91	1.12	0.12	0.09	8.0	31	8.12	191	728	23	0.10	6.23	62.8
Kilbirnie	100.3	29	1.32	0.38	0.29	22.0	30	9.72	232	717	105	0.39	1.85	4.7
Castle Semple	89.6 [May 7, 1896]	54	1.72	0.38	0.18	10.4	5	2.50	1816	3632	22	0.32	35.73	111.7
Gryte	598.2	26	0.94	0.32	0.19	20.2	34	17.35	146	286	87	0.18	2.45	13.6
Thorn	632.4	61	1.78	0.52	0.29	16.3	42	19.25	224	488	277	0.52	5.66	10.9
		2593									93,410	29.23	317.73 *	10.9

\* The drainage area of Loch Lomond includes those of Loch Sloy and Geal Loch; and that of Castle Semple Loch includes that of Kilbirnie Loch.

From the table on page 268 it will be seen that in the ten lochs under consideration 2593 soundings were taken, and that the aggregate area of the water-surface is  $29\frac{1}{4}$  square miles, so that the average number of soundings per square mile of surface is 88. The aggregate volume of water contained in the lochs is estimated at 93,410 millions of cubic feet. The area drained by these lochs is 318 square miles, or eleven times the area of the lochs.

## LOCHS OF THE ETIVE BASIN.

WITHIN the area draining into Loch Etive (see Index Map, Fig. 28) the staff of the Lake Survey sounded some twenty lochs, including Loch Awe, one of the most important of the Scottish fresh-water lochs, which was surveyed by naval officers in 1861, as already mentioned when speaking of Loch Lomond, in the Clyde basin, the only other loch in Scotland surveyed by the Government. Loch Awe has the distinction of being the longest lake in Scotland, and in comparison with it the other lochs in the basin are dwarfed into insignificance; still, Lochs Avich and Tulla are good-sized basins, exceeding each a square mile in superficial area, but the remaining lochs are mostly very small. Dubh Lochan, near Kingshouse, drains by the river Etive into the head of Loch Etive; Loch Dochard drains into Loch Tulla, and thence by the river Orchy into Loch Awe; Lochan na Bi, near Tyndrum, drains by the river Lochy, which joins the river Orchy just before entering Loch Awe at Dalmally; Loch Ederline, near the head of Loch Awe, Loch Avich, to the west of the central part of Loch Awe, Lochs an Leòid, an Droighinn, and na Gealaich, to the west of the lower part of Loch Awe, and the four little hill lochs near Portsonachan (Lochs Rainbow, Choire na Cloich, Dhu, and Allt na Mult) all drain into Loch Awe by longer or shorter streams; Loch Sior drains into Loch Nant, and thence by the river Nant into Loch Etive at Taynult; the Black Lochs drain by the Lusragan burn into Loch Etive at Connel ferry, while Lochans nan Ràth and na Beithe lie on the north side of Loch Etive, opposite Connel ferry. The scenery of the district is very fine, and the fishing in most of the lochs good. Loch Awe contains salmon and *Salmo ferox*, as well as trout.

*Loch Awe* (see Plates CXXII. and CXXIII.).—Loch Awe being so well known, and the depth conditions having been known since the publication of the Admiralty chart in 1863, no lengthy description is called for here. It is extremely elongate, but sinuous, in outline, and is peculiar in that a long narrow arm branches off at right angles to the main axis, and leads through the Pass of Brander to the outflow (see Fig. 36). As already indicated, Loch Awe exceeds in length all other Scottish fresh-water lochs, for measured along the central axis from the head of the loch to the exit of the river Awe, in the Pass of Brander, it is almost  $25\frac{1}{2}$  miles in length. Even excluding the narrow arm, and measuring from the head of the loch



The superficial area is nearly 15 square miles, which places Loch Awe third in this respect among the Scottish lakes, being exceeded only by Loch Lomond with  $27\frac{1}{2}$  square miles, and Loch Ness with  $21\frac{3}{4}$  square miles.

Loch Awe was surveyed on May 9 to 22, 1903, and during this time the level of the water varied to the extent of about 2 feet, the highest level, as measured from bench-mark, being 117.9 feet above the sea, and to this level all the soundings on the map have been reduced. It is interesting to note that this elevation is identical with that determined by the naval officers during their survey in 1861, so that the depths shown on the Admiralty chart are strictly comparable with those shown on the Lake Survey map now published. Thus the maximum depth given on the Admiralty chart is 51 fathoms, or 306 feet, four soundings at this depth being indicated between 4 and 5 miles from the head of the loch, while the maximum depth recorded by the Lake Survey is 307 feet, two soundings being taken at this depth in a similar position. As regards maximum depth, Loch Awe is exceeded by fourteen Scottish lakes, and as regards mean depth, which is estimated at 105 feet, Loch Awe is exceeded by nineteen Scottish lakes. The volume of water in Loch Awe is estimated at 43,451 millions of cubic feet, which is exceeded by only four Scottish lakes (Lochs Ness, Lomond, Morar, and Tay).

The floor of Loch Awe is uneven, as will be seen from the longitudinal section along the axis of maximum depth placed at the foot of the map. Some of the cross-lines of soundings also show irregularities of the bottom. The 50-foot contour-line is continuous, and coincides, on the whole, with the outline of the loch, extending nearly from end to end. The 100-foot contour encloses three separate areas—(1) the largest extending from little more than a mile from the head of the loch to near the islands at the junction of the arm at the Pass of Brander, a distance of about 18 miles; (2) the second, extending from about half a mile from the entrance of the river Orchy into the arm at the Pass of Brander, is over 4 miles in length; and (3) the smallest, based on soundings in 125 and 128 feet, in the Pass of Brander, separated from the second area by a depth of 86 feet. The 200-foot contour encloses no fewer than five separate areas: (1) a very small area based on an isolated sounding in 200 feet about 2 miles from the head of the loch, separated from the second area by a depth of 195 feet; (2) the principal area, including the deepest water in the loch, about  $5\frac{1}{2}$  miles in length, extending from the entrance of the Kames river to little more than 2 miles from the head of the loch; (3) an area about  $1\frac{1}{2}$  miles in length at the junction of the main loch with the arm at the Pass of Brander, having a maximum depth of 249 feet; (4) a small area, based on soundings in 207, 217, and 230 feet, lying between the islands of Innis Chonain and Eilean Beith; and (5) a small area with a maximum depth of 234 feet, off Rudha Dubhairt, about  $1\frac{1}{2}$  miles from the entrance of the river Orchy. It is to be noted that the middle

portion of the loch between Port-in-Sherrick and Inistrynich—a stretch of over 12 miles in length—is less than 200 feet in depth, the deepest sounding recorded between these two places being 196 feet. The 300-foot contour encloses an area about  $1\frac{1}{2}$  miles in length, less than 5 miles from the head of the loch, two soundings at the maximum depth of 307 feet being recorded about half a mile apart.

The following table, giving the approximate areas between the contour-lines drawn in at intervals of 100 feet, and the percentages to the total area of the loch, shows that considerably more than one-half of the lake-floor is covered by less than 100 feet of water:—

Feet.	Acres.	Per cent.
0 to 100	5474	57·6
100 „ 200	2900	30·5
200 „ 300	1017	10·7
Over 300	114	1·2
	9505	100·0

*Temperature Observations.*—During the progress of the survey four series of temperatures were taken, which showed a total range throughout the whole body of water of only  $3\frac{1}{2}^{\circ}$  Fahr., as given in the following table:—

SERIAL TEMPERATURES IN LOCH AWE.

Depth in feet.	May 11, north-east of Rudha Gainmheine, in 160 feet.	May 21, between Portsonachan and Taychreggan, in 158 feet.	May 9, off Ceann Mara, in 153 feet.	May 20, between Badan Tomain and Innis Chonain, in 163 feet.
	° Fahr.	° Fahr.	° Fahr.	° Fahr.
0	45·2	46·1	45·2	47·1
5	—	—	45·0	—
10	—	46·0	44·4	—
15	—	—	44·1	—
25	—	45·8	44·1	46·8
50	43·8	45·6	44·1	45·1
100	43·8	45·2	43·9	44·8
150	43·6	—	43·8	—
155	—	44·9	—	—
160	—	—	—	44·4

*Dubh Lochan* (see Plate CXXVI.).—The name Dubh Lochan is applied to four little lochs lying about a mile south-east of Kingshouse. They are all weedy, and only the one lying farthest to the south-east was surveyed. It takes the form of a V with one limb pointing to the north, the other to the north-west. The length is a little over a quarter of a mile, and the superficial area about 17 acres. The maximum depth of 10 feet was found about 150 yards from the end of the north limb. The volume of water is estimated at 2 million cubic feet, and the mean depth at nearly 3 feet. Dubh Lochan was surveyed on May 21, 1903, but the level could not be determined; the elevation given on the Ordnance Survey

map is 1001 feet above the sea, though the date is not mentioned. The temperature of the surface water was  $49^{\circ}.5$  Fahr.

*Loch Dochard* (see Plate CXXVII.) lies about 3 miles to the west of Loch Tulla, into which it drains. There are some huge boulders on the shore, and the river both on entering and leaving the loch has considerable volume, silting up having taken place at the inflow, while at the outflow rock is exposed on both sides. The loch is somewhat irregular in outline, trending east and west, and is about two-thirds of a mile in length. The superficial area is about 86 acres, and the drainage area nearly 8 square miles. The maximum depth of 42 feet was recorded near the centre of the wide part of the loch. The volume of water is estimated at 44 million cubic feet, and the mean depth at 12 feet. The loch was surveyed on May 18, 1903, but the level could not be ascertained, though it was estimated from spot-levels to be about 735 feet above the sea. The loch is fairly simple in conformation, the deep water occupying a central position, but a sounding in 15 feet was taken towards the northern shore, surrounded by depths exceeding 25 feet. A spit of sand and boulders projects into the loch from the southern shore, and from its extremity a shoal or causeway, covered by 2 or 3 feet of water, extends to the western shore; in close proximity to this shoal soundings in 17 and 18 feet were recorded.

The surface temperature over the deep part of the loch was  $48^{\circ}.0$  Fahr., whereas in the shallow bay at the east end the temperature of the surface water was no less than  $6^{\circ}$  higher, viz.  $54^{\circ}.0$ .

*Loch Tulla* (see Plate CXXVIII.) lies about 8 miles north-west of Tyndrum, and only 2 miles to the south of Lochan na h-Achlaise, in the Tay basin. It trends in a north-east and south-west direction, and is  $2\frac{1}{2}$  miles in length, and nearly a mile in maximum breadth, the mean breadth being nearly half a mile. The superficial area is about 703 acres, or over a square mile, and the drainage area about 57 square miles, including Loch Dochard. The maximum depth of 84 feet was recorded in two places near the centre of the loch, about a quarter of a mile to the north-east of the central island. The volume of water is estimated at 1167 millions of cubic feet, and the mean depth at 38 feet. The loch was surveyed on April 16, 1903, the elevation above the sea being determined by levelling from benchmark as 542.3 feet. According to the hotel-keeper, the water was low at the time, the range in level being about 6 feet.

The loch is complex in conformation, due largely to the presence of a small island (Eilean an Stalcair) near the middle of the loch, opposite the exit of the river Orchy, in the vicinity of which the bottom is irregular, and the contour-lines sinuous in character. The main body of water lies to the north-east of the island, where there is a 50-foot basin nearly  $1\frac{1}{2}$  miles in length, enclosing a 75-foot basin over three-quarters of a mile in length. To the south-west of the island there is a small subsidiary 50-foot

basin opposite the entrance of the Allt Bhreacnais, based on half a dozen soundings, the deepest in 58 feet. Silting up has taken place at the embouchures of the inflowing streams, notably at the two ends of the loch; to this is evidently due the curious loop in the 25-foot contour at the western end. In the south-western angle of the loch, where the Allt Orain enters, lies a little basin with a maximum depth of 24 feet, cut off from the main loch by the narrows between Eilean Mhic na h-Ainnis and the western shore, in which the depth is only a foot. The areas between the contour-lines, and the percentages to the total area, are as follows:—

Feet.			Acres.		Per cent.
0 to 25	...	...	263	...	37·4
25 „ 50	...	...	214	...	30·5
50 „ 75	...	...	148	...	21·1
Over 75	...	...	78	...	11·0
			703		100·0

A series of temperatures taken in the deepest part of the loch at 6.10 p.m. indicated a uniform temperature of 41°·0 Fabr. from surface to bottom. Two surface readings near shore earlier in the day gave 43°·9 and 44°·1.

*Lochan na Bì* (see Plate CXXVI.) lies in Argyllshire near the boundary of Perthshire, 10 miles from Dalmally and a mile from Tyndrum, the road and railway between these places passing along the northern shore. It is a shallow loch, trending almost east and west, surrounded by swampy ground covered in places with small trees. It is about three-quarters of a mile in length, with a maximum breadth of about one-eighth of a mile, and covers an area of about 39 acres. The maximum depth of 6 feet was observed near the centre of the loch. The volume of water is estimated at 6 million cubic feet, and the mean depth at over 3 feet. The loch was surveyed on May 21, 1903, when the elevation was 823·25 feet above sea-level; the elevation is given on the Ordnance Survey map as 822 feet, but the date is not mentioned.

*Loch Ederline* (see Plate CXXII.) is situated near the head of Loch Awe, and is irregular in outline, trending almost north and south. The loch is nearly two-thirds of a mile in length, with a maximum breadth of over one-third of a mile, covering an area of about 70 acres, and draining an area of over 12 square miles. The basin is simple, though the contour-lines are sinuous in character, the maximum depth of 58 feet being observed towards the south end. The volume is estimated at 70 million cubic feet, and the mean depth at 23 feet.

It was surveyed on May 22, 1903, when the elevation was found to be 122·4 feet above sea-level; on June 25, 1864, the Ordnance Survey officers determined the elevation as 122·0 feet. The temperature of the surface water was 51°·0 Fabr.

*Loch Avich* (see Plate CXXII.) lies little more than a mile to the west of the central part of Loch Awe, into which it drains by the river Avich. It is the largest loch after Loch Awe in the Etive basin, and trends east-north-east and west-south-west; it is narrowly triangular in outline, the east end forming the base and the west end the apex. The length is  $3\frac{1}{3}$  miles, and the greatest breadth nearly half a mile. The superficial area is about 776 acres, or nearly  $1\frac{1}{2}$  square miles, and the drainage area over 11 square miles. The maximum depth of 188 feet was recorded in two places towards the eastern end. The volume of water is estimated at 3327 millions of cubic feet, and the mean depth at  $98\frac{1}{2}$  feet, or more than half the maximum.

Loch Avich was surveyed on May 26 and 27, 1903, the elevation being 310.85 feet above sea-level, which is identical with the level observed by the Ordnance Survey on March 3, 1865. The conformation of the loch is simple, the contour-lines coinciding approximately with the outline. The 50-foot basin is about 3 miles, the 100-foot basin about  $2\frac{1}{2}$  miles, and the 150-foot basin nearly 2 miles, in length, in each case approaching closer to the east than to the west end. One of the soundings at the maximum depth (188 feet) was taken a little more than half a mile, and the other about a mile, from the promontory called Rudha Bàrr na h-Earba, at the east end of the loch. The off-shore slope is in places very steep; for instance, off the northern shore, about three-quarters of a mile from the east end, soundings in 60 and 82 feet were taken close in-shore, the latter only 80 feet off, giving a gradient exceeding 1 in 1; and off the south shore, where the Abhainn Mhor enters, a sounding in 100 feet was recorded about 120 feet off-shore, indicating a gradient of nearly 1 in 1; and at the extreme east end a sounding in 102 feet was taken comparatively close in.

The approximate areas between the contour-lines drawn in at equal intervals, and the percentages to the total area, are as follows:—

Feet.		Acres.	Per cent.
0 to 50	... ..	230	29.6
50 „ 100	... ..	144	18.6
100 „ 150	... ..	185	23.8
Over 150	... ..	217	28.0
		776	100.0

The flat-bottomed nature of the basin, giving the well-marked U-section characteristic of glacier-eroded rock-basins, is strikingly shown by the large areas of the deep-water zones, especially of the deepest zone of all, which is nearly equal to the shore zone, although the interval between the 150-foot contour and the greatest depth is only 38 feet as compared with 50 feet for the other zones.

*Temperature Observations.*—During the two days devoted to the survey the surface temperature varied from  $50^{\circ}8$  to  $60^{\circ}1$  Fahr. The following temperatures were taken in the deepest part of the loch at 6 p.m. on May 27, 1903:—

Surface ... ..	55°·9 Fahr.
5 feet ... ..	55°·0 "
10 " ... ..	50°·5 "
15 " ... ..	49°·5 "
25 " ... ..	47°·0 "
50 " ... ..	45°·1 "
75 " ... ..	45°·0 "
100 " ... ..	44°·8 "
180 " ... ..	44°·1 "

The range from surface to bottom was 11°·8, the greatest fall being one of 4°·5 between 5 feet and 10 feet, or nearly 1° per foot of depth.

*Loch an Leòid* (see Plate CXXIII.) lies about 2 miles north-west of Loch Awe at Kilchrenan, and drains into the neighbouring Loch an Droighinn, and thence into Loch Awe by the Kilchrenan burn. It is separated from Loch Nant, distant about half a mile to the west, by a very low-lying divide, little more than 100 feet above the lochs at its highest part. Loch an Leòid is almost rectangular in outline, and trends in a north-east and south-west direction, the length being half a mile, the maximum breadth a quarter of a mile, and the superficial area about 73 acres. The greatest depth of 84 feet was recorded near the southern end. The volume of water is estimated at 114 million cubic feet, and the mean depth at nearly 36 feet. The loch was surveyed on May 22, 1903, the elevation on that date being 602·2 feet above sea-level, nearly identical with that observed by the Ordnance Survey officers on August 27, 1864, viz. 602·1 feet. The basin is rather irregular; across the centre of the loch there is a slight shallowing, with deeper water both to the north and south, a sounding in 79 feet being recorded about 300 yards from the northern shore, and the deepest sounding in 84 feet about 200 yards from the southern shore.

Temperatures taken in the deepest part show a range of 2°·2 Fahr. from surface to bottom, the greatest fall being observed between 50 and 75 feet:—

Surface ... ..	48°·5 Fahr.
25 feet ... ..	48°·2 "
50 " ... ..	47°·6 "
75 " ... ..	46°·3 "

*Loch an Droighinn* (see Plate CXXIII.)—Loch an Droighinn (or Loch Wren) lies immediately to the east of, and runs parallel with, its neighbour, Loch an Leòid. It is over half a mile in length, and covers an area of about 50 acres. The maximum depth of 48 feet is centrally placed, but rather nearer to the north end. The volume of water is estimated at 32 million cubic feet, and the mean depth at nearly 15 feet. The loch was surveyed on May 25, 1903, when the elevation was 601·65 feet above sea-level; when determined by the Ordnance Survey officers on August 27, 1864, the elevation was 601·0 feet above the sea. There are two 20-foot basins, the one to the south of the central island having

a maximum depth of 29 feet, the other to the north of the island including the deepest water in the loch.

The following temperatures taken in the deepest part show a range of 6°·9 Fahr., a fall of 4°·8 being recorded between 25 and 45 feet:—

Surface ...	...	...	...	...	...	56°·0 Fahr.
25 feet ...	...	...	...	...	...	53°·9 „
45 „ ...	...	...	...	...	...	49°·1 „

*Lochan na Gealaich* (see Plate CXXIII.).—This small loch is situated about a mile to the north-west of Loch Awe, into which it drains at Taychreggan, and is sub-circular in outline, with a maximum diameter of about one-fifth of a mile, and covering an area of about 16 acres. Two soundings were taken at the maximum depth of 25 feet near the middle of the loch. The volume is estimated at 7 million cubic feet, and the mean depth at 10 feet. It was surveyed on May 25, 1903, but the level could not be determined. The surface temperature was 59°·0 Fahr.

*Portsonachan Hill Lochs* (see Plate CXXIII.).—Four little lochs at an elevation of 1300 feet and over on the hill to the south of Portsonachan were sounded by members of the Lake Survey staff, while engaged on the survey of Loch Awe, on May 28, 1903. The most northerly one, called Rainbow Loch, has a maximum depth of 26 feet; the neighbouring one, to the south-west, called Loch Choire na Cloich, has a maximum depth of 20 feet; the next one, to the south, called Lochan Dhu, has a maximum depth of 12 feet; while the most southerly one, called Lochan Allt na Mult, is the smallest and shallowest of the group, not exceeding 3 feet in depth.

*Sior Loch* (see Plate CXXIX.).—The name Sior Loch is applied to three shallow little lochs about  $1\frac{1}{2}$  miles to the south-west of Loch Nant, into which they drain by the Abhainn Càrn Linne. They are rapidly becoming bog—very reedy, with the bottom covered by a thick mass of vegetation. The middle loch was the only one sounded on June 4, 1903, as the boat could not be transported to the other basins; the maximum depth of 4 feet was observed in several places towards the east end. The elevation given on the Ordnance Survey map is 733 feet above the sea, though the date is not mentioned.

*Loch Nant* (see Plate CXXIII.) lies little more than 2 miles north-west of Loch Awe at Kilchrenan, but drains northward into Loch Etive. It is irregular in outline, trending in a north and south direction, and is nearly a mile in length, with a maximum breadth of one-third of a mile. Its waters cover an area of about 140 acres, and it drains an area exceeding 9 square miles, including Sior Loch. The maximum depth of 92 feet was recorded in the southern portion of the loch. The volume of water is estimated at 148 million cubic feet, and the mean depth at over 24

feet. The loch was surveyed on May 23, 1903, but the level could not be determined; from spot-levels the elevation is apparently about 606 feet above the sea. There are two deep basins in the loch, the northern one having a maximum depth of 59 feet, while the southern one includes the deepest water in the loch. It is curious to note near the middle of the southern basin a shoal sounding in 22 feet surrounded by much deeper water, and a short distance to the south an isolated deep sounding in 70 feet.

The following temperatures taken in the deepest part of the loch show a range of less than 3° Fahr. from surface to bottom:—

Surface ... ..	49°·8 Fahr.
25 feet ... ..	49°·3 "
50 " ... ..	48°·9 "
60 " ... ..	47°·9 "
70 " ... ..	47°·0 "
85 " ... ..	46°·9 "

*Black Lochs* (see Plate CXXX.)—The Black Lochs may be looked upon as three expansions of the Lusragan burn (or rather four, since the upper loch is cut into two basins), stretching for a distance of about 2 miles in a north-east and south-west direction. The upper or northern extremity is about a mile to the south-east of Connel ferry. The basins decrease in depth on proceeding from north to south, the maximum depth of 36 feet having been observed close to the north end, while the maximum depth in the lower half of the upper loch is 32 feet, in the middle loch 27 feet, and in the southernmost basin 22 feet. The lowest part is blocked for a considerable distance by reeds, which are found also at various places along both shores up to the head. They were surveyed on May 25, 1903, the approximate elevation, judging from spot-levels, being about 80 feet above the sea. The temperature of the surface water was 58°·3 Fahr.

*Lochan nan Ràth* and *Lochan na Beithe* (see Plate CXXXI.) lie close to the northern shore of Loch Etive, opposite Connel ferry. They seem to have been formed by landslips. *Lochan nan Ràth* covers an area of about 14 acres, and is cut into two basins by a ridge across the narrow central part, on which there is only 2 feet of water. To the south-west of the ridge a depth of 19 feet was recorded, while the maximum depth of 32 feet was found to the north-east of the ridge. The temperature of the surface water on May 26, 1903, was 62°·2 Fahr.

*Lochan na Beithe* forms a comparatively simple deep basin, covering an area of about 19 acres. The deepest part lies towards the western shore, where four soundings exceeding 50 feet (maximum 58 feet) were taken. The volume of water is estimated at 23 million cubic feet, and the mean depth at 28 feet, or nearly one-half of the maximum. There is a slight constriction near the middle, accompanied by a slight shoaling of the water. The surface temperature on May 26, 1903, was 58°·4 Fahr.

SUMMARY TABLE.  
Giving Details concerning the Lochs in the Eivne Basin.

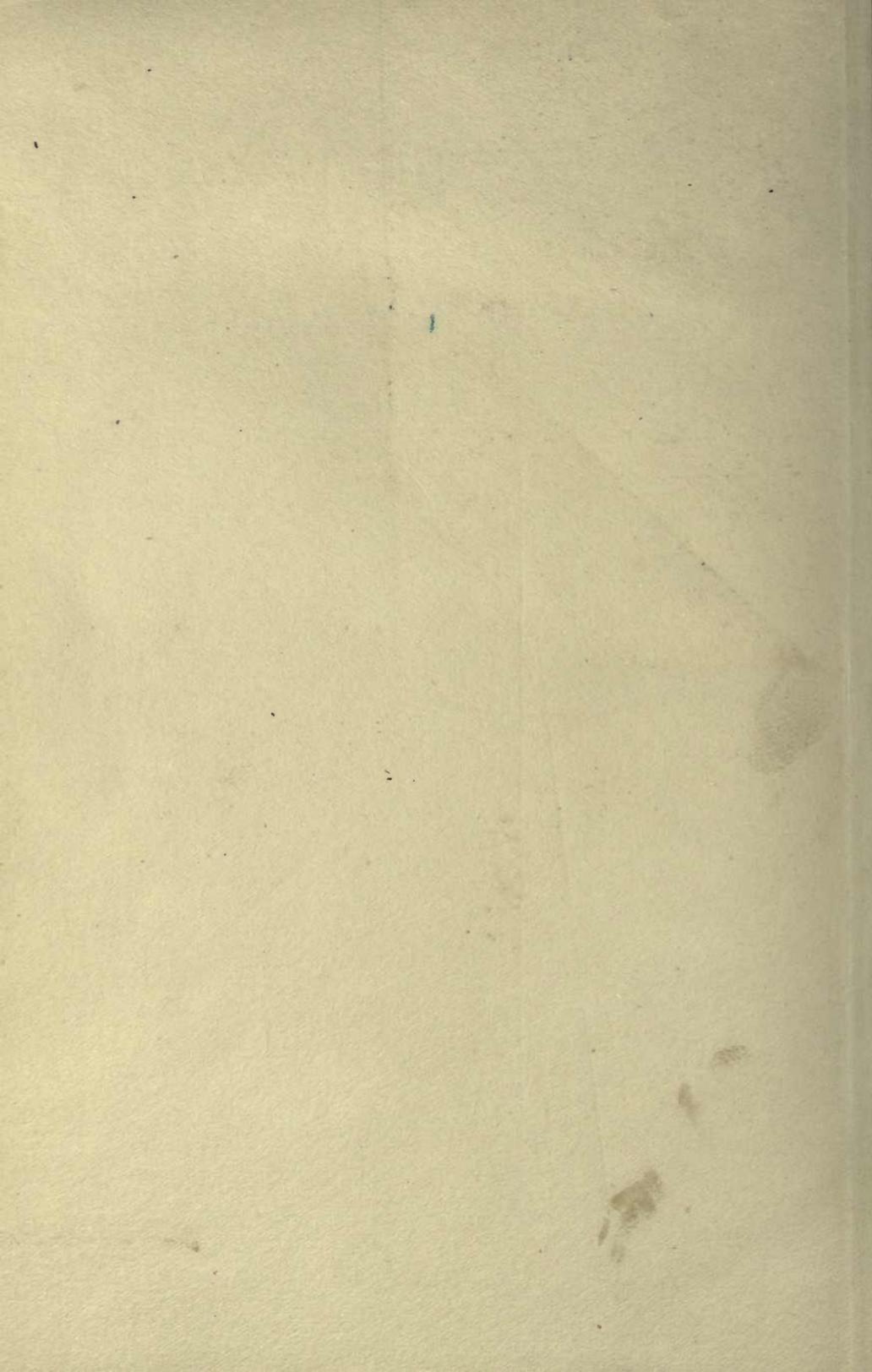
Loch.	Height above sea. Feet.	Number of soundings.	Length in miles.	Breadth in miles.		Mean breadth per cent. of length.	Depth.			Ratio of depth to length.		Volume in million cubic feet.	Area in square miles.	Drainage area.		
				Max.	Mean.		Max. Feet.	Mean. Feet.	Mean percent. of max.	Max.	Mean.			Total in square miles.	Ratio to area of loch.	
Awe ...	117·90	1493	25·47	2·22	0·58	2·3	307	104·95	34·2	438	1281	43,451·0	14·85	291·18	19·6	
Dubh ...	—	11	0·35	0·14	0·08	21·8	10	2·76	27·6	185	670	20	0·03	0·62	20·7	
Dochard ...	about 735	48	0·62	0·30	0·22	35·0	42	11·84	28·2	78	277	44·0	0·13	7·63	58·7	
Tulla ...	542·30	318	2·50	0·86	0·44	17·6	84	38·08	45·3	157	347	1,167·0	1·10	56·94	51·8	
na Bl ...	823·25	32	0·70	0·12	0·09	12·4	6	3·30	55·0	616	1121	60	0·06	1·23	20·5	
Ederline ...	122·40	55	0·60	0·37	0·18	30·0	58	23·15	39·9	55	137	70·0	0·11	12·28	111·6	
Avich ...	310·85	159	3·30	0·44	0·37	11·2	188	98·42	52·4	93	177	3,327·0	1·21	11·36	9·4	
an Leoid ...	602·20	35	0·50	0·26	0·23	45·8	84	35·75	42·5	31	74	114·0	0·11	0·48	4·4	
an Droighinn ...	601·65	51	0·60	0·18	0·13	21·5	48	14·78	30·8	66	214	32·0	0·08	0·86	10·75	
an Grealach ...	—	14	0·21	0·19	0·12	55·2	25	9·94	39·8	44	112	7·0	0·02	0·41	20·5	
Rainbow ...	about 1300	13	0·10	0·08	0·06	58·3	26	14·33	55·1	20	37	2·0	0·01	0·06	6·0	
Choire na Cloich ...	about 1304	22	0·20	0·06	0·04	18·7	20	9·44	47·2	53	112	2·0	0·01	0·10	10·0	
Dhu ...	about 1308	11	0·12	0·04	0·03	23·1	12	5·00	41·7	53	127	0·5	0·003	0·05	16·7	
Ailt na Mult ...	about 1335	9	0·12	0·02	0·02	19·3	3	1·50	50·0	212	424	0·1	0·003	0·07	23·3	
Sior ...	about 733	43	0·32	0·14	0·09	26·6	4	2·00	50·0	422	845	20	0·03	2·30	76·7	
Nant ...	about 606	74	0·90	0·32	0·24	27·0	92	24·31	26·4	52	195	148·0	0·22	9·38	42·6	
(East ...	about 80	75	0·32	0·16	0·09	14·7	36	13·39	37·2	91	244	21·0	0·06	1·89	31·5	
(Mid ...		61	0·56	0·19	0·10	17·0	27	11·27	41·7	111	263	17·0	0·05	2·85	57·0	
(West ...		33	0·56	0·14	0·08	15·1	22	7·34	33·4	134	403	10·0	0·05	6·22	124·4	
nan Rath ...	—	21	0·28	0·16	0·08	26·9	32	8·23	25·7	46	180	5·0	0·02	0·07	3·5	
na Beithe ...	—	41	0·25	0·15	0·03	12·0	58	27·72	47·8	23	48	23·0	0·03	0·08	0·08	2·7
		2619										48,450·6	18·186	307·55*	16·9	

\* The drainage area of Loch Awe includes that of all the other lochs in this table except those of Lochs Dubh, Sior, Nant, nan Rath, na Beltae, and the Black Lochs. The drainage area of Loch Tulla includes that of Loch Dochard; that of Loch an Droighinn includes that of Loch an Leoid; that of Loch Choire na Cloich includes that of Lochan Dhu; that of Loch Nant includes that of Sior Loch; and that of the West Black Loch includes those of the East and Mid Black Lochs.

From the table on p. 280 it will be seen that in the twenty-one lochs under consideration 2619 soundings were taken, and that the aggregate area of the water surface is about  $18\frac{1}{5}$  square miles, so that the average number of soundings per square mile of surface is 144. The aggregate volume of water contained in the lochs is estimated at about 48,451 millions of cubic feet. The area drained by these lochs is about  $307\frac{1}{2}$  square miles, or nearly seventeen times the area of the lochs.







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