EIGHTEENTH

ANNUAL REPORT

OF THE

FISHERY BOARD FOR SCOTLAND,

Being for the Year 1899.

IN THREE PARTS.

Part I.—GENERAL REPORT.
Part II.—REPORT ON SALMON FISHERIES.
Part III.—SCIENTIFIC INVESTIGATIONS.

PART II.—REPORT ON SALMON FISHERIES.

Presented to Parliament by Command of Her Majesty.

GLASGOW:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE
By JAMES HEDDERWICK & SONS,
At the "Citizen" Press, St. Vincent Place.

And to be purchased, either directly or through any Bookseller, from
JOHN MENZIES & CO., 12 Hanover Street, Edinburgh, and
90 West Nile Street, Glasgow; or
EYRE & SPOTTISWOODE, East Harding Street, Fleet Street, E.C., and
32 Abingdon Street, Westminster, S.W.; or
HODGES, FIGGIS, & CO., Limited, 104 Grafton Street, Dublin.

1900.

[Cd. 200.] *Price 6½d.*

SALE OF GOVERNMENT PUBLICATIONS.

The under-mentioned Firms have been appointed sole Agents for the sale of Government Publications, including Parliamentary Reports and Papers, Acts of Parliament, Record Office Publications, &c., &c., and all such works can be purchased from them either directly or through retail booksellers, who are entitled to a discount of 25 per cent. from the selling prices :—

IN ENGLAND :—

For all publications *excepting* Ordnance and Geological Maps, the Hydrographical Works of the Admiralty, and Patent Office Publications :—Messrs. Eyre and Spottiswoode, East Harding Street, E.C.
For Geological Maps :—Mr. E. Stanford, Cockspur Street, S.W.
For Hydrographical Works of the Admiralty :—Mr. J. D. Potter, 31 Poultry, E.C.
Patent Office Publications are sold at the Patent Office.

For all Publications *excepting* the Hydrographical Works of the Admiralty and Patent Office Publications :—

IN SCOTLAND :—Messrs. John Menzies & Co., 12 Hanover Street, Edinburgh, and 90 West Nile Street, Glasgow.

IN IRELAND :—Messrs. Hodges, Figgis, & Co., Limited, 104 Grafton Street, Dublin.

ORDNANCE SURVEY MAPS OF GREAT BRITAIN AND IRELAND :—There are Agents for the sale of these Maps in most of the chief towns. Copies can also be ordered at many Head Post Offices, and through any Bookseller, or from the Director-General Ordnance Survey, Southampton ; or, in the case of Ireland, from the Officer in Charge Ordnance Survey, Dublin.

The following is a list of some of the more important Parliamentary and Official Publications recently issued :—

Parliamentary :

Statutes—

Public General, Session 1899. With Index, Tables, &c. Cloth. Price 3s.
Second Revised Edition. A.D. 1235-1713 to A.D. 1872-1883. XV. Vols. Price 7*s.* 6*d.* each.
Revised Editions. Tables showing subsequent Repeals, effected by Acts of Session 62 & 63 Vict. 1899. Price 6*d.*
Statutes in Force. Index to. 15th Edition. To end of 62 & 63 Vict. 2 Vols. Price 10*s.* 6*d.*
The Statutory Rules and Orders revised. Statutory Rules and Orders, other than those of a Local, Personal, or Temporary Character, issued prior to 1890, and now in force. Vols. I. to VIII. Price 10*s.* each.
Statutory Rules and Orders, other than those of a Local, Personal, or Temporary Character. With a List of the more important Statutory Orders of a Local Character arranged in classes ; and an Index. Roy. 8vo. Boards. Issued in the years 1890, 1891, 1892, 1893, 1894, 1895, 1896, 1897, 1898, and 1899. Price 10*s.* each.
Statutory Rules and Orders in force on 1st January 1893. Index to. Price 10*s.*
Statutory Rules and Orders, 1900. Registered under the Rules Publication Act, 1893. In course of issue.

Acts of Parliament, Public and Local and Private, Session 1900. In course of issue.

[H.C. No. 97/1900.] Life Assurance Companies. Statement of Account, 1899. Price 2*s.* 10*d.*
[H.C. No. 134/1900.] Coal. Tables showing Production, &c., 1883 to 1898. Price 6*d.*
[Cd. 46.] Proposed Construction of a Cable across the Pacific Ocean. Canada—Australia. Price 10½*d.*
[Cd. 67.] Aged Deserving Poor. Report of Departmental Committee on the Financial Aspects of Proposals ; with Appendices. Price 1*s.* 3*d.*
[C. 68.] Colonial and other Possessions of the United Kingdom. Statistical Tables. 1894-95-96. Price 6*s.* 10½*d.*
[Cd. 71.] Railway Passenger Communication. Circular by the Board of Trade. Price 3½*d.*
[Cd. 94.] China, No. 2. Correspondence with the United States respecting Foreign Trade. Price 1½*d.*
[Cd. 167.] Mines and Quarries. General Report and Statistics, 1899. Part I. Persons employed, output, accidents, &c. Price 8*d.*
[Cd. 120.] Industrial Associations of the United Kingdom. Labour Department Directory. Price 7½*d.*
Mines. Reports of Her Majesty's Inspectors for 1899, with Summaries of the Statistical portion under the provisions of the Coal Mines Regulation Act, 1887 ; Metalliferous Mines Regulation Acts, 1872-1875 ; Slate Mines (Gunpowder) Act, 1882, Districts Nos. 1 to 13. In course of issue.
Mines in the United Kingdom and the Isle of Man. List of, for 1898. Price 3*s.*
Quarries Ditto. ditto. ditto. 1898. Price 3*s.* 8*d.*
Mines Abandoned. List of the Plans of. Corrected to 31st December 1898. Price 10*d.*

EIGHTEENTH

ANNUAL REPORT

OF THE

FISHERY BOARD FOR SCOTLAND,

Being for the Year 1899.

IN THREE PARTS.

Part I.—GENERAL REPORT.
Part II.—REPORT ON SALMON FISHERIES.
Part III.—SCIENTIFIC INVESTIGATIONS.

PART II.—REPORT ON SALMON FISHERIES.

Presented to Parliament by Command of Her Majesty.

GLASGOW:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE
By JAMES HEDDERWICK & SONS,
At the "Citizen" Press, St. Vincent Place.

And to be purchased, either directly or through any Bookseller, from
JOHN MENZIES & CO., 12 Hanover Street, Edinburgh, and
90 West Nile Street, Glasgow; or
EYRE & SPOTTISWOODE, East Harding Street, Fleet Street, E.C., and
32 Abingdon Street, Westminster, S.W.; or
HODGES, FIGGIS, & CO., Limited, 104 Grafton Street, Dublin.

1900.

[Cd. 200.] *Price* 6½*d.*

TABLE OF CONTENTS.

EIGHTEENTH ANNUAL REPORT OF THE FISHERY BOARD FOR SCOTLAND.

APPENDICES.

EIGHTEENTH ANNUAL REPORT.

TO THE RIGHT HONOURABLE

LORD BALFOUR OF BURLEIGH,

Her Majesty's Secretary for Scotland.

OFFICE OF THE FISHERY BOARD
FOR SCOTLAND,
EDINBURGH, 15*th April* 1900.

MY LORD,

In continuation of our Eighteenth Annual Report we have the honour to submit—

PART II.—REPORT ON SALMON FISHERIES.

Returns of Scottish Railway and Steamship Companies.

The fishing season of 1899 appears, from all available sources of information, to have been below the average of recent years. The returns furnished by the Scottish Railway Companies and Steamship Owners as to the weight of salmon forwarded by them from all parts of the country show a total of 2092 tons. This figure, although slightly above the total given for 1898, is lower than the average, as given in last year's report, by 638 tons. The slight improvement on last year's returns is due, we believe, to the large run of grilse which obtained during the summer months, and which saved many tacksmen from serious loss. Adult salmon appear to have been comparatively scarce.

We subjoin a Table which shows the totals for the four divisions of the coast usually adopted in dealing with these returns, and which embraces the six last years, and the average for the five years from 1894-1898.

TABLE showing the Weights of Salmon Carried by Scottish Railways and Steamships.

District.	1894. Weight.				1895. Weight.				1896. Weight.				1897. Weight.				1898. Weight.				Average. Weight.			
	Tons.	Cwts.	Qrs.	Lbs.	Tons.	Cwts.	Qrs.	Lbs.	Tons.	Cwts.	Qrs.	Lbs.	Tons.	Cwts.	Qrs.	Lbs.	Tons.	Cwts.	Qrs.	Lbs.	Tons.	Cwts.	Qrs.	Lbs.
Berwick to Cairnbulg Point, .	963	8	2	23	1,834	1	3	24	1,583	6	1	26	987	5	1	4	666	8	3	13	1,166	18	1	4½
Cairnbulg Point to Cape Wrath,	729	2	3	17	1,492	12	..	7	987	13	1	8	717	4	..	7	577	16	2	20	900	17	3	8
Cape Wrath to Glasgow, . . .	471	13	3	4	576	7	..	10	414	2	3	5	270	15	..	1	283	18	2	1	403	7	1	20
Glasgow to the Border, . . .	273	6	..	..	326	..	1	17	293	3	..	1	219	8	..	21	189	...	..	20	259	3	2	6
Total, . . .	2,437	11	1	16	4,229	1	2	2	3,278	5	2	12	2,194	12	2	5	1,717	4	..	26	2,730	7	..	10½

District.	1899. Weight.			
	Tons.	Cwts.	Qrs.	Lbs.
Berwick to Cairnbulg Point, . .	819	17	2	6
Cairnbulg Point to Cape Wrath,	753	12	2	..
Cape Wrath to Glasgow, . . .	365	12	..	3
Glasgow to the Border, . . .	152	18	1	19
Total, . . .	2,092	..	2	..

Monthly Return of Scottish Salmon sent to Billingsgate.

A monthly return of the number of boxes of salmon received at Billingsgate has been, as hitherto, kindly furnished by The Fishmongers' Company. The column referring to Scotland shows the following totals:—January, —; February, 295; March, 686; April, 759; May, 1,600; June, 3,369; July, 4,919; August, 3,518; September, 264; October, 1; November, —; December, —; total, 15,411. The highest monthly figure occurred, as usual, in July. The following Table admits of comparison with previous years:—

Table of Boxes of Scottish Salmon sent to Billingsgate, 1884–1899.

TABLE showing Number of Boxes of Scottish Salmon delivered at Billingsgate each Month for the Years 1884 to 1899 inclusive:—

Month.	Average of 10 years, 1884-93.	1894.	1895.	1896.	1897.	1898.	1899.	Average Monthly Price per lb. during 1893-96.	Average Monthly Price per lb. during 1897.	Average Monthly Price per lb. during 1898.	Average Monthly Price per lb. during 1899.
								s. d.	s. d.	s. d.	s. d.
January,	..	..	..	..	..	..	..	..	..	2 9	..
February,	*818*	327	400	822	773	525	295	1 9½	2 0½	1 10	2 5½
March,	*1,071*	692	1,207	1,385	724	866	686	1 8½	2 5½	2 1	2 9
April,	*1,416*	887	1,160	1,580	1,038	809	759	1 9½	2 2½	2 4	2 7
May,	*2,335*	1,745	2,567	2,376	2,311	1,430	1,600	1 8	1 6	2 0	2 0¾
June,	*3,540*	3,078	4,611	3,595	3,127	2,668	3,369	1 4¾	1 4½	1 5	1 6
July,	*7,949*	4,464	9,066	7,450	5,081	4,166	4,919	0 11¼	1 4	1 4	1 2½
August,	*6,094*	3,968	5,694	4,477	3,001	3,169	3,518	1 1	1 5	1 4	1 5
September,	*526*	328	659	750	213	487	264	1 10	2 0	2 0	2 3¾
Do.,	..	..	..	..	*6	18	1	..	*1 7	..	2 0
October,	..	..	..	..	*9	*20	..	..	*1 7	2 11	..
November,	..	..	..	..	..	*14	..	..	..	*1 9	..
December,	..	..	..	..	*1	*2	..	..	..	..	..
Total,	*23,749*	15,489	25,364	22,435	16,284	14,174	15,411	..	..	..	..

* Frozen salmon.

For purposes of comparison with the quantities of salmon sent to Billingsgate from other countries the following Table may be of interest at the present time:—

[TABLE.

Table showing Billingsgate Returns from all Sources.

TABLE showing the Number of Boxes of Salmon delivered at Billingsgate in each Month of the Year 1899, and Average Monthly Price per Lb.

Month.	English.	Scotch.	Irish.	German.	Danish and Norwegian.	Dutch.	Canadian.	Totals.	English.	Scotch.	Irish.	German.	Danish.	Norwegian.	Dutch.	Canadian.
									s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
January,	...	...	18	...	1	129	5	153	...	...	4 6	...	3 6	...	4 1	0 7½
February,	31	295	92	...	...	114	20	552	2 6	2 5½	2 10½	...	...	...	2 9	0 8½
March,	96	686	286	...	...	97	33	1,198	2 8	2 9	2 9	...	...	...	2 9	0 9
April,	136	759	286	5	5 Norwegian.	124	34	1,349	2 7	2 7	2 7	2 4	2 4	...	2 7	0 8
May,	382	1,600	508	..	63	74	43	2,670	2 0¾	2 0¾	2 0¾	...	...	1 1	2 0¾	0 7½
June,	484	3,369	1,274	...	774	3	16	5,920	1 6	1 6	1 6	...	...	1 1	1 6	0 7
July,	355	4,919	1,696	...	414	...	...	7,384	1 2½	1 2½	1 2½	...	...	1 1¼	...	...
August,	141	3,518	102	...	...	...	22	3,783	1 5	1 5	1 4½	...	...	...	...	0 11
September,	46	264	3	...	...	2	34	349	2 10¼	2 3¾	2 3	..	...	...	2 0	0 11
October,	16	1	...	...	...	11	5	33	2 5¾	2 0	...	...	...	...	2 1	0 9¼
November,	5	...	...	1	...	11	3	20	3 6	...	...	...	...	...	4 10½	0 7¼
December,	...	...	...	2	...	19	3	24	...	..	...	...	...	...	5 11	0 6½
	1,692	15,411	4,265	8	1,257	584	218	23,435	...	...	...	...	...	...	...	...

For purposes of further comparison, although the practice of distributing salmon direct from fishing stations in Scotland to markets other than Billingsgate is on the increase, the following Table is given:—

Table of Boxes of Scottish Salmon sent to Billingsgate from 1834 to 1899 inclusive.

TABLE showing the Number of Boxes of Scottish Salmon sent to Billingsgate from 1834 to 1899 inclusive:—

Year.	Boxes of Salmon.	Year.	Boxes of Salmon.
1834	30,650	1867	23,006
1835	42,330	1868	28,020
1836	24,570	1869	20,474
1837	32,300	1870	20,648
1838	21,400	1871	23,390
1839	16,340	1872	24,404
1840	15,160	1873	30,181
1841	28,500	1874	32,180
1842	39,417	1875	20,375
1843	30,300	1876	34,655
1844	28,178	1877	28,189
1845	31,062	1878	26,465
1846	25,510	1879	13,929
1847	20,112	1880	17,457
1848	22,525	1881	23,905
1849	23,690	1882	22,968
1850	13,940	1883	35,506
1851	11,593	1884	27,219
1852	13,044	1885	30,362
1853	19,485	1886	23,407
1854	23,194	1887	26,907
1855	18,197	1888	22,857
1856	15,438	1889	21,101
1857	18,654	1890	18,931
1858	21,564	1891	25,889
1859	15,823	1892	21,919
1860	15,870	1893	18,903
1861	12,337	1894	15,489
1862	22,796	1895	25,364
1863	24,297	1896	22,435
1864	22,603	1897	16,284
1865	19,009	1898	14,174
1866	21,725	1899	15,411

Salmon Disease.

Reports from rivers seem to indicate that during the past year disease has not been excessive. From the following rivers "no disease" is reported:—Bervie, Dee (Aberdeen), Dee (Solway), Deveron, Findhorn, Nairn, Ness, Conon, Alness, Kyle of Sutherland, rivers of north coast of Sutherland, rivers of west coast of Sutherland, Kennart, Lochy, Ayr, Doon, Girvan, Stinchar, and Cree. On the east coast of Sutherland only one diseased fish was noticed, as also in the river Balgay and in the Snizort of Skye. In the North Esk one grilse was found dead. In the South Esk 48 diseased fish were seen. The numbers of fish affected are not given in the case of both the Tay and the Forth.

In those districts diseased fish are not counted. It may be remarked, however, that both rivers were in a flooded state during practically the whole autumn, and that in spite of this the disease appeared. It reached its height in January. In the Spey, also, the percentage of deaths from disease seems to have been comparatively small.

Inspections during 1899.

In his annual tour of inspection, Mr. Calderwood visited 23 fishery districts of the West Highlands—viz., Awe, Lussa, Baa, Shiel, Sligachan, Balgay, Torridon, Badachro, Ewe, Broom, Kirkaig, Inver, Laxford, being districts fished on their coast lines by means of bag nets; and Creran, Pennygown, Sunart, Moidart, Aylort, Morar, Kilchoan, Glenelg, Snizort, and Ullapool, being districts in which fishing by means of bag nets is not practised. The object of Mr. Calderwood's tour was to compare the one set of districts with the other, and to study, as far as possible, the influence of bag-net fishing upon the stock of fish. The results, which may be regarded in a measure as an introduction to the larger subject of coast salmon fishing in general, will be found in Appendix I. to Mr. Calderwood's Annual Report (p. 15). Lists are given for the first time of those carrying on the fishery in the various districts, and of the number of nets employed. An estimate is also made of the value of nets and boats, and of the working expenses. From these lists it appears that the coast of Scotland is fished by 1945 fixed engines, representing a value of £143,900, and that this branch of salmon fishing gives employment to 1352 men.

Number and Cost of Fixed Salmon Nets, &c.

Mr. Calderwood also inspected the Nith district, and in his Annual Report he deals at some length with the difficulties in the way of successfully developing the salmon fisheries of that district and of the Solway generally. Two fish-passes in the neighbouring river of Kirtle are also reported upon, as are points of interest connected with the ascent of fish in the Cree, Ayr, Awe, and Balgay.

District Reports.

Appendix II. contains the reports from Clerks of District Boards. They take the usual form of answers to printed queries issued by the Inspector of Salmon Fisheries.

Cruive with "Mid-stream," p. 74.

Appendix III. is a report by Mr. Calderwood on the existence of a cruive with a "mid-stream" slap. This cruive the Inspector considers of interest, as showing that the slap in cruive dykes, as in dam dykes, required by all ancient Statutes, cannot be considered as completely in disuetude in Scotland as has been held by the Courts.

The Re-measuring of Estuaries, p. 78.

Appendix IV. deals with the necessity of remeasuring the exact limits of the estuary of the river Bervie, being correspondence between the Clerk to the District Board and the Inspector of Salmon Fisheries. The general subject of such remeasurements is referred to in Mr. Calderwood's Annual Report.

Investigations on Life-History of Salmon, p. 80.

Appendix V. contains an account by Dr. D. Noël Paton and M. I. Newbigin, D.Sc., of further investigations on the life-history of the salmon, and renders more complete the researches on this subject commenced a few years ago and previously published in the Special Report of 1898.

Receipts and Expenditure of District Boards. Rateable Value of Salmon Fisheries.

Receipts and expenditure of District Fishery Boards are given in Appendix VI., and the rateable value of salmon fisheries in Appendix VII.

The annual close times applicable to Scotch salmon rivers are given in Appendix VIII., and the list of Chairmen and Clerks of District Fishery Boards in Appendix IX.

Annual Close Times.
List of Chairmen and Clerks.

We have the honour to be,

Your Lordship's most obedient servants,

ANGUS SUTHERLAND, *Chairman.*
D. CRAWFORD, *Deputy-Chairman.*
D'ARCY W. THOMPSON.
J. RITCHIE WELCH.
W. R. DUGUID.
L. MILLOY.
D. MEARNS.

WM. C. ROBERTSON, *Secretary.*

EIGHTEENTH ANNUAL REPORT

OF

THE INSPECTOR OF SALMON FISHERIES FOR SCOTLAND.

MR. CALDERWOOD'S REPORT.

FISHERY BOARD FOR SCOTLAND,
April 1900.

I HAVE the honour to submit to the Fishery Board for Scotland my Annual Report for the year 1899.

Annual tour of inspection.

The different conditions which govern the proper maintenance of salmon fisheries situated in widely different localities induced me during my annual tour of inspection to visit 23 of the small fishery districts of the West Highlands. The purpose of my tour was more especially to study a group of districts much fished by means of bag-nets, and to compare this group with another where no bag-net fishing is carried on, so that, if reliable information could be gained, the question of the coast salmon fishings in general might be approached.

Report on coast salmon fisheries.

I have, therefore, prepared a report dealing with certain aspects of this question of coast salmon fishing. This forms Appendix I. to the present Report.

Nith.

In last year's Report on Salmon Fisheries by the Fishery Board for Scotland (p. x.) the unfortunate state of the fisheries which obtains in the district of the river Nith is referred to. After some correspondence with the Clerk of the District Board at Dumfries with a view to ascertain what steps were proposed in order to carry out the requirements of the Salmon Acts, more especially by modifying the sixteen dam dykes adversely reported upon in the Sixteenth Annual Report, Part II., p. 9, I obtained the permission of the Board to make a personal examination of the district.

So far as the dam dykes are concerned in hindering the proper development of the fisheries, a noticeable feature is that all the impassable dams of the district are on the tributaries, and in several cases are situated near to the confluence with the main river. The main stream itself has no natural obstruction of any moment, and has only one built obstruction—the Dumfries cauld. The general appearance of the Nith and its tributaries is such as to lead one to believe that, given the conditions by which a sufficient stock of fish could reach the upper waters, a high state of efficiency might be maintained. Under existing conditions of the Solway fisheries it seems highly probable that only a moderate supply of fish can be expected to reach their natural spawning grounds, and on this account there seems some excuse for the argument that until a greater run of fish is noticeable the opening up of additional spawning grounds is to a certain extent unnecessary. Compared to rivers of somewhat similar size—the Annan, the Solway Dee, the Findhorn, or the Deveron—the rateable value of the fisheries of the Nith is very insignificant. Smaller rivers, where conditions of water-flow are similar, such as the Nairn or the Ythan, show a rateable value considerably in excess of the value of the Nith. From Note V. appended to Part II. of the Sixteenth Annual Report it will be seen that in the quinquennial period 1890-1895 the average values for the

Nairn, the Ythan, and the Nith are respectively £1341, £993, and £633. When the beauty of the Nith as a salmon river is realised this circumstance seems the more unfortunate.

The various dam dykes having been reported upon in the Sixteenth Report on Salmon Fisheries, p. 9, I propose in the present instance to consider the question of the improvement of the salmon fisheries of the Nith district under three general heads :—

(*a*) The difficulty of securing the entrance to fresh water of a sufficient number of fish, owing to the great amount of netting by fixed engine at the mouth of the river.

(*b*) The difficulty of securing the ascent of fish owing to polluted water, more especially in the neighbourhood of Dumfries.

(*c*) The lack of facilities for the proper distribution of fish to the spawning grounds.

(*a*) The Difficulty of Securing the Entrance to Fresh Water of a Sufficient Number of Fish, owing to the Great Amount of Netting by Fixed Engine at the Mouth of the River.

The three Solway Salmon Fisheries Commissioners, who were given extensive powers by the Act of 1877, decided on the legality or illegality of each fixed engine in the Solway, and granted certificates of privilege and orders of abatement or removal.

Reference to the list of fixed engines prepared by the Commissioners shows that in Dumfriesshire 20 paidle nets erected between the mouths of the Nith and Annan, on the property of Mr. Mackenzie of Newbie, declared to be for the purpose of taking white fish according to public right, were proved to the satisfaction of the Commissioners to be erected for the purpose of taking salmon, and were ordered to be removed. Other 20 paidle nets on the property of Lord Herries, at the mouth of the Nith, had been erected with the leave of the proprietor, but claimed no certificates of privilege. These nets are constructed so as almost exactly to resemble salmon bag nets or stake nets, but are of smaller size, and have, though not invariably, the addition of the "paidle" or cylindrical trap attached to the rectangular pocket.

By the 33rd section of the Salmon Fisheries (Scotland) Act, 1862, the shores of the Solway Firth situate in Scotland are exempt from the provisions of the Act ; and the English Salmon Fishery Act, 1861 (24 and 25 Vict., c. 109), in so far as it relates to the use of fixed engines for the taking of salmon, is substituted.

Section 11 of the English Act referred to enacts that "no fixed engine of any description shall be placed or used for catching salmon in any inland or tidal waters ; and any engine placed or used in contravention of this section may be taken possession of and destroyed ; . . . . . but this section shall not affect any ancient right or mode of fishing, as lawfully exercised at the time of the passing of this Act, by any person by virtue of any grant or charter or immemorial usage, provided always that nothing in this section contained shall be deemed to apply to fishing weirs or fishing mill dams."

In certain localities it seems perfectly admissible for a member of the public to fish for white fish by means of stake nets or other fixed engines, and much litigation has arisen as to fishing in this way with intent to catch salmon, or so as to injure salmon fishings of a private nature. A case of note is that of the *Duke of Buccleuch v. Kean*, 30th May 1890 (17 R. 829), in which interdict was sought against such method of fishing. Referring to this case, Stewart (Law of Fishing, p. 365) says:— "It was proved that the defender's nets, though alleged to be intended for the capture of white fish, were fitted up to capture and did capture salmon, and were such as to interfere with the salmon fishings of the pursuer. The Court found that the defender's nets were illegal, and granted interdict against the use by the defender of the nets complained of, or of similar nets, both during the open salmon season and during the close time, and ordered the nets to be removed."

Even if the application of the English Act of 1861 to this part of Scotland had proved insufficient for dealing with the injury to salmon fisheries by the placing of stake nets at the mouths of the Solway rivers, the difficulty could be met (and I am informed it is preferably met) by the Solway Act of 1804 (44° Georgii III., c. 45). The 9th section of this Act prevents persons who are not owners or occupiers of fisheries from taking fish (whether white or red) unless duly authorised to do so.

It may, we think, be contended with some reason that stake nets exclusively for the purpose of taking white fish, which on the sand flats of the Solway means flat-fish, do not require to be constructed in the same way as nets for the purpose of taking salmon, and that such nets need not necessarily be placed, without permission, within the boundaries of rivers.

For the purposes of the Solway Act, 1804, as stated in the 28th section of that Act, "the limits of the mouth or entrance of the river *Nith*, situate in the county of *Dumfries* . . . shall for the future be deemed and taken to be and extend from the large house at *Carsethorn* of *Arbigland* . . . , in a line across the said river *Nith* due east."

On the 11th May I visited the mouth of the Nith, and within the mouth of the river as specified I counted 20 stake nets. I visited the locality when the tide had ebbed from the nets, and I was able to note that both flat-fish (common dabs and flounders) and salmon were captured by them. The nets stand 6 feet above the level of the sand or mud, being supported by stakes about 7 feet high. The leaders or cross-arms are about 43 to 45 yards long, and are set at right angles to the direction of the river, across the flat banks left bare by the receding tide. At the river end of the cross-arm of each net the pocket or bag is set. This I found to be a rectangular chamber, set to fish either in one or in two directions, and measuring $8\frac{1}{2}$ to 10 feet by 4 feet, having a floor of netting and a roof of netting, as in the ordinary salmon fly net. On either side of this rectangular pocket transverse leaders or wings were set, termed the ebb-arm and the flood-arm. These were of less length than the cross-arm, but in the majority of instances the end of one of the wings was attached to the cross-arm of a second net, so that two pockets fished unitedly; the continual expanse of parallel netting being about 90 yards in length. In addition to this formation, many of the pockets had paidle nets attached to their seaward ends. I examined eight nets minutely, taking measurements, and four of these had paidles. The term "paidle net" is, however, used in the district to describe generally the stake nets with or without the paidle proper. In the evidence led before the Commission on Crown Rights in Scottish Salmon Fisheries it is repeatedly so used. The paidles proper I found to be constructed of five hoops 2 feet 10 inches to 3 feet in diameter, the whole cylindrical structure being about 4 feet long. The inverted mouth, which was suspended with cord, reached to the centre of the paidle.

I was informed by a member of the District Fishery Board that the fishermen who use these stake nets do so without permission from the proprietor (Lord Herries). If this is so it would appear that they contravene Section 9 of the Solway Act of 1804. Further, however, it would appear that, from the time of the elaborate judgment of Lord

Curriehill, after the full enquiry by the Court of Session in 1879 into the use of paidle nets, the Nith nets can in no way be excepted from the ruling that fixed engines of this description are illegal inasmuch as they are formed in a precisely similar way to recognised salmon nets, are fished in the same manner as salmon nets, and catch salmon as well as white fish. Indeed, in the report of the Commission on Crown Rights (p. ix.) it is stated that the paidle nets more especially considered by the Commissioners—being those situated some distance to the east of the natural mouth of the river Nith—owing to the narrowness of the channel, must inevitably catch salmon. It is to be regretted if the salmon fisheries, on account of their major right over the white-fish fisheries, interfere with the livelihood of those who say that they cannot, in the Solway, catch white fish except by means of such stake nets as are identified with the capture of salmon; but the information on the subject elicited through the Law Courts seems to allow of no opinion but that the paidle-net fishermen live by the proceeds of fisheries other than white-fish fisheries. Extensive nets, with pockets roofed at a height of six feet, seem to be unnecessarily expensive for the capture of comparatively valueless fish like flounders, and the practice of setting such nets from the line set down as marking the confines of the *river* Nith to a point four miles up the tidal mouth of that river, as ascertained at the time of my visit, seems to me to be a bold repetition of an offence already most clearly defined. My reason for thus dealing with the matter is that I am of opinion, after viewing the array of fixed engines on the flat tidal banks of the river, that very serious damage is done by these fixed engines to the salmon fisheries of the district, and that the District Board should give the matter their careful attention.

In the Answers to Queries addressed to the Nith Board, and appended to this Report (p. 71), will be found a reference to a case in which two men have been convicted, since the above was written, for fishing by means of stake nets without permission in the estuary of the Nith.

(*b*) The Difficulty of Securing the Ascent of Fish owing to Polluted Water, more especially in the Neighbourhood of Dumfries.

The Parliamentary Burgh of Dumfries has a population of 17,821. The river Nith receives the sewage of the town, in addition to the sewage of adjacent villages and of the Royal Crichton Asylum.

A very deleterious pollution of the river also results from the establishment of a dye work, two large tweed mills, and two hosiery mills. On the tributary of Crawick Water, above Sanquhar, there is also a blanket manufactory, from which I observed a sulphur-coloured fluid being given off. In the town of Dumfries the pollutions which more especially attracted my attention were those from the dye work (Messrs. Shortridge) and the two tweed mills (Messrs. Charter & Spence and Messrs. Scott). On the date of my inspection of the Dumfries section of the water, a light brown fluid was flowing from the dye work, which is situated above Dumfries Bridge, in the non-tidal portion of the river. I was informed that the colour of the bye-product is subject to great variation. Below Dumfries cauld, which separates the tidal from the non-tidal water, as it does the upper and lower proprietors, Messrs. Charter & Spence's mills were giving off, from a drain pipe which appeared to have a diameter of 2 feet, a fluid of a strong French-grey colour, and, apparently from a smaller pipe at the side of the other, a fluid of a dark blue colour. About 150 yards down the river the grey colour was still very evident, and here, from the opposite or left bank, a greenish-coloured substance from Messrs. Scott's mills entered, so that a large pool had its waters completely discoloured. The general appearance of the river also shows that it is considered the convenient receptacle for refuse of other sorts. At low tide I had experience of the fact that even with a comparatively high river the margins of the stream are coated with fœtid refuse, while the quieter parts of the water carry a disagreeable scum. I can well imagine that during dry weather the condition of the bed of the stream must become extremely bad. I was informed that at such times anglers of Dumfries who hold tickets to fish this section of the water abandon the river, finding wading unbearable. I learned also that at present a proposal is on foot to drain the suburb of Maxwelltown into a small burn which enters the Nith at a pool, called the Round Pool, opposite the centre of the War Department ground. The 13th Section of the 1862 Act (25th and 26th Vict., c. 97), as amended by Section 16 of the 1868 Act (31st and 32nd Vict., c. 123), is deprived of the strength with which it originally was vested, on account apparently of the amendment being incomplete. The result is that District Fishery Boards, although composed of riparian proprietors, are in a worse position to cope with the evils of pollution than are individual proprietors. The fact, therefore, that District Fishery Boards are the bodies organised for the purpose of dealing with salmon fishery regulation and protection is, in view of this, a hindrance to the organised action of proprietors apart from the District Boards. Yet, in the case of the *Countess Dowager of Seafield and others v. Kemp*, the decision of which will be found in Note IV. of the 17th Annual Report, Part II., we have an example of a successful objection to serious river pollution and injury to salmon fishings, apart from the Fishery Board of the Spey District.

Until such time as the powers of District Boards are improved in this matter, therefore, it would appear that the evil spoken of can be more readily combated by the action of individual proprietors than by the action of the District Fishery Board.

(*c*) The Lack of Facilities for the Proper Distribution of Fish to the Spawning Grounds.

In the main river, the natural possibilities for developing the salmon fisheries (angling) and for increasing the stock of fish are, in my opinion, considerable. A beautiful series of streams and pools exists, and there are not a few places where the bed of the river is very well suited for spawning. The extensive mileage of water belonging to His Grace the Duke of Buccleuch could, I think, be rendered of great value were the evils of which I have spoken under headings (*a*) and (*b*) overcome, and a suitable stock of fish obtained. Dumfries cauld has already been cited as the only obstruction in the main river, and this, at such times as the gap and fish-pass are plentifully supplied with water (as during the time of my visit), does not appear to me to offer very serious difficulty to ascending fish, although I have no doubt that during low conditions of water the two lower of the three pools which form the pass proper are of small service. During the latter conditions the pass is probably unsatisfactory, but on the individual merits of each cauld in the district it is unnecessary for me to enter, in view of the report which has already been presented on those structures by my predecessor. I would only state that I found during my visit that the heavy floods of the previous winter had carried away three of the dams—viz., the dam to the blanket work on Crawick Water, the dam of the disused mill on Menock Water, and the lower of the two dams at Dalgoner on the Cairn Water. In any attempt to rebuild the structures named, and probably the dam at the disused mill on Menock Water might remain unrepaired, full provision should be made for the requirements of Schedule G of the 1868 Act (31st and 32nd Vict., c. 123). At the same time the more serious obstructions on the Cairn Water, as the first tributary to ascending fish, should certainly be attended to without delay. These are:—The dams at Cluden Mills, the so-called cruive in the same locality, reference to which is made in Note III. of the 17th Annual Report, Part II., and the natural obstruction at Gribton Sawmill. Much additional spawning ground would thus be opened up in the Nith district.

Solway. In attempting thus to indicate the evils which in my opinion injure most seriously the salmon fisheries of the Nith district, I should like also to be permitted to point out that the salmon fisheries of the Solway, so far as the Scotch side is concerned, may be regarded generally as injured by the great extent to which netting by fixed engine in the estuary is carried on. Whether the netting is by paidle nets up the mouths of the rivers, or by recognised salmon stake nets of a legal sort in the estuary, seems to me to make little difference, if we view the matter strictly in the interests of the fisheries. All the old statutes which deal with the question of fixed engines and their position, and which were reviewed by the Lord Justice-Clerk in the case of *Kintore v. Forbes*, 31st May 1826 (4, S. 641), have acted as an interference with private right of fishing in order to secure, as the primary object, the benefit of the fisheries in general by the free passage of salmon from the lower to the upper waters or spawning grounds of our rivers. At a very early date it was decided to prohibit the use of fixed engines in estuaries; yet, owing to the geographical position of the Solway, and the special Acts which deal with its fisheries, fixed engines were permitted to remain in this special locality. In view of the present condition of the Solway fisheries, this exception may serve as an indication that the provisions which obtain in all other parts of Scotland are more beneficial in their results.

Cree. A request having been made by the Earl of Galloway that, in view of certain points of difficulty amongst proprietors of the Cree district, the Kirkpool dam dyke be inspected for the purpose of determining the most suitable position for the erection of a salmon pass, as referred to in a memorandum to the Fishery Board for Scotland, prepared by Mr. James Drew, Lord Galloway's commissioner, I visited the Cree for the purpose indicated. At the same time I had the opportunity of viewing the
Fleet. fixed engines at the mouth of the Cree and at the mouth of the Fleet. These are referred to in my separate report on the Coast Salmon Fishings (Appendix I.). I also took the opportunity of viewing the yair nets of
Dee. the Dee in the neighbourhood of Kirkcudbright, as well as the doaches of Tongueland and the hatchery conducted by Messrs. J. Anderson & Sons, Edinburgh.

Kirtle. At a subsequent date I visited the river Kirtle in the Annan district for the purpose of inspecting Beltenmont fish-pass and Kirtlebridge cauld.

Beltenmont Fish-Pass.

The cauld at Beltenmont has recently been repaired and rendered as nearly as possible watertight, the crest or sill at the same time having been finished off with a broad and flat layer of cement. The fish-pass has been erected *upon* rather than *in* the down-stream face. It is a ladder of four complete steps, having a widened entrance which, in very low conditions of the water, constitutes a fifth step. The structure is of concrete. The steps are of different heights, the two upper being perpendicular jumps of 18 inches; the three lower being set on a slope, the actual rises being, in descending order, 12 inches, 10 inches, and 9 inches. These united heights give a total rise of 5 feet 7 inches. A raised parapet runs down each side of the ladder, but there is no slap in the crest or sill of the weir, as is required by Schedule G of the Salmon Fisheries (Scotland) Act, 1868. By measuring the depth of water at points on the sill, I was able to detect a difference of 1½ inches between the level of the sill at the top of the ladder and the slightly higher level at other points. At the time of my visit 2 inches of water was the depth at top of the ladder and half an inch on the rest of the sill, but the absence of a proper 6-inch slap causes a very deficient water supply in the ladder itself. The series of shallow basins between the steps are, in my opinion, quite inadequate to enable the fish to leap the steps. They contain no depth of water when the river is low, and during a flood their extremely small dimensions and the consequent proximity of the steps to each other will cause a very unnecessary amount of broken water. An equally serious fault, in my opinion, is seen in the formation of the top of the ladder. At this point (where the sill of the dam should have been cut down six inches) the flat surface of the sill, already referred to, has been carried out to an extra extent, so that above the last step of the ladder an almost level platform extends for a distance of 7 feet 4 inches. If an ascending salmon could overcome the difficulties of the shallow basins and closely approximated steps, it would therefore be stranded on this long flat surface, which clearly constitutes a superadded obstacle. Owing, however, to the manner in which the whole ladder is raised above the surface of the dam face, I believe ascending fish will, when a suitable water flow obtains, overcome the obstacle of the cauld by making use of the angle caused by the raised edge of the ladder and the dam face on the right side of the ladder rather than in the passage which has been prepared for them.

I cannot, therefore, regard the Beltenmont fish-pass as in any sense efficient, and I should like to take this opportunity of expressing my regret that when the construction of fish-passes is contemplated, an early supervision of the plans is not in every case sought from the Fishery Board for Scotland, so that the provisions of the regulations may be adjusted without loss of money and time.

Kirtlebridge Cauld.

This cauld, which is above Beltenmont and is the property of Mr. Irving of Burnfoot, has no fish-pass, although the proprietor has caused a platform of stone upon which to form a pool to be constructed at the left side. The masonry of the cauld itself is considerably out of repair, water percolates through almost the whole substance of the dam, and the sill is very irregular. The slope of the down-stream face I estimated as about one in three.

In view of the course which the stream takes, I think it inadvisable to construct a pass at the left side of the channel; moreover, to form an efficient pool-pass would, in view of the deep water immediately below the cauld, be a somewhat costly process. I would recommend, rather, that, after the level of the sill has been more accurately fixed, a 6-inch slap be excavated at a point 10 yards from the left end of the cauld, and the slap carried down the face of the cauld. In order, however, that the gradient may agree with at least the minimum requirements of Schedule G of the Salmon Fisheries (Scotland) Act, 1868, viz., one in five, I would propose that the upper end of the pass be carried back from the actual sill of the cauld, in an up-stream direction, till the proper gradient throughout the pass has been attained. The pass, which would then be about 22 feet long, would require to be provided with two stops or breaks. I would suggest that the stops be only carried two-thirds of the way across the pass, that they be placed on alternate sides, and that the higher of the two be twelve feet from the top or exit of the pass, the other eighteen feet from the top, and that the stops themselves be fourteen inches in height.

Garnock.

In the Irvine district I inspected another passless weir on the Garnock water.

The weir is the first obstruction met by fish ascending the river, being situated below Kilwinning at the iron works of Messrs. William Baird & Co. The river at this point has been constructed artificially for a distance of about 200 yards, the course having formerly been to the west of the present river. The weir is at the lower end of this artificial channel, the channel being 80 feet across. It is constructed of concrete faced with smooth cement. The down-stream face is deeply concave, so that the water passing over the sill falls first in a vertical direction. Below the weir an apron of stones exists, the distance from the crest of the weir to the lowest or furthest down-stream part of the apron being 42 feet. The height of the weir at the upper end of the apron is 3 feet 3 inches. The height of the weir above the level of the pool below the apron is 5 feet.

The river Garnock joins the main river Irvine about 300 yards above the mouth of the latter, but the Irvine is now ruined as a salmon river, and fish entering from the sea prefer apparently to ascend the Garnock, although the latter, in its lower reaches, is also polluted to an almost fatal extent. I have not seen any river in Scotland polluted to a more serious extent.

In my opinion the weir of the Lanarkshire and Ayrshire Railway Company, specially referred to in this report, is a most serious obstacle to the ascent of salmon and sea trout, not primarily on account of the height of the weir, but because the form in which it is constructed permits neither of a leap, owing to the shallowness of the water on the surface of the apron, nor of fish swimming up, owing to the concave face of the weir and the entire absence of a fish-pass or even of a gap.

The requirements of the weir, in order to provide for the ready ascent of salmon and sea trout, seem to me to be (*a*) to provide for a greater depth of water on the surface of the apron, (*b*) to furnish a gap in the sill of the weir.

(*a*) In order to provide for a depth of water suitable for a "take-off" to fish ascending the weir—and this I consider the more important of the two requirements—I recommend that a shallow pool be formed on the surface of the apron, by the erection of a subsidiary dam dyke at the extreme end of the apron, the structure to reach completely across the river and to be 2 feet 6 inches in height. In accordance with the requirements of Schedule G of the Salmon Fisheries (Scotland) Act, 1868 [31 & 32 Vict., cap. 123], this dam, the river being of a breadth less than 100 feet, shall be provided with a gap in the sill, and down-stream face, 4 feet wide and 6 inches deep. This subsidiary dyke should be constructed of masonry or concrete, and the down-stream face should have an inclination of one perpendicular to five horizontal. The end of the down-stream face should coincide with the end of the present apron, the crest of the subsidiary dyke being 12½ feet up-stream from this point, or about 30 feet down-stream from the crest of the main weir.

(*b*) A gap shall be provided in the sill of the main weir of the same capacity as that mentioned in connection with the subsidiary dyke, but in this case, in order to overcome in some measure the unfortunate curve of the down-stream face, I would recommend that the gap in the sill be narrowed to 3 feet, and that the sill of this 3-feet gap be then hollowed out so as to be deeper in the centre than at the sides, the extent of the deepening to be the equivalent of the 12 inches by 6 inches omitted in the first instance.

Early in August I visited the weir at Overmills, on the river Ayr, for the purpose of inspecting the fish-pass constructed under the agreement referred to in my last year's report. I arranged that I should see the pass previous to the entrance of water, and have the coffer-dam of sandbags removed during my visit so as to view the descent of the water and its action in the pass. I found that my suggestions as to construction had been carried out in every particular. The pass is reported to have worked with every satisfaction during the autumn and winter. Ayr.

On 30th May I was enabled to make an inspection of the cruive at Inverawe. A description of the structure will be found in Appendix III. So far as I am aware, and I believe I have visited all the cruives in Scotland, this Inverawe cruive is unique in having the dyke so constructed as to have a free passage or "mid stream." The fact that the mid-stream of ancient times has been accepted in the Courts as in disuetude induces me to make special reference to this case. When in the district I also visited the Lusragen Burn, which flows from a chain of small lochs, named the Black Lochs, into Loch Etive at Connel Ferry. A dam exists on this burn for the purpose of supplying water to a meal mill. Frequent complaints have been made by the local inspector to the miller on account of obstructions being placed in the fish-pass which exists. I found the dam to be 23 feet across and 3 feet high. An iron sill is inserted so as to be continuous with the up-stream face of this dam. The gap at the upper end of the pass is therefore of iron. It measures 2 feet 9 inches, by 6 inches. The pass itself is of wood, and about fourteen and a half feet in length, but appears to have had about a foot broken off from its lower end. The stream is considered of importance on account of the number of sea-trout which ascend for purposes of spawning. On the day of my visit I found a plank placed across the upper end of the pass so as to completely close the gap and raise a greater head of water for the use of the mill. Awe.

In the 15th section of the Salmon Fisheries (Scotland) Act, 1868 [31 and 32 Vict., cap. 123], the 6th sub-section reads—"Who does any act for the purpose of preventing salmon from passing through any fish-pass, or taking any salmon in its passage through the same"; and any person who commits this offence is liable to a specified penalty. But the difficulty in a case of this kind, and such cases are not uncommon, is that the obstruction is not placed *for the purpose* of preventing the ascent of salmon, but for the purpose of obtaining greater water power.

The loss of power caused by the presence of a 6-inch gap in the sill of a weir has, however, been repeatedly interpreted by the Courts as a loss incidental to the requirements of the Salmon Acts.

It has been stated in reports that the waterfall on the Balgay is a barrier to the further passage of ascending fish. I visited the fall in June, and was fortunate to see fish leaping. The fall, no doubt, acts as an obstruction, but it is certainly surmounted both by salmon and by Balgay.

sea-trout. The latter are caught in numbers in Loch Coultrie, after they have traversed Loch Damph above the fall, but although many salmon are reported as ascending, I am informed that only about 20 are taken during the season. The spawning ground of the district is above Loch Damph, in the stream between Loch Damph and Loch Coultrie and in higher streams. On the left side of Balgay Fall—that at which fish appear mostly to ascend—a secondary flow of water passes off for a short distance so as to form a long, rocky island. By cutting into the sill of the fall on the left side, the upper part of this flow could be used with advantage as a salmon pass, or the secondary flow, which is of comparatively easily gradient, could without much difficulty, I think, be made to serve as the main channel of the river, leaving the serious obstacle untouched.

Remeasuring of Estuaries.

The Clerk to the District Fishery Board of the river Bervie—who is also Clerk to the North Esk Board—has written to me with reference to the proper time for remeasuring the estuary of the Bervie. The mouth of this river varies to some extent from year to year, and since, by Schedule B of the Salmon Fisheries (Scotland) Act, 1868, the limits of the estuary have to be determined by taking "a portion of a circle of 150 yards radius, to be drawn from a centre placed mid-channel in the river where it joins the sea at low water at equinoctial spring tides, and continued shorewards by tangents to the circle drawn to the nearest points of the shore of the respective sides of the river at high-water mark, also of equinoctial spring tides," it happens that the limits of the estuary have to be remeasured annually. The interpretation of the expression "low water at equinoctial spring tides" seems to give rise to some ambiguity, and since it happens that in some cases, as in that of Bervie, a position suitable for the setting of a fixed net may during one year be within the estuary, and during another year be outside the limits, precise measurement at the proper time becomes highly necessary. It has been thought that some more definite understanding than at present exists might, with advantage to many District Boards, be arrived at. In Appendix IV. will be found correspondence between Mr. Dickson, Clerk to the Bervie Board, and myself as to the proper time for measuring the estuary. The establishment of estuarine limits in cases where rivers run directly into the sea over what may be described as the line of shore is necessarily matter of some difficulty, and in almost all cases in Scotland where rivers enter the sea in this manner the definition is drawn up on lines exactly analagous to those already quoted in the case of the Bervie. Reference to Schedule B of the Salmon Fisheries (Scotland) Act, 1868, shows that the estuaries of the following rivers are so defined:—Bervie, Brora, Dee (Aberdeenshire), Deveron, Don, North Esk, Girvan, Inner (Jura), Iorsa (Arran), Laggan (Islay), Nairn, Spey, Stinchar, Ugie, and Ythan. In the case of the Aberdeenshire Dee it cannot be said that the limits of the estuary can be uncertain, since the mouth of the river is confined by two pier-heads, but in the case of the other large river on the list—the rapid Spey—we have an instance of perhaps the most variable river mouth in the country. When a flood on the river and a storm in the Moray Firth occur simultaneously, immense banks of gravel are removed, or thrown up in a marvellously short time. In the winter of 1897 the District Fishery Board found it advisable to cut a new mouth for the river, to give the current a more direct entrance into the sea, and if possible to prevent the spread of a delta-like formation. The new single and direct entrance seems to be most satisfactory, but probably affords greater facilities for netting the mouth of the river.

In the case of many rivers, however, the variation of the mouth necessitates annual remeasurement and expense, and it appears to me that the establishing of estuarine limits from fixed points on either side of the river mouth, and some distance beyond the limits of all past variation, would in all probability prove a much more satisfactory method of definition.

Scientific Investigations.

The investigations into the life-history of the salmon in fresh water have been continued along the lines indicated in last year's Report. Dr. Noël Paton has supplied me with a report by himself and Dr. M. I. Newbigin. This will be found in Appendix V. It is divided into four sections, the three first being by Dr. Noël Paton, the last by Dr. M. I. Newbigin, as follows:—

(*A*) Further evidence on the factors determining the migration of salmon from sea to river.

(*B*) Male salmon.

(*C*) On the nature of the phosphorus compounds of the muscle of salmon, and the synthesis of the organic phosphorus compounds of testes and ovaries.

(*D*) Further observations on the source of the pigment of salmon muscle.

The conclusions previously accepted with regard to the factors determining the migration of salmon from the sea to the fresh water are considered as fully confirmed, viz.:—"That the salmon goes to the sea to feed and returns to the river when it has accumulated its full store of nourishment irrespective of the condition of the reproductive organs. The factor determining migration from sea to river is not the *nisus generativus*, but the state of nutrition."

Salmon Marking.

By the co-operation of several interested in the further investigation of salmon migration, etc., marking operations have again been continued. The Thurso, Brora, Beauly, Spey, and Tay are the rivers in which marking has been chiefly carried on. A number of marks have again been sent to Ireland to E. W. L. Holt, Esq., Royal Dublin Society.

Answers to Printed Queries.

In the Answers to the printed Queries issued to all District Fishery Boards, which will be found in Appendix II., three returns for the year 1898, which were received too late for publication in last year's Report, are here included. They refer to the districts of North Esk, South Esk, and Bervie. I am indebted to Mr. Donald M'Lean, factor to His Grace the Duke of Sutherland, for the returns of the numbers of salmon, grilse, and sea-trout taken in the rivers of East and West Sutherland.

W. L. CALDERWOOD,

Inspector of Salmon Fisheries for Scotland.

APPENDIX I.

THE COAST SALMON FISHERIES OF SCOTLAND.

By W. L. Calderwood, F.R.S.E.,
Inspector of Salmon Fisheries for Scotland.

The unfortunate absence of official statistics dealing with the actual catch of salmon makes a definite statement as to the decline or the maintenance of the stock of fish impossible.

While this is so, it cannot escape the notice of anyone interested in salmon fisheries that at present there exists a very general complaint throughout Scotland that the supply of salmon is diminishing. So far as my present experience goes, there are only two sources from which no complaint comes, or from which statements have been received to the effect that there are still plenty of salmon. Several proprietors in the West Highlands interested exclusively in angling in districts where no coast fishing by fixed engine is carried on, and a section of those interested exclusively in fixed-engine fishing or in the commercial aspects of salmon fishing, on the most closely netted part of the East Coast, make such statements. It need hardly be said the statements originate by reason of widely different interests.

All must be agreed that a stock of breeding salmon sufficient to withstand the great mortality now caused by the action of man, by the salmon's natural enemies, and by disease, is a matter essential to the continuance of the salmon fisheries of the country. We have, therefore, to deal with the capture of the fish, and we have also to deal with the upkeep of the species. This latter question seems now to be receiving more attention than formerly, and I should like to be permitted to say that it cannot receive too much attention at the present time. In many districts where the belief is held that a decline, by reason of over-fishing or other cause, has set in, District Fishery Boards or private individuals are establishing hatcheries in order to augment artificially the supply of fish. The establishment of hatcheries is a feature of the last year or two. Viewing the fisheries in general, I think it must be admitted, however, that if the present catching power continues to be developed, a very great increase in the number and in the capacity of hatcheries will be necessary to produce noticeable results. In artificially augmenting the stock of salmon we must necessarily be prepared to compete with a vast mortality.

The bag-net or fly-net fishing of our coast is the most productive and important factor on the purely commercial side of salmon fishing. To gain more definite information on certain aspects of this industry was the object of my last annual tour of inspection.

There are 94 salmon fishing districts on the mainland of Scotland with the islands of Skye and Mull, and the difference in the size of the drainage areas may be estimated from the relative number of districts which occur on the three coasts. On the East Coast there are 26 districts; on the West Coast, including the Solway, there are 60; on the North Coast, 8 districts. On the whole of the West Coast only one really large district exists—the Clyde—and it is unhappily of insignificant value as a district for salmon fishing. The large rivers of the East Coast, draining, as they do in several instances, more than a thousand square miles of land, and having their head-waters in a few cases—Ness, Beauly, Conon, and Kyle of Sutherland—within a few miles of the sea on the west side of the country, offer a very marked contrast to the small and numerous districts of the West. North of the Clyde, therefore, by far the greatest extent of the country is drained to the East, owing to the abrupt water parting caused by the steep hills of the West Highlands. The largeness of the East Coast rivers enables a much larger proportion of fish to enter fresh water and to be retained in fresh water during the year. The water flow of the small rivers and streams of the West Highlands is so slight or so variable that only during floods can many districts be entered by salmon. In addition to this, we have on the East an open coast indented only by a few long estuaries, such as those of the Forth, Tay, Ness and Beauly, Conon, and Kyle, or we have the line of coast practically unbroken where such rivers as Tweed, North Esk, Don, Ythan, Deveron, Spey, and Helmsdale enter the sea. On the West Coast, north of the Clyde, the condition of the latter group of rivers is altogether absent, and we have salt water lochs, the remains of ancient estuaries, where now for the most part streams enter at a considerable distance from the open sea.

In order that the catching power in coast salmon fishing as it at present exists may be more clearly understood, and a record made of the names of those interested in the industry, whether as lessees or as proprietors, I have prepared the following Table, giving the name of the district, the names of proprietors in the district who lease fishings, the names of those who carry on the operation of fishing by means of fixed engine, the number of nets recently used, together with an estimate of the cost of the fishing and the number of men employed. In cases where a proprietor exercises his own right of fishing his name is entered as a lessee as well as a lessor. The return cannot be taken as complete. In many instances great difficulty has been experienced in obtaining the information, and in one or two cases there is a probability that the number of nets given is inaccurate. If error occur, it will, I think, be on the side of understatement.

Table Showing Coast Salmon Fisheries.

District.	List of Proprietors who Grant Leases.	List of Lessees of Coast Salmon Fishings.	Variety of Nets.	Total Number.	Estimated Cost of Nets, Boats, and Working Expenses.	Estimated Number of Men.
TWEED. (Including the bounds of Berwick.)	The Crown. Col. D. Milne Home of Wedderburn. R. C. Campbell Renton, Esq. of Mordington. J. A. Swanston, Esq., London.	Joseph Johnston & Sons, Montrose. George A. Brownlee.	Bag Nets, 71 —	71	£6,045 0s.	50
FORTH.	The Crown. Sir John Gilmour of Montrave. George Johnston, Esq. of Lathrish. Major-General Briggs of Strathairly. William Baird, Esq. of Elie. The Trustees of the Earl of Rosslyn. R. M. Christie, Esq. of Durie. The Earl of Rosebery. The Earl of Haddington.	Joseph Johnston & Sons, Montrose. Andrew Selkirk, Lower Largo. John Turbyne, St. Andrews. James Turbyne, Guardbridge. John Anderson & Sons, Edinburgh.	Bag Nets, 175 Fly Nets, 26 Other Nets, 4 —	205	£17,531 5s.	145

TABLE SHOWING COAST SALMON FISHERIES—*continued*.

District.	List of Proprietors who Grant Leases.	List of Lessees of Coast Salmon Fishings.	Variety of Nets.	Total Number.	Estimated Cost of Nets, Boats, and Working Expenses.	Estimated Number of Men.
TAY.	Mrs. E. K. Maitland Dougall of Scotscraig. Alex. Speedie, Esq. of Kinshaldie. The City of St. Andrews. The Crown. The War Department. Lord Dalhousie. The Trustees of P. Allan Fraser, Esq. The Town of Arbroath. The Earl of North Esk.	Andrew Robertson. Joseph Johnston & Sons, Montrose. James Cheape, Esq. of Strathtyrum. David B. Meldrum, Esq. Carnoustie Police Commissioners.	Bag Nets, 88 Fly Nets, 43 Other Nets, 2	133	£8,700 0s.	90
SOUTH ESK.	Joseph Johnston & Sons. Mrs. C. A. Smyth, Stredregh, Londonderry. Mrs. E. Stanfeld, Duninald. George Keith, Esq. of Usan. W. B. Imrie, Esq. of Lunan. The Earl of North Esk. The Earl of Dalhousie. Miss Elizabeth Carnegie of Craigo.	Joseph Johnston & Sons, Montrose.	Bag Nets, 44 Fly Nets, 23 Other Nets, 4	71	£8,395 0s.	50

NORTH ESK.	The Crown. Capt. F. G. Forsyth Grant of Ecclesgreig. A. Dingwall Fordyce, Esq. of Brucklay. Col. G. L. Fraser of Kirkside. Mrs. Fanny Fitzmaurice Scott. Rev. J. M. Gordon of Kinnaber and Charleton.	Alex. Hector, Aberdeen. Messrs. A. & D. Speedie, Perth. Joseph Johnston & Sons, Montrose. A. Dingwall Fordyce, Esq. of Brucklay.	Bag Nets, Fly Nets,	91 32 —	123	£10,551 5s.	85
BERVIE.	James Farquhar, Esq. of Hallgreen. The Crown.	Alex. Hector, Aberdeen. Alfred Gibb & Brothers, Bervie.	Bag Nets,	50	50	£4,256 5s.	35
DEE. (Aberdeenshire.)	Aberdeen Harbour Commissioners. Aberdeen City Treasurer. Commissioners of Woods. James Davidson, Esq. Alexander Kilgour, Esq. Trustees of Mrs. Rosa Taylor. Simpson Duguid, Esq. Rev. W. Desiney Innes. Sir Alex. Baird, Bart.	Aberdeen Harbour Commissioners. Representatives of James Brown. John Hector, Aberdeen. James Marr, Findon. G. & W. Davidson, Aberdeen. Alex. Hector, Bervie. Alfred Gibb & Brothers, Bervie.	Bag Nets, Fly Nets,	121 6 —	127	£10,826 5s.	89
DON.	Aberdeen Shipmasters' Society. Tutors of M. V. Hay. Trustees of Alex. Gordon. Aberdeen Society of Advocates. Col. Geo. Leith Fraser. W. H. Lumsden, Esq. Commissioners of Woods. The Misses Turner.	Aberdeen Shipmasters' Society. William Greig, Bridge of Don. Alex. Hector, Bervie. Isaac Scott, Belhelvie. Alex. Baird, Belhelvie. Miss Turner.	Bag Nets, Fly Nets,	59 44 —	103	£8,867 10s.	70

TABLE SHOWING COAST SALMON FISHERIES—*continued.*

District.	List of Proprietors who Grant Leases.	List of Lessees of Coast Salmon Fishings.	Variety of Nets.	Total Number.	Estimated Cost of Nets, Boats, and Working Expenses.	Estimated Number of Men.
YTHAN.	The Crown. General Mackenzie of Torran. J. H. Udny of Udny. Trustees of late Mr. Gordon of Cluny. The Earl of Erroll.	G. & W. Davidson, Aberdeen. Mitchell & Mundie, Cruden.	Bag Nets, 35 Fly Nets, 10 Other Nets, 3 —	48	£4,118 15s.	33
UGIE.	Governors of Merchant Maiden Hospital, Edinburgh. Henry Barnett, Esq., Edinburgh. The Lords Commissioners of the Admiralty. The Crown. Col. G. A. Ferguson of Pitfour. John Duthie, Esq. of Cairnbulg. Trustees of late Mr. Cumine of Rattray. A. Hay, Esq., as Lessee of the Crown.	West & Strachan, Peterhead. George Noble, Junr., Port Erroll. Cumine Summers, Peterhead. J. & J. Summers, Peterhead.	Bag Nets, 20.	20	£1,706 5s.	15

Deveron.	The Countess Dowager of Seafield. The Duke of Fife. Lord Farquhar. W. P. Lindsay, Esq. The Crown. A. Dingwall Fordyce, Esq. of Bruck-lay. Lord Saltoun. John Duthie, Esq. of Cairnbulg.	A. L. Gillan, Portsoy. Joseph Bisset, Macduff. West & Strachan, Peterhead. Alexander Morrison, Rosehearty. George Noble, Cairnbulg. A. Dingwall Fordyce, Esq. of Brucklay.	Bag Nets, 54	54	£4,605 0s.	40
Spey and Lossie.	The Countess Dowager of Seafield. Sir Robert G. Gordon, Bart. Lady Gordon Cathcart of Cluny. Duke of Richmond and Gordon. Capt. Dunbar Brander of Pitgaveny.	A. L. Gillan, Portsoy. W. L. Taylor, Cullen. Duke of Richmond and Gordon. Cooper & Smith, Lossiemouth.	Bag Nets, 69 Fly Nets, 7 —	76	£6,492 10s.	55
Findhorn.	R. C. Munro Ferguson, M.P., of Novar. J. J. R. Murray Grant, Esq. of Glenmoriston. J. W. Brodie Innes, Esq. of Melton Brodie. Hugh Young, Esq. of Burghead. The Crown. Sir William G. Gordon Cumming, Bart. of Altyre. G. R. M'Kessach, Esq. of Ardgyr.	Hogarth & Co., Aberdeen. G. R. M'Kessach, Esq. of Ardgyr, Forres. John Bisset, Findhorn. A. L. Gillan, Portsoy.	Bag Nets, 95 Fly Nets, 41 —	136	£11,687 10s.	96

TABLE SHOWING COAST SALMON FISHERIES—*continued.*

District.	List of Proprietors who Grant Leases.	List of Lessees of Coast Salmon Fishings.	Variety of Nets.	Total Number.	Estimated Cost of Nets, Boats, and Working Expenses.	Estimated Number of Men.
NAIRN.	The Earl of Cawdor. Brodie of Brodie.	Hogarth & Co., Aberdeen.	Bag Nets, 27 Fly Nets, 17	44	£3,790 0s.	32
NESS.	The Earl of Cawdor. J. D. Fletcher, Esq. of Rosehaugh. Captain Ross of Cromarty.	Hogarth & Co., Aberdeen. John Bisset, Findhorn. George Paterson, Cromarty.	Bag Nets, 36 Fly Nets, 5	41	£3,482 5s.	30
KYLE OF SUTHERLAND.	The Crown.	Messrs. Tough, Portmahomack. Dr. Almond, Musselburgh (unfished).	Bag Nets, 6	9	£780 0s.	10
FLEET, BRORA, HELMSDALE.	Messrs. J. Sellar & Sons, Boddam, Sutherland in 1896. The Nets of the 1899 season for the purpose	obtained a lease from the Duke of were, however, bought off at the end of protecting the angling interests.				
BERRIEDALE.	The Duke of Portland.	Mrs. Dunbar, Kilmarnock.	Bag Nets, 5	5	£431 5s.	5

DUNBEATH.	Edwyn S. A. Sinclair, Esq. of Freswick. The Crown.	Hogarth & Co., Aberdeen.	Bag Nets, 6	6	£513 15s.	5
WICK.	Trustees of Mr. Garden Duff, Dunbar. The Crown.	Hogarth & Co., Aberdeen. J. Sellar & Sons, Boddam.	Bag Nets, 6 Fly Nets, 6 (or Jumpers.) —	12	£1,038 15s.	9
THURSO.	J. G. Sinclair, Esq. of May. Edwin S. A. Sinclair, Esq. of Freswick. The Crown. J. C. Brodie & Sons, W.S., Edinburgh. Trustees of late Mr. James Sinclair of Forss.	J. C. Sellar & Sons, Boddam. Alex. P. Hogarth, Aberdeen. William Smith, Forss.	Bag Nets, 24 Fly Nets, 7 —	31	£2,667 10s.	24
FORSS.	Thomas Pilkington Esq. of Sandside. J. C. Brodie & Sons, W.S., Edinburgh.	Thomas Pilkington, Esq. of Sandside.	Bag Nets, 5	5	£431 5s.	5
HALLADALE.	Duke of Sutherland.	Alexander Speedie, Perth.	Bag Nets, 6	6	£513 15s.	5
STRATHY.	Duke of Sutherland.	Alexander Speedie, Perth.	Bag Nets, 6	6	£513 15s.	5

TABLE SHOWING COAST SALMON FISHERIES—*continued.*

District.	List of Proprietors who Grant Leases.	List of Lessees of Coast Salmon Fishings.	Variety of Nets.	Total Number.	Estimated Cost of Nets, Boats, and Working Expenses.	Estimated Number of Men.
NAVER.	Duke of Sutherland.	Alexander Speedie, Perth.	Bag Nets, 4	4	£348 15s.	5
INCHARD.	Duke of Sutherland.	Alexander Speedie, Perth.	Bag Nets, 6	6	£462 16s. 6d.	5
LAXFORD.	Duke of Sutherland.	Alexander Speedie, Perth.	Bag Nets, 8	8	£628 13s.	10
INVER.	Duke of Sutherland.	Alexander Speedie, Perth.	Bag Nets, 6	6	£462 16s. 6d.	5
KIRKAIG.	Countess of Cromarty.	Wm. Rae, Ullapool.	Bag Nets, 18	18	£2,024 11s.	20
KENNART.	Countess of Cromarty.	Wm. Rae, Ullapool.	Bag Nets, 9	9	£682 18s.	10
BROOM AND LITTLE LOCH BROOM.	} Fishing reported as having been given	up.				

GRUINARD.	H. M'Kenzie, Esq. of Dundonnell.	A. Powrie & Sons, Perth.	Bag Nets,	12	12	£925 13s.	10
EWE.	Sir Kenneth M'Kenzie, Bart. of Gairloch.	A. Powrie & Sons, Perth.	Bag Nets,	12	12	£925 13s.	10
BADACHRO.	Sir Kenneth M'Kenzie, Bart. of Gairloch.	A. Powrie & Sons, Perth.	Bag Nets,	16	16	£1,239 19s. 6d.	15
TORRIDON.	Sir Kenneth M'Kenzie, Bart. of Gairloch.	A. Powrie & Sons, Perth.	Bag Nets,	20	20	£1,554 6s.	20
SLIGACHAN (SKYE), INCLUDING RAASAY.	Lord Macdonald. Trustees of late Mr. Baird of Kilmuir. MacLeod of MacLeod (unlet).	Joseph Johnston & Sons, Montrose.	Bag Nets,	80	80	£1,613 14s.	80
MOIDART, SHIEL, AND SUNART.	R. H. Rudd, Esq. of Ardnamurchan.	Powrie & Pride, Perth.	Bag Nets,	20	20	£1,554 6s.	20
LUSSA AND BAA (Isle of Mull).	The Duke of Argyll. The Crown. Col. G. C. Cheape of Carsaig. Maclaine of Lochbuie. W. M. Guthrie, Esq. of Duart.	A. & F. Ritchie, Iona. W. & A. Mitchell, Tobermory. Captain Paterson, Oban. G. & J. Rae, Lochbuie.	Bag Nets,	35	35	£2,720 0 6	35

TABLE SHOWING COAST SALMON FISHERIES—*continued.*

District.	List of Proprietors who Grant Leases.	List of Lessees of Coast Salmon Fishings.	Variety of Nets.	Total Number.	Estimated Cost of Nets, Boats, and Working Expenses.	Estimated Number of Men.
LOCHY.	George Sheriff, Esq. of Kingairloch.	Joseph Johnston & Sons, Montrose.	Bag Nets, 9	9	£702 18s.	10
AWE.	Trustees of the late Mr. Campbell of Lochnell. The Duke of Argyll. A. J. H. Campbell, Esq. of Dunstaffnage. Mrs. Jane Campbell of Inverawe. The Marquess of Breadalbane. The Crown. J. Patten M'Dougall, Esq. of Gallanach. W. H. R. Bedell Sivright of Ardincaple. Trustees of Mrs. Paterson of Kilchoan. Trustees of the late Mr. MacLellan of Melfort. Mr. Campbell, Preston.	David Baird, Taynuilt. William M'Niven, Taynuilt. Dugald M'Niven, Taynuilt. Archibald M'Intyre, Kerrera. Angus M'Donald, Oban. George Paterson, Cromarty. Archibald Buchanan, Oban.	Bag Nets, 26 Other Net, 1	27	£2,098 7 6	25
ADD.	Lord Malcolm of Poltalloch.	David Baird, Taynuilt.	Bag Nets, 6	6	£462 16 6	5

Ormsary, etc.	Captain Hector Macneal of Ugadale.	Alexander Rae, Machrihanish.	Bag Nets, 4	4	£314 6 6	5
Carradale.	The Dowager Lady Charlotte Campbell. The Duke of Argyll. Colonel M'Leod of Saddill. Neil M'Neill, Esq. of Ardnacross.	James Rae, Kildaloig. George Eaglesome, Peninver. Donald Rae, Campbeltown.	Bag Nets, 12	12	£925 13s.	10
Loch Fyne.	John M'Lachlan, Esq., of Strathlachlan. Col. M'Ivor Campbell of Lochgair. Graham Campbell, Esq. of Shirvain. Sir Arthur C. Orde of Kilmory. G. Rankin, Esq. of Ottar. Col. D. Campbell of Inverneil. A. Campbell, Esq. of Auchindarroch.	John M'Lachlan, Esq. of Strathlachlan. Col. M'Ivor Campbell of Lochgair. Miss Gilmour, Tighnabruaich. Sir Arthur C. Orde of Kilmory. Mr. Boyd, Ardrishaig. Duncan Ferguson, Ardrishaig.	Stake Nets, 7	7	£554 8s. (Calculated as Bag Nets.	15
Drummachloy (Bute).	The Marquess of Bute.	James Buchanan, Craigmore.	Bag Nets, 7	7	£554 8s.	8
Irvine.	The Duke of Portland.	James Cameron, Troon.	Bag Nets, 5	5	£402 6 6	4
Ayr.	R. A. Oswald, Esq. of Auchincruive.	John Wregg, Ayr.	Bag Nets, 6	6	£479 6 6	4

TABLE SHOWING COAST SALMON FISHERIES—*continued.*

District.	List of Proprietors who Grant Leases.	List of Lessees of Coast Salmon Fishings.	Variety of Nets.	Total Number.	Estimated Cost of Nets, Boats, and Working Expenses.	Estimated Number of Men.
DOON.	The Marquess of Ailsa, Culzean Castle. The Crown.	Clark and Smith, Annan. John C. Kennedy, sublet to J. Buchanan, Kilmarnock. The Marquess of Ailsa.	Bag Nets, 11 Fly Net, 1 Other Net, 1	13	£1,056 13s.	10
GIRVAN.	The Marquess of Ailsa, Culzean Castle. John C. Kennedy, Esq. of Dalquharran. George Kerr, Esq. of Chapeldonan. Major Hon. North Dalrymple Hamilton of Bargany. The Crown.	Mrs. Elizabeth Allan, Ayr. Thomas Alexander, Girvan. James Buchanan, Rothesay. Mrs. Joan Carson, Girvan. John Wright, Kilmarnock.	Bag Nets, 32	32	£2,550 12 6	20
STINCHAR.	Joseph Charlesworth, Esq. of Glenapp. The Crown.	Clark & Smith, Annan. Wm. Hannah, Jun., Ballantrae. Alexander Lyons, Ballantrae.	Bag Nets, 10	10	£804 13s.	8

LUCE, BLADENOCH, CREE.	The Earl of Galloway. Sir Wm. F. Maxwell, Bart. Mrs. C. R. M. Jamieson. J. A. H. Caird, Esq. Lieut.-Col. R. W. R. Hannay. Lieut. A. J. Henniker Hughan, R.N. Lady M'Taggart Stewart. A. K. M'Donall, Esq. J. C. Cunningham, Esq. of Dunragit.	Thomas Craig, Garliestown. Thomas M'Connell, Gatehouse. Charles Turner, Dumfries. Wm. Birrell's heirs, and Lowther Birrell, Creetown. Hugh M'Dowall, Kirkcolm. Thomas Lockhart, Terally. J. C. Cunningham, Esq., of Dunragit.	Stake Nets, 25. with 43 pockets.	43	...	...
FLEET.	H. G. Murray Stewart, Esq. of Cally. Sir Wm. F. Maxwell, Bart. of Cardonness. Mrs. Christian Jameson of Ardwell.	Wm. Davidson, Gatehouse. Thomas M'Connell, Gatehouse.	Fly Nets, 7. with 14 pockets. Stake Nets, 2. with 3 pockets.	17	...	...
NITH.	R. A. Oswald, Esq. of Cavens.	Thomas M'Queen Pool, Portling.	Stake Nets, 5. with 16 pockets.	* 16	...	...
ANNAN.	The Duke of Buccleuch. Sir Frederick J. W. Johnstone, Bart. The Burgh of Annan. Wm. D. Mackenzie, Esq. Earl of Mansfield.	William Blake, Annan. W. J. P. Beattie, Moffat. Clark & Smith, Annan. Wm. D. Mackenzie, Esq. Earl of Mansfield.	Stake Nets, 29. with 72 pockets. Fly Nets, 25.	† 97	£5,293 11 6	46
			TOTALS,	1,945	£143,900 17 0	1,352

* Many paidle nets are also used.
† In addition there are 500 Clouts, or 2000 Poke Nets in use. They are let annually by the Burgh of Annan in small lots to local fishermen.

It will be noticed that in the case of all the large river districts of the East Coast, the number of proprietors is greater than the number of the tenants; that in some cases—Tweed, Forth, and Tay—the proportion is almost two to one; while in one case—the South Esk—a single tenant, who is also a proprietor with seven others, fishes the whole district coast line. This fact is, I think, worthy of notice, for if it should be found there is truth in the statement that the great amount of bag-net fishing in modern times is seriously injuring the fisheries, we are able to see that the injury is, at present, in the hands of a limited number of enterprising tacksmen, and that coast proprietors, by allowing unrestricted netting on the part of their lessees, may, while gaining a personal return by way of rent, be affecting the interests and the personal returns of a very much larger number of proprietors in the inland parts of the district. In the case of the Deveron, the Spey, and the Findhorn, the relative proportion of tacksmen is not so great. In the Wick district, proprietors and tenants are equally balanced. In the districts of Fleet, Brora, and Helmsdale, on the east coast of Sutherland, it will be noticed that, in the interests of angling, the bag-net fishing of the coast has been stopped. The effect of introducing bag-net fishing is said to have been almost immediately experienced in a marked diminution of the number of fish in fresh water. In this connection a point of considerable interest arises when we consider the case of the North Esk. The coast of the North Esk district appears to be more closely netted than any other part of Scotland. Reference to the Tables shows that there are 123 nets; and since the coast of the district is only about 9 miles in length, it would appear, if my information is correct, that there must be a net every 130 yards. It seems probable, however, that very many of the large number of fish taken are not North Esk fish, and that the same is true of the South Esk, which river might to a considerable extent be described as a sea-trout river.

An insignificant amount of bag-net fishing is carried on along the North Coast; and a glance at the Tables is sufficient to show that on the west coasts of Sutherland and Ross-shire each small district is fished by a single lessee from a single proprietor. The only other districts which may be mentioned are the Awe and Loch Fyne. The former, though possessed of a small coast line, has its fishings more broken up amongst both proprietors and tenants than any other district. The latter is remarkable by reason of the number of small fishings which are worked by proprietors.

It is important now to notice the estimated value of the fishings and the number of men employed. The computations have been based upon the statements as to initial cost and working expenses given in the 13th, 14th, and 15th Annual Reports by my predecessor, Mr. Archer. For the East and North Coasts the estimate is made up as follows:—

Bag nets (per pair) at . .	£33
Working expenses . .	£49 10s. each, annually.
Boat to each 7 nets, say . .	£18 15s.
(5 men to each boat.)	
Fly nets (per pair) . .	£35
Working expenses . .	£52 10s.
(2 men to 3 nets.)	

On the West Coast from Cape Wrath to Ardlamont Point.

Bag nets (per pair) . .	£33
Working expenses . .	£41 5s.
Boat to each 5 nets . .	£17 6s. 6d.
(5 men to each boat.)	

From Ardlamont Point to Mull of Galloway.

Bag nets (per pair) . .	£33
Working expenses . .	£44
Boat to each 7 nets . .	£17 6s. 6d.
(4 men to each boat.)	

This arrangement has necessary disadvantages, since in all probability a hard and fast line cannot be drawn at the points named, but more especially in dealing with boats in the estimate of cost. The figure first used (£18 15s.) is calculated to cover the boats both of less and of greater cost which are referred to in Mr. Archer's report. A greater amount of ambiguity arises, however, in cases where a comparatively small number of nets are used by several lessees in one district. In such cases the number of boats calculated for is probably too small, since each lessee is bound to have at least one boat. In a case such as Loch Fyne, where a number of proprietors fish their own nets, it may happen that several boats are used which are not of the recognised type, and which, it may be, are of a different value. I have, however, thought it advisable, except in the case of Loch Fyne, where an exact enumeration of boats is impossible, to calculate all in the uniform way, giving a boat to every 7 nets on the East or North Coasts, a boat to every 5 nets on the West Coast from Cape Wrath to Ardlamont Point, including Loch Fyne district, and a boat to every 7 nets south of this point to the Mull of Galloway.

Since the stake nets of the Solway do not conform either to the usual bag-net or fly-net type, and are "privileged engines" of a varied type, I have not attempted to estimate their value.

The totals show that 1945 fixed nets are used annually at present on the coast of Scotland; that the value of the nets and boats may be estimated at £143,900 17s.; and that 1352 men are probably employed in this branch of the fishing industry.

With regard now to the particular localities where observations regarding coast fishing and its results might be expected to yield evidence of interest, it appears to me natural to suppose that on such a highly indented coast as that of Argyllshire, West Inverness-shire, West Ross-shire, and West Sutherland, remunerative localities for the establishment of coast salmon fishing stations have in a great many cases, perhaps in every case, been established as the result of experience after many failures. But once good stations have been found it seems natural to suppose further that, owing to the absence of large rivers where fish can leave the salt water even in dry weather, the toll taken of fish hanging about the mouths of the various lochs, and at certain headlands, must, *in proportion*, be greater than would be the case on an open coast; and that individual districts will more quickly feel the effects of fishing. If, then, an undue amount of bag-net fishing is having an injurious effect upon the stock of salmon, we might expect to find the most marked signs of it in certain districts of the West Coast where successful fishing has long been carried on. On the East Coast it appears to me the issue of any observations on the subject is much more uncertain owing to the open coast along which fish can travel, it may be to a neighbouring river, it may be to a larger river further on. The concentration, or at least the apparent concentration, is absent. Fish on the coast of the Ugie district, for instance, at Peterhead, are taken in the bag nets all through the season, although no salmon enter the Ugie river till quite the end of the season, and then they enter only in small numbers. It seems necessary, in this case, to believe that a large proportion of the fish taken in the bagnets are not Ugie fish at all, but are fish striking the coast on their way to other rivers. I am, indeed, of opinion that on the East Coast generally, on account of its open, uniform character, stake or bag net fishing is probably far-reaching in its influence upon the fisheries; that, in other words, as I have already indicated, the coast fishings of, say, the North and South Esks Districts are likely to capture more than North and South Esk fish. Salmon are captured on both sides of Fife Ness where no salmon rivers exist. They have as far to go to the Forth or the Tay—the two nearest rivers—as is the distance from the North or South Esk to the Tay. In support of this opinion the returns of salmon marking carried on during recent years give instances of fish being recaptured considerable distances from the points where they were marked, and in not a few cases in rivers other than might be described as their own rivers.

In view, therefore, of the different conditions which exist on the East and on the West Coast, it would appear that to the bag-netted districts of the North-West Highlands we must look for our clearest evidence as to the influence of coast fishing by fixed engine.

During my annual tour of inspection I visited 23 districts between the Awe in Argyllshire and the Laxford in Sutherland. I shall divide them into two groups—

Those Fished by Bag Nets.	Those not so Fished.
Awe.	Creran.
Lussa.	Pennygown.
Baa.	Sunart.
Shiel.	Moidart.
Sligachan.	Aylort.
{ Balgay.	Morar.
{ Torridon.	Kilchoan.
Badachro.	Glenelg.
Ewe.	Snizort.
Broom	Ullapool.
Kirkaig.	
Inver.	
Laxford.	

From Moidart northwards a consecutive series of 12 districts—to Loch Torridon—are not fished by bag nets, although the Sound of Sleat on the Skye side is so fished. At several points along this line of coast attempts have been made with bag nets, but hitherto with no success. Great complaints are made in the neighbourhood on account of extensive "scringing" by boats' crews hailing from the villages of Plocton and Avernish—nine crews appear to be particularly bold in this illegal pursuit—but in none of the districts which I visited in this series did there appear to be complaint as to decline in the stock of fish. These are the angling districts to which I referred at the commencement as constituting one of the two sources from which no general statement of decline was received.

The east coast of Skye, on the other hand, is heavily netted, as are the districts of Torridon and Badachro on the mainland. Here, complaints are rife. Referring to last year's report from the Clerk to the District Fishery Board of Torridon, we find, "No fish at all taken in 1898. Salmon fishing quite ruined by the outside nets"; and no recent reports existent in this office show record of a greater number of salmon than 14 having been taken in fresh water in one year. Mr. Darroch of Torridon supplied to Mr. Archibald Young, then Inspector of Salmon

Fisheries, a report on the decline of the salmon fisheries of the district This is published in the Third Annual Report (1884), p. 136. From Mr. Darroch's statement, as from the evidence of many witnesses he cites, it appears that since the introduction of bag-net fishing to the district in 1838, at which time fish are reported as having been in abundance, a steady decline has continued.

I visited several of the bag-netting stations in this district and in Skye, and had an opportunity of seeing from time to time the catches obtained. My best thanks are due to C. H. Akroyd, Esq., without whose aid I should have found it impossible to have reached so many inaccessible points of coast. The tacksmen seemed to be suffering from a worse season than they had ever experienced, and were therefore increasing the number of their nets. This may be a perfectly natural method for the tacksman, but it does not seem likely to have a good effect upon the fishings in general. I found, further, that the great majority of the fish taken in this neighbourhood are grilse. The fishery might indeed be described as a grilse fishery, sea trout being added in the earlier part of the season, and salmon proper towards the end of the season. This may in itself have a marked significance when we consider the absence of salmon in the rivers. The direction in which these grilse travel becomes a point of considerable interest also, and may, I hope, be to some extent explained by future marking of fish in the neighbourhood. At present the positions of the netting stations, and the absence of all nets at particular parts of the coast, form a slight if somewhat uncertain guide to the directions from which grilse and salmon approach the various rivers of the neighbourhood. I hope in a subsequent report to be able to deal at greater length with this matter. The capture of so few fish in such a river as Torridon need not necessarily imply that fish were equally scarce after the close of the rod-fishing season; indeed, in view of the continued fishing by means of bag-nets, it seems necessary to believe that the stock is almost entirely maintained in these districts by virtue of the close season permitting late fish to enter the rivers and reproduce their species. But such a condition is manifestly of no value to those who hold rights of salmon fishing in the rivers, and is perhaps with equal certainty to the disadvantage of the general interests of the fisheries.

APPENDIX II.

THE FOLLOWING QUERIES HAVE BEEN SENT TO CLERKS OF DISTRICT BOARDS, AND OTHERS:—

Take of Fish—

1. Has the take of fish in your district in 1899 been above, about, or below the average—
   (*a*) In tidal waters?
   (*b*) In fresh waters?
   (*c*) By fixed engines?
   (*d*) Generally throughout the district?

2. Can you give the number of fish caught in your district, exactly or approximately—
   (*a*) By net and coble?
   (*b*) By fixed engines?
   (*c*) By rods?

3. At what period of the year in your district during 1899—
   (*a*) Were the first clean fish taken?
   (*b*) When was the main take of salmon?
   (*c*) When did the grilse and sea-trout run?

4. In order that accurate records be kept as to whether the run of salmon in your district is becoming earlier or later, it is desirable that you should, if possible, obtain and furnish me with statistics of the percentage of fish taken in each month—
   (*a*) By net and coble?
   (*b*) By fixed engines?

5. What was the weight of the heaviest salmon or trout caught in your district in 1899—
   (*a*) By net and coble?
   (*b*) By fixed engines?
   (*c*) By rods?

Protection—

1. Please state the amount of the assessable rental of your district in 1899?
2. What was the assessment levied thereon during the year?
3. State the number of water bailiffs employed in your district in 1899?
4. Were any prosecutions instituted under the Salmon Fishery Acts in 1899? If so, for what offences were they instituted, and what was the result?

Obstructions to the Passage of Fish—

1. Give full particulars of any dams destroyed or disused in your district in 1899; or any new dams built or old dams altered?
2. Are the dams and cruives (if any) in your district worked in accordance with the provisions of the bye-laws (Schedules F and G) regulating the same?

3. Have any fish-passes been built or altered in 1899 ?
4. Do the existing fish-passes afford at all, or any, or at what times a free passage to salmon wishing to ascend ?
5. Have any natural obstructions been opened up during 1899 ?
6. Generally, have any acts been done, either by new fisheries being started, old fisheries not being used, or in any other way, whereby the ascent of fish has been influenced ? If so, state fully what changes have taken place.

Pollutions—

1. Were any fresh causes of river pollution introduced in your district in 1899 ?
2. Were any steps taken in 1899 to remove causes of pollution; and if so, were they attended with success ?

The Salmon Disease—

1. Has the salmon disease shown itself in your district this year? If so, when did it first make its appearance ? When was it at its height ? When did it disappear ?
2. What was the level of the river during the prevalence of the salmon disease ?
3. Can you state the number of diseased salmon taken from the river in each month, specifying the proportion of male and female, of kelts and of clean fish ?
4. Generally, have you any remarks or suggestions to make with regard to the salmon disease ?

The Spawning Season—

1. What was the earliest date, during the season of 1898–99, on which salmon were noticed spawning ?
2. Between what dates did the greatest number spawn ?
3. When did the spawning season finish ?
4. What was the level of the river during the spawning season ?
5. Were the numbers of spawning fish more or less than usual ?
6. Which were the principal spawning streams in your district ?

Kelts—

1. On what date, during last season, were kelts first noted migrating seawards ?
2. When did the chief migration take place ?
3. When was the river free from kelts ?
4. What was the level of the river during the period kelts were migrating ?

Smolts—

1. On which dates, during the year, were smolts noticed migrating ?
2. Was it a good smolt year ?

Artificial Propagation of Salmon—

Is there any hatchery in your district for the artificial propagation of salmon and trout, either belonging to the District Board or supported by private enterprise ? If so, describe its situation, and state how many ova have been secured during the past season.

Proportion of Male to Female Salmon—

Can you state the proportion of the male to the female salmon in your district or river, specifying whether your return, so far as it goes, is based upon an estimate or on actual enumeration ?

General Question—

Are there any other points relating to the salmon fisheries in your district to which you would wish to direct the attention of the Board, in addition to those suggested by the preceding queries ?

ANSWERS TO THE FOREGOING QUESTIONS.

THE DISTRICT OF THE RIVER FORTH.

Take of Fish—

1. (*a*), (*b*), (*c*), and (*d*) Above.
2. (*a*), (*b*), and (*c*) No means of knowing, the tenants always refusing to give information.
3. (*a*) 11th February; (*b*) June, July, and August; (*c*) grilse ran during June, July, and August, and sea-trout all through the fishing season.
4. (*a*) and (*b*) See answer to No. 2.
5. (*a*) 32 lbs.; (*b*) 48 lbs.; (*c*) 28 lbs.

Protection—

1. £3,791 14s. 4d.
2. 2s. 6d. per £.
3. Twelve.
4. —

Offences.	Offenders.	Penalty.	Expenses.	Remarks.
			£ *s.* *d.*	
Dragging with rake hooks or jiggering, .	Alexander Brown.	...	...	Not proven.
	C. E. Cummings.	10s.	1 10 0	...
	James Oliver.	...	...	Not proven.
Taking sea-trout in close time, ...	Joseph Duffin.	5s.	0 15 0	...
	Alexander Brown.	5s.	0 15 0	...
Taking smolts, . .	Alexander Hunter.	2s. 6d.	1 1 6	...
Gaffing out of drift nets, being use of gaff not as auxiliary to rod and line, . . .	James Bremner.	10s.	2 3 6	...
	James Horne.	...	...	Not proven.
Taking salmon with gaff not as auxiliary to rod and line, . . .	Alexander Grant.	12s. 6d.	2 0 0	...
	William Freckleton.	10s.	2 0 6	...
	Alexander White.	1s.	0 9 6	...

Obstructions to the Passage of Fish—

1. None.
2. Yes. This answer applies to ordinary mill dams and Craigforth Cruive, the only cruive in the district.
3. No.
4. They all do so except the fish-passes at the mouth of Loch Venacher.
5. No.
6. Nothing has been done with reference to the matters embraced in this query.

Pollutions—

1. Not so far as known.
2. From 25th August to 2nd September 405 dead salmon were taken from the Forth between Alloa and Stirling, believed to have been destroyed by polluted discharges into the Devon, a tributary of the Forth, from Glenochil and Cambus Distilleries, Tullibody Tannery, and Alva Mills. Analyses of samples of the water of the Devon were made, and the proprietors of the distilleries, tannery, and mills communicated with. The proprietors of the distilleries and tannery have since made improvements for the purification of the discharges from their works

into the Devon, but the proprietors of the Alva Mills have not yet made any improvement, although they have promised to do so. The several works mentioned will be visited from time to time to see that the Devon is kept free from pollution.

The Salmon Disease—
1. Yes. 1st December 1898. Middle of January. End of March.
2. Very high.
3 and 4. No.

The Spawning Season—
1. 15th November.
2. 25th November and 10th December.
3. 15th January.
4. Very high.
5. About the same as usual.
6. Rivers Teith and Allan.

Kelts—
1. 1st December.
2. January.
3. End of March.
4. Very high.

Smolts—
1. April and May.
2. Yes.

Artificial Propagation of Salmon—
No.

Proportion of Male to Female Salmon—
No.

General Question—
(*a*) The catching of salmon by small mesh nets on the pretence of fishing for sparlings. No convictions can be got in the Courts unless the fishermen retain salmon so caught as showing their intention to fish for salmon.
(*b*) The practice of drift-net fishing, which prevails to a great extent in the Forth between the railway bridge, a short distance above Alloa, and Borrowstounness.

THE DISTRICT OF THE RIVER TAY.

Take of Fish—
1. Perhaps slightly below average ; (*a*) good average ; (*b*) slightly below average ; (*c*) good average ; (*d*) nearly, if not, average.
2. No note of number kept ; (*a*) and (*b*) the same applies under all these heads ; (*c*) the rod fishing a good average.
3. (*a*) At opening of fishings, 11th February (clean salmon in Tay at all seasons) ; (*b*) during July and August ; (*c*) early in June, but chiefly in July and August.
4. At present there is no possible means of obtaining this except in a general way.
5. (*a*) 49 lbs.; (*b*) 46½ lbs.; (*c*) 53 lbs.

Protection—
1. £22,482 3s. as per Valuation Roll of September 1899.
2. 10 per cent. of ordinary assessment.
3. 27—18 by the Tay Fishery Board, and nine are paid for by the Tay Salmon Fishing Company.
4. A number of people convicted for illegal fishing, and mostly either paid fines or were imprisoned.

Obstructions to the Passage of Fish—

1. Dornoch Dam, on the Earn, about two miles below Crieff, was destroyed by a flood about a year ago, and has not been rebuilt. No new dams.
2. Yes.
3. A fish-pass has been built on the Shochie at Luncarty Dyke this season, but is not quite complete yet, and it is too late for this season.
4. The fish-passes in our district up till the present time have been useless.
5. No.
6. Owing to the Salmon Fishing Company having nearly all the stations in the estuary, a number of stations were unfished, but no greater run of salmon seemed to get beyond the tideway.

Pollutions—

1. No. But the growth of towns and increase of trade is always making it worse.
2. No. Several distilleries have been visited, and owners warned as to danger of pollution.

The Salmon Disease—

1. Yes. Towards end of October 1898 : at its height about New Year 1899, and disappeared with last of spent fish, returning to sea in beginning of June 1899.
2. River generally in flood during whole of autumn.

3 and 4. No.

The Spawning Season—

1. About end of October 1898.
2. 10th and 30th November.
3. A few salmon spawned as late as first week in January.
4. Abnormally high.
5. Less than an average.
6. Tay, Earn, Almond, Tummel, Garry, Ericht, and Isla ; sea-trout in small tributaries.

Kelts—

1. Early in December.
2. April and first week of May.
3. About end of May.
4. Above average spring level.

Smolts—

1. April, May, and first week in June.
2. Best for a good many years.

Artificial Propagation of Salmon—

There is a hatchery on the Earn at Dupplin belonging to the Board. Last year only about 57,000 ova were got owing to excessive flooding during spawning season.

Proportion of Male to Female Salmon—

No.

THE DISTRICT OF THE RIVER SOUTH ESK.

(This Return is for the Year 1898.)

Take of Fish—

1. Below the average throughout the district.
2. No.
3. (*a*) 16th February ; (*b*) month of August ; (*c*) July and August.
4. Not possible to say.
5. (*a*) 45 lbs.; (*c*) 28 lbs.

Protection—
1. £3,500.
2. 10 per cent. on rentals.
3. Ten.
4. Seven prosecutions instituted, chiefly for taking and possessing unclean fish, dragging for fish, and taking smolts. All convicted and fined.

Obstructions to the Passage of Fish—
1. None.
2. Dams worked in accordance with provisions of the bye-laws (Schedules F and G) partly.
3. Fish-passes at Kinnaird and Blackiemill altered and much improved.
4. Yes ; at all times, except when water very low.
5. No.
6. No changes.

Pollutions—
1. No.
2. No steps necessary to be taken.

The Salmon Disease—
1. Yes ; appeared first in August ; at height in January and February ; disappeared in May.
2. Low.
3. In December and January proportion 2 male to 1 female kelts. About 20 clean fish.
4. No.

The Spawning Season—
1. 26th October 1897.
2. November and December.
3. 6th January 1898.
4. Above ordinary size.
5. Less.
6. All good above tidal water, especially at Brechin, Finavon, Tannadice, New Mill, Prosen, and all above.

Kelts—
1. 15th January.
2. Month of February.
3. 1st March.
4. About two feet above usual size.

Smolts—
1. 12th April.
2. Fair.

Artificial Propogation of Salmon—
No hatchery in district.

Proportion of Male to Female Salmon—
Unable to say as to this.

General Question—
Nothing occurs for remark.

THE DISTRICT OF THE RIVER SOUTH ESK.

(Return for 1899.)

Take of Fish—
1. (*a*), (*b*), (*c*), and (*d*) About average.
2. No information to enable us to answer this.
3. (*a*) 16th February ; (*b*) August ; (*c*) July and August.
4. Cannot supply this, having no information to enable us to do so.
5. (*b*) 42 lbs.; (*c*) 26 lbs.

Protection—
1. £3,424.
2. Eleven per cent.
3. Ten bailiffs.
4. Eight prosecutions. All convicted; offences chiefly for gaffing and dragging for salmon.

Obstructions to the Passage of Fish—
1. None.
2. Dams generally worked so. No cruives in operation.
3. No.
4. At all times.
5. No.
6. No changes.

Pollutions—
1. No.
2. No steps found necessary to be taken.

The Salmon Disease—
1. Scarcely any disease. Only 48 seen marked with disease during season.
2. River above ordinary size.
3. About equal.
4. No.

The Spawning Season—
1. 10th November.
2. Between 21st November and 30th December.
3. End of December.
4. About ten inches above usual size.
5. About an average.
6. Careston, Finavon, New Mill, Craigessie, and Prosen.

Kelts—
1. 4th January.
2. February and March.
3. April.
4. About two feet above usual size.

Smolts—
1. April and May.
2. Yes.

Artificial Propagation of Salmon—
No.

Proportion of Male to Female Salmon—
About equal. Return based on appearance shown on spawning beds.

General Question—
Nothing else occurs to us to mention.

THE DISTRICT OF THE RIVER NORTH ESK.

(This Return is for the Year 1898.)

Take of Fish—
1. (*a*), (*b*), (*c*), and (*d*) All below average.
2. (*a*), (*b*) and (*c*) No.
3. (*a*) and (*b*) 16th February; (*c*) June and July.
4. (*a*) and (*b*) Cannot give statistics.
5. (*a*) Salmon 28 lbs., trout 6 lbs.; (*b*) salmon 40 lbs., trout 8 lbs.; (*c*) salmon 26 lbs., trout 3 lbs.

Protection—
1. £6,523.
2. $6\frac{1}{4}$ per cent.
3. Thirteen bailiffs and one superintendent.
4. No.

Obstructions to the Passage of Fish—
1. Morphie Dam Dyke partially taken down and rebuilt.
2. The answer to this query in 1897 was to the effect that the Craigo Dyke was not worked in accordance with the provisions of the bye-laws, one member dissenting.
3. Pass in Morphie Dyke damaged by flood and restored.
4. The Craigo Pass does not at all times. A case is at present pending in the Court of Session regarding it at the instance of upper proprietors.
5. No.
6. None.

Pollutions—
1. Yes ; by Auchinblae Distillery Company.
2. Letters were sent to the different Distillery Companies, and the Auchinblae Company undertook to construct settling ponds.

The Salmon Disease—
1. A few diseased fish were found during the season, most of them in January.
2. Below ordinary level.
3. Ninety-two fish in all.
4. No.

The Spawning Season—
1. November.
2. December and January.
3. End of February.
4. Average level.
5. Less.
6. Gannochy, King's Ford, Pert Ford, Stob Ford, Bothy Stream, Peter's Stream, Bailie Middleton's Stream, Broad Rack, and Bridge Streams.

Kelts—
1. Early in January.
2. January and February.
3. May.
4. Above average level.

Smolts—
1. April and May.
2. Fair.

Artificial Propogation of Salmon—
No hatchery.

Proportion of Male to Female Salmon—
Estimate three-fourth males and one-fourth females.

General Question—
Yes. By a clerical mistake in the 12th Section of the Act of 1868, the word "less" is used in place of "more" relating to the raising during the weekly close time of the Kinnaber Lade Sluice at the Morphie Dyke.

THE DISTRICT OF THE RIVER NORTH ESK.

(Return for 1899.)

Take of Fish—
1. (*a*), (*b*), (*c*), and (*d*) Average.
2. (*a*), (*b*) and (*c*) No.
3. (*a*) and (*b*) 16th February ; (*c*) June and July.
4. (*a*) and (*b*) Cannot give statistics.
5. (*a*), 25 lbs.; (*b*) $51\frac{1}{2}$ lbs.; (*c*) 30 lbs.

Protection—
1. £6,523.
2. £408.
3. Thirteen bailiffs and one superintendent.
4. None.

Obstructions to the Passage of Fish—
1. No change on dykes worth noting.
2. As last year.
3. No.
4. As last year. The action has recently been dismissed.
5. No.
6. None.

Pollutions—
1. None.
2. Steps have been taken to remove causes of pollution both at Auchinblae Distillery and Fettercairn Distillery, but the result has not yet been fully proved.

The Salmon Disease—
1, 2, and 3. Only one grilse found dead. Very little appearance of disease.
4. No.

The Spawning Season—
1. November.
2. December and January.
3. End of February.
4. Average level.
5. Less.
6. Gannochy, King's Ford, Pert Ford, Stob Ford, Bothy Stream, Peters' Stream, Bailie Middleton's Stream, Broad Rack, and Bridge Streams.

Kelts—
1. Early in January.
2. January and February.
3. May.
4. Above average level.

Smolts—
1. April and May.
2. Very good.

Artificial Propagation of Salmon—
No hatchery.

Proportion of Male to Female Salmon—
Estimate three-fourth males and one-fourth females

General Question—
Yes. By a clerical mistake in the 12th Section of the Act of 1868, the word "less" is used in place of "more" relating to the raising during the weekly close time of the Kinnaber Lade Sluice at the Morphie Dyke.

THE DISTRICT OF THE RIVER BERVIE.

(This Return is for the Year 1898.)

Take of Fish—
1. (*a*), (*b*), (*c*), and (*d*) All below average.
2. (*a*), (*b*) and (*c*) About 4000 fish in all—estimate.
3. (*a*) 25th February ; (*b*) July and August ; (*c*) June and July.
4. (*a*) and (*b*) Cannot.
5. (*a*) About 40 lbs.; (*c*) about 20 lbs.

Protection—
1. £575.
2. 15 per cent.
3. Six.
4. None.

Obstructions to the Passage of Fish—
1. None.
2. Yes. No cruives.
3. No.
4. Yes ; when river above ordinary level.

5 and 6. No.

Pollutions—

1 and 2. None.

The Salmon Disease—
Only one diseased salmon found during the season.

The Spawning Season—
1. End of October.
2. November and December.
3. End of December.
4. Ordinary level.
5. Less.
6. Main river.

Kelts—
1. End of January.
3. End of February.
3. March.
4. Ordinary level.

Smolts—
1. May and June.
2. Yes.

Artificial Propogation of Salmon—
No hatchery.

Proportion of Male to Female Salmon—
About equal estimate.

THE DISTRICT OF THE RIVER BERVIE.

(Return for 1899.)

Take of Fish—
1. (*a*), (*b*), (*c*), and (*d*) Below the average.
2. (*a*) About 5,000.
3. (*a*) 25th of February; (*b*) July and August ; (*c*) June.
5. (*a*) About 40 lbs.

Protection—
1. £870 13s.
2. Twelve per cent.
3. Six bailiffs.
4. None.

Obstructions to the Passage of Fish—
3 and 5. None.

Pollutions—
1. None.

The Salmon Disease—
1. None.

The Spawning Season—
1. October.
2. November and December.
3. December.
4. Ordinary level.
5. More.
6. Main river.

Kelts—
1. January.
2. February.
3. March.
4. Ordinary.

Smolts—
1. May and June.
2. Ordinary.

Artificial Propagation of Salmon—
None.

Proportion of Male to Female Salmon—
About the same.

THE DISTRICT OF THE RIVER DEE (ABERDEEN).

Take of Fish—
1. Below the average in each of these four cases.
2. No. The Inspector has endeavoured to obtain information on these questions, but has not succeeded.
3. (*a*) 11th February; (*b*) April was the most successful month throughout the district; (*c*) grilse began to run about 1st May; sea-trout, 11th February; largest takes of grilse in July.
4. The Inspector has found it impossible to get these statistics.
5. (*a*) 35 lbs.; (*b*) 38½ lbs.; (*c*) 41 lbs.

Protection—
1. £17,427 3s. 6d.
2. Six per cent. on said rental.
3. Twenty-one.
4. Two prosecutions—both for taking smolts. Both accused fined £1 4s. 6d. or 3 days in prison.

Obstructions to the Passage of Fish—
1. No dams in district.
2. No cruives in district.
3. Point of a rock blasted off on Duke of Fife's water at Linn of Dee to make passage of fish easier.

4. No fish-passes in the ordinary sense of that word in district.
5. No; but there is a natural obstruction at the Falls of Lui which prevents salmon from going further up, and the attention of the Duke of Fife has been called to this with the view of having it removed.
6. None, except as above.

Pollutions—

1 and 2. No fresh causes of pollution were introduced. The Board were able to conclude an agreement with the Town Council of Aberdeen under which the latter became bound to convey out to the sea at Girdleness the sewage at present being discharged into the river near the mouth. The Town Council are now proceeding with the scheme for carrying this agreement into effect.

The Salmon Disease—

1, 2, 3, and 4. No diseased fish seen in river in 1899.

The Spawning Season—

1. End of October.
2. Upper river between 1st and 30th November. Lower river between 15th December and 15th January.
3. Practically about the end of January.
4. High as a rule.
5. Less than usual.
6. Upper river and tributaries in upper district.

Kelts—

1. At 1st January.
2. During April.
3. Never quite free, but freest in May, after which few seen.
4. As a rule high.

Smolts—

1. Middle of March.
2. Yes.

Artificial Propagation of Salmon—

Hatchery at Drum carried on as formerly. 714,000 ova put into the hatchery boxes in 1899. Doing well as far as can be seen. Should hatch about 1st February, and will be put into the river early in June.

Proportion of Male to Female Salmon—

No information obtainable on this point.

THE DISTRICT OF THE RIVER DON.

Take of Fish—

1. (*a*) Average; (*b*) below the average; (*c*) and (*d*) average.
2. No.
3. (*a*) 11th February; (*b*) month of July; (*c*) middle of June to middle of July.
4. No information on these points.
5. (*a*) 25 lbs.; (*b*) 45 lbs.; (*c*) 40 lbs.

Protection—

1. £3,429 18s. 11d.
2. 23 per cent. on above rental.
3. Fourteen bailiffs.
4. Ten prosecutions, implicating 14 persons, chiefly for offence of having in their possession instruments for catching salmon. All convicted, three of whom settled, but others went to prison.

Obstructions to the Passage of Fish—

1. None in either case.
2. Yes.
3. None.
4. Salmon have difficulty in ascending at Mugiemoss and Stoneywood Dykes, especially when river low.
5. No.
6. No charges under this inquiry.

Pollutions—

1. No fresh causes, but former causes still exist, and sewage naturally increases with the population.
2. As the result of representations by the Board to the Secretary for Scotland his Lordship called upon the Town Council of Aberdeen and the Aberdeen District Committee of the County Council of Aberdeen, the respective sanitary authorities of the district at the lower reaches of river, where pollution is worst, to take proceedings under the Rivers Pollution Prevention Act, 1876, against the mill owners and others within their district who were allowing polluting matter to be discharged into the river. Both these bodies are themselves to a large extent responsible for the pollution of the river by means of sewage, and no proceedings have as yet been taken by them as directed. It is understood, however, that the Town Council have now in contemplation a scheme for the disposal of the sewage from their district which at present finds its way into the river. The Board also made representations to the Garioch District Committee of the County Council of Aberdeen with regard to the pollution of the river from mills at Inverurie, and as a result the pollution from this source was to some extent decreased.

The Salmon Disease—

1. Little disease seen—observed most in November and December. Disappeared in January.
2. Low for the winter level.
3. In October 5 (3 males, 2 females). In November 7 (3 males, 4 females). December 13 (7 males, 6 females).
4. The view here is that it is caused, or at all events increased, by large numbers of fish congregating in pools below Mill Dykes, where they may remain for two or three months.

The Spawning Season—

1. Early in November.
2. Between 15th November and 15th December.
3. End of January 1899.
4. Slightly above normal level.
5. Above average.
5. Kildrummy and Alford Districts.

Kelts—

1. Beginning of January.
2. In February.
3. Never quite free.
4. Above normal.

Smolts—

1. Towards end of March.
2. Very good.

Artificial Propagation of Salmon—

A small hatchery at Fish Street, capable of receiving from 50,000 to 60,000 ova. Stored in January 1899 to its full capacity, and 40,000 hatched and put into the rivers at end of May—one-half into the Dee and one-half into the Don, from 10 to 18 miles above Aberdeen.

Proportion of Male to Female Salmon—

No definite information—supposed to be about equal.

THE DISTRICT OF THE RIVER YTHAN.

Take of Fish—
1. (*a*), (*b*), (*c*), and (*d*) Below the average.
2. (*c*) about 100 salmon.
3. (*a*) on 25th February; (*b*) May ; (*c*) July.
5. (*b*) 41 lbs. salmon, 12 lbs. sea-trout ; (*c*) 19 lbs. salmon.

Protection—
1. £1,298 10s.
2. ·125693 per £.
3. One for the whole year, and other four during close time.
4. None.

Obstructions to the Passage of Fish—
1. None.
2. As far as practicable.
3. None.
4. All afford a free passage with the exception of one at Mill of Kinbarrachy.

5 and 6. None.

Pollutions—
1. None.

The Salmon Disease—
1. Yes ; December, 1898 ; at height in February ; clear in April.
2. Rather below ordinary winter level.
3. Please look up diseased fish return.
4. None.

The Spawning Season—
1. 5th November 1898.
2. From 15th December 1898 to 1st January 1899.
3. About the end of January.
4. Rather above ordinary winter level.
5. Less than usual.
6. Ebrie, Little Water, Bronie, Fordon Burns, and Ythan.

Kelts—
1. We cannot say, as we have no obstructions that we see them falling over.
2. About 1st April.
3. May.
4. Above the ordinary level.

Smolts—
1. May.
2. Very good.

Artificial Propagation of Salmon—

There is one under construction belonging to the District Board quite near to Ythan.

Proportion of Male to Female Salmon—

I would estimate 5 male to 4 female salmon.

General Question—

No.

THE DISTRICT OF THE RIVER UGIE.

Take of Fish—

1. (*a*) Slightly below the average; (*b*) a good deal below the average; (*c*) about the average; (*d*) slightly below the average.
2. (*a*) and (*b*) About 700 salmon and 900 grilse; (*c*) about 60 grilse and very few salmon
3. (*a*) First of July; (*b*) from the middle of August to the end of season; (*c*) During July and August.
4. The salmon fishings are in the hands of private enterprise, and the tacksmen decline to keep any record or give information.
5. (*a*) 43 lbs.; (*b*) 43 lbs.; (*c*) 16 lbs.

Protection—

1. £767 10s.
2. 9¼d. per £.
3. Five.
4. There were no prosecutions.

Obstructions to the Passage of Fish—

1. There have been no alterations on the dams during the year 1899, and no new ones have been built.
2. The dams are worked in accordance with the provisions of the bye-laws (Schedules F and G) regulating the same. The cruives are not worked at all, except for the purpose of catching fish for the hatchery.
3. No fish-passes have been built or altered in 1899.
4. The existing fish-passes afford at all times a free passage to salmon wishing to ascend.
5. None.
6. No. A temporary obstruction was put in at the dam at Ravenscraig by the tenant of the mill, but it was removed, and interdict granted against its replacement.

Pollutions—

1 and 2. There were no causes of pollution during 1899.

The Salmon Disease—

Owing to the appointment of a new head water bailiff in or about the month of September last, it is to be regretted that no statistics in regard to disease are available for the season of 1898-9, as the old bailiff left no particulars with the new one, and they cannot now be got.

The Spawning Season—

There are no statistics in connection with this owing to the change of water bailiffs as before mentioned.

Kelts—

No statistics available for reason before stated.

Smolts—

No statistics available for reason before stated.

Artificial Propagation of Salmon—

There is a hatchery now in use, as explained in last year's report, at English Mill, Inverugie, for the artificial propagation of salmon or trout. It is maintained at the expense of the various proprietors. A quantity of salmon ova was secured this past season, but the number is not yet known.

Proportion of Male to Female Salmon—

Five males to three females, based on estimate.

General Question—

None.

THE DISTRICT OF THE RIVER DEVERON.

Take of Fish—
1. (*a*) and (*c*) About an average ; (*b*) below the average.
2. No.
3. (*a*) February 13th ; (*b*) July and August ; (*c*) July.
4. No alteration visible ; it mostly depends on the state of the river.
5. (*a*) 27 lbs.; (*b*) 47 lbs.; (*c*) 31 lbs.

Protection—
1. £3,078 4s. 9d.
2. 2s. 6d. per £ for protection and 3s. 6d. per £ for repayment of loan and interest.
3. Nine watchers.
4. Yes. One. Dragging for salmon with a creeper composed of three large hooks attached to a piece of twine. Two persons—father and son—were convicted and fined £5 and £1 respectively.

Obstructions to the Passage of Fish—
3. No.

Pollutions—
None.

The Salmon Disease—
1. No disease ; only 76 dead fish altogether.

The Spawning Season—
1. October 17th.
2. From November 1st to December 15th.
3. January 15th.
4. About half-flood.
5. About the average.
6. Principally in the upper half of the river

Kelts—
1. About the middle of November.
2. April 10th to May 1st.
3. About the middle of May.
4. Half-flood.

Smolts—
1. April 18th, and 1st and 16th May.
2. Yes.

Artificial Propagation of Salmon—
The hatchery has not been used for the past two years.

Proportion of Male to Female Salmon—
No.

General Question—
No.

THE DISTRICT OF THE RIVER SPEY.

Take of Fish—
1. (*a*), (*b*), (*c*), and (*d*) See below.
2. No.
3. (*a*) 11th February ; (*b*) Scarce all the season ; (*c*) May, June, and July.
4. No statistics available.
5. (*c*) 39½ lbs. at Arndilly.

Protection—
1. Amount of assessable rental 1899-1900, £10,122.
2. Assessment, £1,096 11s., being at rate of 2s. 2d. per £.
3. One superintendent, one inspector, and forty-five bailiffs ; also special bailiff for pollution detection.
4. See Superintendent's Annual Report herewith sent.

Obstructions to the Passage of Fish—
1. See Report.
2. None used in district last year.
3, 4, 5, and 6. See Report.

Pollutions—
1. A new distillery (Knochando).
2. Every effort is being made by riparian owners to remove causes of pollution.

The Salmon Disease—
1. See Report.
2. Various.
3. See Report.
4. No.

The Spawning Season—
1. See Report.
2. 15th October and 30th November.
3. By 1st of March.
5 and 6. See Report.

Kelts—
1. About 20th October.
2. From 20th October till end of January.
4. Various.

Smolts—
1. April till July.
2. Yes.

Artificial Propagation of Salmon—
See Report.

Proportion of Male to Female Salmon—
See Report.

The following is a copy of the Superintendent's Annual Report for the year ending 26th August 1899, submitted to the Meeting of the Spey District Board held in Elgin on 20th October 1899 :—

I.—*Salmon Spawning.*

The following Table shows the dates of the first appearance of Salmon Spawning Beds, and the number seen by bailiffs during the last three spawning seasons on the following named streams or tributaries :—

1896.

Name of Stream.	Spawning Commenced.	No. of Beds for Season.
Fiddich - - -	6th October	292
Avon - - -	10th „	754
Livet - - -	14th „	773
Conglass - - -	14th „	189
Lochy - - -	22nd „	74
Dulnain - - -	13th „	868
Nethy - - -	15th „	418
Druie - - -	13th „	215
Feshie - - -	12th „	636
Tromie - - -	17th „	210
Truim - -	14th „	198
Spey (above Laggan, Badenoch)	10th „	151
Total, - - -		4778 Spawning Beds.

1897.

Name of Stream.	Spawning Commenced.	No. of Beds for Season.
Fiddich - - -	7th October	657
Avon - - -	6th "	1200
Livet - - -	14th "	1534
Conglass - - -	18th "	312
Lochy - - -	18th "	104
Dulnain - - -	14th "	464
Nethy - - -	19th "	185
Druie - - -	12th "	200
Feshie - - -	13th "	528
Tromie - - -	21st "	154
Truim - - -	20th "	119
Spey (above Laggan, Badenoch)	4th "	204
Total, - - -		5661 Spawning Beds.

1898.

Name of Stream.	Spawning Commenced.	No. of Beds for Season.
Fiddich - - -	5th October	463
Avon - - -	5th "	718
Livet - - -	7th "	917
Conglass - - -	11th "	153
Lochy - - -	11th "	29
Dulnain - - -	4th "	410
Nethy - - -	19th "	302
Druie - - -	16th "	172
Feshie - - -	14th "	610
Tromie - - -	15th "	100
Truim - - -	19th "	26
Spey (above Laggan, Badenoch)	12th "	83
Total, - - -		3983 Spawning Beds.

TABLE OF TWELVE YEARS' SPAWNING BEDS COUNTED ON TRIBUTARIES.

Total number of Beds for year		1887 - - -	3,849
Do.	do.	1888 - - -	5,637
Do.	do.	1889 - - -	2,932
Do.	do.	1890 - - -	2,768
Do.	do.	1891 - - -	4,591
Do.	do.	1892 - - -	5,287
Do.	do.	1893 - - -	4,635
Do.	do.	1894 - - -	7,214
Do.	do.	1895 - - -	6,203
Do.	do.	1896 - - -	4,778
Do.	do.	1897 - - -	5,661
Do.	do.	1898 - - -	3,983

The past year's spawning season shows a decrease of 1678 spawning beds when compared with the number counted upon the tributaries for the previous year. Owing to the scarcity of grilse and salmon during the summer and autumn of last year a large falling-off in spawning fish was a reasonable result. It was upon the Avon and Livet where the major decrease took place, the deficiency of these two streams alone being 1089 beds. Avon and Livet depend upon the autumn run of fish. The decrease on Fiddich was 194 beds. The bulk of spawning on this stream now takes place during the months of November and December by sea-trout in the upper or Auchindoun district. Owing to the sudden check which befel the "whisky boom" last winter, the Dufftown district distilleries were considerably reduced in their work or output, and this fact, more than by any improvement otherwise made by the distillers in the way of purification treatment of their effluents, had the effect of reducing to a certain extent the previously disgusting state of pollution upon this stream. There is yet, however, much fungoid and distillery pollution visible on Fiddich, although somewhat reduced through the above cause.

The spawning upon the fords of the River Spey was scarcely up to the appearance of the previous year, but, on the other hand, long-continued high and brown-coloured water made it very difficult to see fish upon the redds during the time the fish were spawning.

Notes by the bailiffs, same as last two years, by order of the Board, were kept, giving the number (as far as could be seen) of spawning beds counted on river Spey in that part of the river lying between Boat o' Brig and Carron Bridge. The bailiffs' respective records for above were as follows:—On Aberlour beat, Carron Bridge to Tunnel Pool, 70 beds; Craigellachie beat, Tunnel Pool to Bulwark, 124 beds; Rothes beat, Bulwark to Hollybush, 394 beds; Boat o' Brig beat, Hollybush to Boat o' Brig, 173 beds; and Mulben Burn mouth, 36 beds—total, 797 spawning beds, being a decrease of 51 beds when compared with previous year. The three years' records in beds for this district are as follows:—Year 1896, 1263 beds; 1897, 848 beds; and 1898, 797 beds.

Upon 5th and 6th December a pretty heavy spate took place upon the river and tributaries, and there is little doubt but that some of the spawning beds were levelled down and deposited ova washed away or disturbed. There was no injury caused to spawning beds by frost or iceflows during the season. Male and female fish were to all appearance evenly matched while on the spawning redds.

II.—*Smolt Season.*

Descending smolts during the spring and summer months had a fair average show. Eight bailiffs carried out the usual six weeks' smolt and salmon fry protection duty from 1st May till 10th June. The bailiffs were stationed as follows:—One in Speymouth district, one at Rothes, one at Dufftown, one at Aberlour, one on Upper Avon and Livet, one at Ballindalloch, one at Grantown, and one at Duthil. Twenty-six dozen of printed notices cautioning persons against killing smolts, parr, or salmon fry were posted up along the sides of the river and tributaries all over the district. All anglers met with by the bailiffs were found agreeable and willing when asked to show their respective "takes" for inspection. A force of bailiffs again went on duty at 1st of August to protect parr or salmon fry.

III.—*Disease among Fish.*

The following particulars relate to the amount of disease observed among spawning fish within the district during the spawning season. These observations have been now tabulated in my annual reports during the last eleven years, as taken from particular observance carried out upon the Fiddich. In giving the death-rate as so much per cent., the percentage is one dead fish for each spawning bed counted upon the stream during the season. Consequently, as it requires two fish to form a bed, the death percentage given herein is twice that of what the percentage would be were each dead counted against each living. The number of spawning beds counted upon Fiddich during the past season was 463, and the number of dead or dying fish removed from the stream and buried by the bailiffs was 33, giving a death-rate of something under 8 per cent. to the number of spawning beds counted. The death percentages for the previous years were as follows:—1898, 17 per cent.; 1897, 7 per cent.; 1896, 21 per cent.; 1895, 9 per cent.; 1894, 8 per cent.; 1893, 19 per cent.; 1892, 16 per cent.; 1891, 18 per cent.; 1890, 13 per cent.; and 1889, 13 per cent. The order of death-rate was pretty general all through the spawning season during the past season, the first deaths being upon 8th October 1898, these being two male and three female sea-trout and one female grilse, all unspawned and evidently poisoned by the then excessively polluted state of the stream. The last diseased fish was removed from same stream on 28th January 1899. With the exception of the above-mentioned six fish, mostly all of the others were spawned, and were composed as follows:—Sea-trout, 1 male and 1 female; grilse, 8 males; salmon, 16 males and 1 female.

IV.—*Poaching during the Year.*

Only one case of salmon poaching was detected by the bailiffs during the close time, and this case was committed by four lodged-out Glasgow pauper boys in the Braes of Glenlivet district. The accused were brought before a J.P. and admonished. Upon the 11th February, the opening day of the fishing, a man in the Aberlour district was detected with a foul or unseasonable salmon in his possession. Accused was for this offence convicted before the Sheriff Court at Banff, and sentenced to pay a fine of 10s., with £1 2s. 6d. of expenses, or seven days' imprisonment.

V.—*Bye-Laws.*

The Bye-laws relating to dam dykes, mill lades, hecks, etc., were well attended to during the season. The new dam dyke intake at Dullan, for Mortlach distillery, mentioned in my report for last year as then in course of construction, was completed at the beginning of October last year in a most satisfactory way. During the summer and autumn of the present year, in connection with the laying down of a railway siding to Mortlach distillery, the Great North of Scotland Railway Company found it necessary to divert the course of the Dullan stream some 300 or 400 yards opposite this distillery, thus necessitating the substitution of a new dam dyke and intake for driving power to the woollen mills of Crachie, Dufftown, which have been bought by and are now the property of the said railway company. The intake dam, etc., have been erected in every detail in accordance with the Bye-laws. The obstruction to ascending spawning fish on Fiddich at Dullan confluence, caused through the design and construction of the original power water intake for Glendullan distillery, has now, by order of the Board, and through a concession as to water right charges or claims by His Grace the Duke of Richmond and Gordon, been removed by the distillery firm changing the old intake from the centre of Fiddich to the right bank edge of the stream, some 50 yards further up stream. The change thus made will have the effect of again providing a good lead for ascending fish passing up to the Auchindoun and upper reaches of Fiddich to the best of the spawning grounds. The old dam dyke on Fiddich giving driving power to Balvenie Mills, near Dufftown, the property of Mr. Findlay of Aberlour, which for many years has been very unsatisfactory to the interests of ascending and descending spawning fish, has, by the order and at the expense of the proprietor, been swept out of existence, and at a heavy cost a model dyke, fish-pass, etc., which should stand for many years to come, have been substituted.

VI.—*General Remarks.*

I would again request the Board to take into consideration the advisability of removing the existing obstruction or barrier caused by an accumulation of a naturally deposited shingle bank in the mouth of the Druie. Very fine unshifty spawning grounds exist upon the Luanic stream just below Loch Morlich, upon the Richmond and Gordon estates, but owing to the obstruction at the mouth of Druie fish are prevented and obstructed from getting up to said grounds. From £5 to £10 would remedy the barrier during the summer months.

The sea coast and river net salmon fishing opened for the season on 11th February, and closed again for the yearly close time on 26th August. The carrying out of the weekly close times during the season were regularly inspected by the Superintendent, the Inspector, and Sergeant Bailiff Charles Chapman, Speymouth. There were no contraventions of the weekly close times met with over the whole district during the season. It is right to mention that on a few occasions, in consequence of stress of weather, it was impracticable to slap the nets, as reported by me to the Board at the time.

Another very successful year's operations were carried out under the able management of Mr. Thomas Rae, Tugnet, at His Grace the Duke of Richmond and Gordon's salmon hatchery at Fochabers. During autumn and winter last, 840,000 salmon ova were deposited within the hatchery and successfully hatched, with a death-rate of not more than one per cent., of ova deposited. The bulk of the fry thus hatched were, after attaining the age of seven or eight weeks, turned loose into the River Spey. This makes the seventh annual huge contribution of hatched salmon fry contributed from this same source. I visited the hatchery several times during the different stages of the deposited ova from embryo to alevin, and saw the lively masses of young fry ready for foreign or extraneous nurture and wider aquatic bounds. During the spring season of present year, six rearing ponds, 48 by 9 feet and 4 feet deep, were erected by order of His Grace upon Cunninghaugh, near Fochabers-on-Spey Railway Station, with a supply of water to flow the ponds diverted and conveyed in pipes from the Bogmoor burn. The ponds are constructed in a most painstaking way, with all the necessary preliminary water settling ponds, in which any solids or sediment which the burn water might contain in suspension and solution during floods or spates are prevented from entering the fish ponds. Fine perforated iron gratings or sieves are placed at the entrance and outlet of water to and from each fish pond. Each pond by means of a sluice can be run dry without stopping the supply of running water to the others. At the end of May last feeding operations were resorted to at the Fochabers hatchery with a batch of 80,000 fry, a man being specially employed or set aside to exclusively attend to said work. Specially prepared food was brought from the Solway Firth for this work. During the month of August last the 80,000 fry were conveyed in large carboy vessels from the hatchery and placed in the rearing ponds, where up till the present time they have been fed and tended by the man in charge with the most satisfactory results. There have been very few deaths among the brood since their removal to the ponds, and the growth in size of the individual fry has been considerable. It is quite a show to visit the ponds at feeding time and see the great multitudes of fry as they flock and swarm to the surface to grab the food thrown into the water. They are fed three times daily. They may also be seen jumping at and catching flies. A boiling-house with all the necessary apparatus has been built within the enclosure at the ponds, and here a considerable amount of the fish food is now being manufactured under the superintendence of Mr. T. Rae.

The full force of bailiffs or Spey police is constituted as follows:—The superintendent, residing in Aberlour; the inspector, stationed at Grantown; eight sergeants and thirty-seven constables.

GEORGE K. MACGREGOR, *Superintendent.*

THE DISTRICT OF THE RIVER FINDHORN.

Take of Fish—

1. (*a*), (*b*), (*c*), and (*d*) Below average.
2. No.
3. (*a*) 11th February; (*b*) from the middle of April to the end of May; (*c*) few grilse are got in May, but July is the best month for grilse and sea-trout.
4. Have no information.
5. (*a*) 38 lbs.; (*b*) 41 lbs.; (*c*) 14 lbs.

Protection—

1. £3,436.
2. £345.
3. Three permanent bailiffs. Fifteen bailiffs employed during spawning season.
4. No prosecutions.

Obstructions to the Passage of Fish—

1, 2, 3, 4, 5, and 6. None.

Pollutions—

1 and 2. A distillery has commenced working in the district in 1899, and the bye-products have found their way into a tributary of the Findhorn. The Board has called on the Distillery Company to desist, and also to remove the existing pollution.

The Salmon Disease—
1, 2, 3 and 4. No disease.

The Spawning Season—
1. Upper district, 16th October; lower district, 24th November.
2. Upper district, between 20th October and 20th November ; lower district, December and January.
3. Upper district, 30th November ; lower district, end of January.
4. Sometimes high and sometimes low.
5. About an average.
6. Upper district, between Drynachan and Coignafearn; lower, between Moy and Sluie.

Kelts—
1. Kelts begin to migrate seaward immediately after they are through spawning.
2. December, January, and February.
3. June.
4. Sometimes very low and sometimes high.

Smolts—
1. From the middle of April to the end of May.
2. Fair.

Artificial Propagation of Salmon—
No Hatchery in district.

Proportion of Male to Female Salmon—
It is estimated that there are more male than female.

General Question—
No.

THE DISTRICT OF THE RIVER NAIRN.

Take of Fish—
1. Below the average ; (*a*), (*b*), (*c*), and (*d*) yes.
2. Approximately, 5150 ; (*a*) none ; (*b*) 5000 ; (*c*) 150.
3. (*a*) 13th February ; (*b*) April ; (*c*) grilse in September and sea-trout in June.
4.

	February.	March.	April.	May.	June.	July.	August.	Total.
Salmon.........	95	110	600	350	300	200	135	1790
Grilse..........	...	...	...	10	200	2000	1000	3210
								5000

(*a*) and (*b*) All by fixed engines—none by net and coble.

5. (*b*) salmon, 35 lbs.; (*c*) salmon, 24 lbs.

Protection—
1. £1,135 10s.
2. £75 14s., or 1s. 4d. per pound.
3. One man constantly. Two during the close season, and other assistance as required.
4. No.

Obstructions to the Passage of Fish—
1. None.
2. There are no cruives and no dams requiring to be worked under bye-laws.
3. No.
4. At all times, unless exceptional droughts.
5. No.
6. No changes.

Pollutions—
1. No.
2. None necessary.

The Salmon Disease—
1. No disease this year.
4. No.

The Spawning Season—
1. 6th November.
2. 20th November and 25th December.
3. Between 10th and 15th January.
4. Between low and half-flood.
5. Less.
6. The Nairn and Inverernis.

Kelts—
1. 1st February.
2. March.
3. By 1st May.
4. Half-flood.

Smolts—
1. From 15th April to 10th June.
2. Yes.

Artificial Propagation of Salmon—
None.

Proportion of Male to Female Salmon—
Upon an estimate there are 5 per cent. more females than males.

THE DISTRICT OF THE RIVER NESS.

Take of Fish—
1. About the average ; (*c*) the average.
2. About 33,000 or thereabouts.
3. (*a*) 11th February 1899 ; (*b*) February and March ; (*c*) from July and August.
4. Can't say.
5. (*a*) 41 lbs.

Protection—
1. £3,510 5s.
2. £3,072 11s.
3. One superintendent, three permanent and three temporary watchers.
4. None.

Obstructions to the Passage of Fish—
1. None.
2. No change.
3. Yes. Dochfour fish-pass.
4. Yes. At all times.
5. No.
6. None except Dochfour pass.

Pollutions—
1. No.
2. No cause.

The Salmon Disease—
1. No.
3. No disease.
4. No.

The Spawning Season—
1. End of October.
2. November and January.
3. End of January.
5. About the average.
6. Ness, Garry, Moriston, Oich, and Kinegie.

Kelts—
1. 11th February.
2. March and April.
3. Middle of May.

Smolts—
1. April.
2. Average.

Artificial Propagation of Salmon—
There is a private hatchery at Glenquoich, supported by Lord Burton. No salmon are hatched *in it.*

Proportion of Male to Female Salmon—
In the month of December there are four males to one female.

THE DISTRICT OF THE RIVER CONON.

Take of Fish—
1. (*a*) Salmon below the average, grilse considerably above the average ; (*b*) the angling in the Brahan waters above the average. The angling in the Strathconon waters about the average. All the rest of the angling waters below the average ; (*c*) two of the bag-net fishing stations above the average. One of the bag-net fishing stations about the average. The other four bag-net fishing stations below the average ; (*d*) the wear-shot net fishing of Balconie, Fowlis, and Findon, all in the Cromarty Firth, the catch of salmon and grilse above the average.
3. (*a*) 11th of February; (*b*) in March and April ; (*c*) in the beginning of May. Clean sea-trout in tidal waters all the year.
5. (*a*) 26 lbs. ; (*b*) 28 lbs.; (*c*) 20 lbs.

Protection—
1. £2,554 2s.
2. £180 18s. 3d.
3. One permanent inspector and three temporary bailiffs.
4. No.

Obstructions to the Passage of Fish—
2. Yes.
3. No.
4. Yes.
5. No.
6. No net fishing has been carried on in any part of the Brahan salmon waters, nor have the cruives been worked. The two fishing boxes have been kept entirely open for the free run of salmon to the angling waters.

Pollutions—
1. Yes ; from the Muir of Ord distillery.
2. No steps have been taken up to date.

The Salmon Disease—
1. No.

The Spawning Season—
1. A few pairs about the last week of October.
2. Between the 5th and 15th of November.
3. About the end of November.
4. High-flood.
5. The number of spawning fish above the average.
6. There are good spawning streams in the River Conon from the tidal waters up to the Falls of Conon, and in the tributaries Orrin, Blackwater, and Meig.

Kelts—
1. In the beginning of March.
2. From the middle of March to the end of April.
3. In the first week in June.
4. Flood, half-flood, and low.

Smolts—
1. April and May.
2. Splendid ; have not seen so many smolts in the Conon for a number of years.

Artificial Propagation of Salmon—
There was erected, in November 1890, a salmon hatchery in this district, principally for the artificial propagation of salmon, capable of hatching about 200,000 ova. The salmon hatchery partly belongs to Colonel Mackenzie of Seaforth, and partly to the District Board.

Proportion of Male to Female Salmon—
The Inspector states :—I have always noticed when netting for spawning salmon during the last ten seasons in the rivers Tweed, North Esk, Ness, Beauly, Conon, and Brora, that the number of male salmon landed was two to one of the female.

THE DISTRICT OF THE RIVER ALNESS.

Take of Fish—
1. (*a*) Net fishings in tidal waters slightly above the average ; (*b*) in fresh water below the average, owing to low state of river in July and August.
2. Impossible to obtain information from lessees of fishings.
3. (*a*) April ; (*b*) July ; (*c*) from 1st June to end of August.
4. Impossible to obtain information.
5. (*a*) About 35 lbs., one sea-trout about 12 lbs.; (*b*) no fixed engines in district ; (*c*) about 16 lbs.

Protection—
1. £610 16s. 8d.
2. 5s. per £.
3. One bailiff, with one assistant during certain periods.
4. No.

Obstructions to the Passage of Fish—
1. No dams destroyed, or new dams built, or old ones altered.
2. Yes ; in Alness River, but not in Scotsburn River.
3. No.
4. Yes.
5. No.

Pollutions—
No river pollutions in Alness district.

The Salmon Disease—
No salmon disease seen in district.

The Spawning Season—
1. 20th October.
2. Between 1st and 20th November.
3. About 20th December.
4. Flood and half-flood.
5. Less.
6. The upper reaches of Alness River.

Kelts—
1. About middle of March.
2. About first week of April.
3. June.
4. Flood and half-flood.

Smolts—
1. About middle of April.
2. Yes.

Artificial Propagation of Salmon—
There is a hatchery situated near a good spring about three miles from mouth of river. About 30,000 ova have been secured during the past season.

Proportion of Male to Female Salmon—
Cannot give this information.

General Question—
Colonel Warrand, Ryefield, Chairman of Board, Factor and Commissioner for Mr. Stewart Munro of Teamnich, died in October last.

THE DISTRICT OF THE KYLE OF SUTHERLAND.

Take of Fish—
1. Below the average generally throughout the district.
2. No.
3. (*a*) 11th February; (*b*) May and June; (*c*) June and July.
4. No reliable information obtainable.
5. (*a*) 46 lbs.

Protection—
1. £2,838.
2. 1s. 5d. per £.
3. Sixteen.
4. None.

Obstructions to the Passage of Fish—
1. None.
2. As far as possible.
3. No.
4. When the rivers are in flood.
5. No.
6. Tain fisheries were not used during 1899.

Pollutions—
1 and 2. No.

The Salmon Disease—
1. No.

The Spawning Season—
1. 15th October.
2. 28th October and 25th November.
3. 21st December.
4. In flood.
5. About the usual.
6. Rivers Oykell, Carron, Cassley, and Shin.

Kelts—
1. 10th December.
2. March.
3. June.
4. About a normal size.

Smolts—
1. 15th April till 10th June.
2. Yes ; better than usual.

Artificial Propagation of Salmon—
Yes ; small hatchery just erected at Culrain.

Proportion of Male to Female Salmon—
No.

General Question—
None, except the suggestions made by the Board at a meeting held on 12th October 1895, at which Mr. Archer, the late Inspector, was present. The suggestions in question were communicated to Mr. Archer on 14th October 1895, but nothing has come of the matter, and no special meeting of the Kyle Board can now be called in respect the "statutory" Chairman is abroad, and there is no person legally clothed to represent him in this country.

SUTHERLAND, EAST AND WEST COAST DISTRICTS.

[*West Coast returns in italics.*]

Take of Fish—
1. (*a*), (*b*), (*c*), and (*d*) Below.
2. (*a*) 335 salmon, 549 grilse, 161 trout ; (*b*) 1792 salmon, 6866 grilse, 94 trout—*887 salmon, 7367 grilse, 164 trout ;* (*c*) Helmsdale, 307 salmon ; Brora, 300 salmon ; Fleet, 30 salmon ; *West Coast rivers, 55 salmon and grilse.*
3. (*a*) January; (*b*) May ; (*c*) June and July.
4. (*a*) February, salmon 5·7 per cent.; March, salmon 13·1 per cent.; April, salmon 16·7 per cent.; May, salmon 30·4 per cent., grilse 1·0 per cent., trout 8·0 per cent.; June, salmon 16·7 per cent., grilse 32·7 per cent., trout 58·4 per cent.; July, salmon 13·2 per cent., grilse 51·4 per cent., trout 27·3 per cent.; August, salmon 4·2 per cent., grilse 14·9 per cent., trout 6·3 per cent. (*b*) February, salmon 4·15 per cent.; March, *salmon ·56 per cent., trout 1·2 per cent.*—salmon 7·86 per cent., trout 2·12 per cent.; April, *salmon 1·95 per cent., grilse ·01 per cent., trout 2·4 per cent.*—salmon 10·93 per cent., trout 2·12 per cent.; May, *salmon 14·43 per cent., grilse ·73 per cent., trout 10·9 per cent.*—salmon 30·91 per cent., grilse ·78 per cent., trout 9·57 per cent.; June, *salmon 45·8 per cent., grilse 49·02 per cent., trout 51·8 per cent.*—salmon 24·72 per cent., grilse 33·29 per cent.; trout 62·76 per cent.; July, *salmon 34·9 per cent., grilse 47·99 per cent., trout 30·4 per cent.*—salmon 15·29 per cent., grilse 55·91 per cent., trout 21·27 per cent.; August, *salmon 2·36 per cent., grilse 2·25 per cent., trout 3·3 per cent.*—salmon 6·13 per cent., grilse 10·02 per cent., trout 2·16 per cent.
5. (*a*) 32 lbs.; (*b*) not known ; (*c*) 27 lbs.

Protection—
1. East Coast, £1,835 ; *West Coast, £1,236.*
2. No assessment.
3. Four, in addition to gamekeepers, who are bound to assist in watching. *Keepers on West Coast watch.*
4. None.

Obstructions to the Passage of Fish—
1. None.
3. No.
4. Yes.
5. No.
6. No.

Pollutions—
1. No.
2. No ; no pollutions.

The Salmon Disease—
1. The salmon disease showed itself in the case of one fish only on September 11th, 1899.
2. River was in a very low state.
3. Only one diseased salmon taken from the river on September 11th, 1899, which was a male fish and clean.
4. No.

The Spawning Season—
1. 12th October.
2. 20th to 30th October.
3. End of November.
4. High ; good spawning condition.
5. Less than usual.
6. Brora, Helmsdale, Fleet, and their tributaries ; *Inver, Kirkaig, Laxford, Inchard and their tributaries,* West Coast.

Kelts—
1. February.
2. March and April.
3. By the 1st of May.
4. Low.

Smolts—
1. Middle of April.
2. Fairly good.

Artificial Propagation of Salmon—
One on the Brora and another on the Helmsdale, both belonging to the Duke of Sutherland. In the Brora, 20,000 salmon and 60,000 Lochleven trout ; and Helmsdale, about 150,000 salmon.

Proportion of Male to Female Salmon—
Some bailiffs give proportion of males to females as at 5 to 1. All bailiffs estimate that males predominate.

General Question—
No.

SUTHERLAND, NORTH COAST DISTRICT.

Take of Fish—
1. Below the average.
2. (*a*) and (*b*) Salmon, 760 ; grilse, 8437 ; trout, 153 ; cannot be separated ; (*c*) about 900 fish. Halladale did well.
3. (*a*) February ; (*b*) May to June ; (*c*) grilse, May July ; trout, March-September.
4. Not known.
5. (*a*) 25 lbs. ; (*b*) 30 lbs. ; (*c*) 23 lbs.

Protection—
1 and 2. No assessments.
3. Six.
4. None.

Obstructions to the Passage of Fish—
1. None.
2. None fished.
3. None.
4. Yes.
5. No.
6. Nothing.

Pollutions—
None.

The Salmon Disease—
No Disease.

The Spawning Season—
1. October 22nd.
2. November 1st-7th.
3. End of November.
4. High.
5. Less.
6. Halladale to Grudie.

Kelts—
1. End of March.
2. April.
3. May.
4. Low.

Smolts—
1. May.
2. No.

Artificial Propagation of Salmon—
See last report.

THE DISTRICT OF THE RIVER KENNART.

Take of Fish—
1. (*b*) Below ; (*c*) and (*d*) under.
2. (*a*) 13 ; (*b*) 3300 ; (*c*) 46.
3. (*a*) End of April ; (*b*) June ; (*c*) July.
4. (*a*) and (*b*) No variation perceptible.
5. (*b*) 29 lbs. ; (*c*) 18½ lbs.

Protection—
2. No assessment made.
3. Two bailiffs employed.
4. No prosecutions during year.

Obstructions to the Passage of Fish—
1. None either way.
2. No dams.
3. No passes.
5. No.
6. No such works made.

Pollutions—
1. No.
2. None.

The Salmon Disease—
1. No.

The Spawning Season—
1. About 1st November.
2. Between 15th November and 7th December.
3. About middle of December.
4. Mid-flood.
5 Fully average.
6. Ullapool River.

Kelts—
1. Beginning of April.
2. During April
3. About 1st May.
4. Flood.

Smolts—
1. Early May.
2. Average.

Artificial Propagation of Salmon.
None.

Proportion of Male to Female Salmon—
Females appear more numerous from number of them taken by rod.

General Question—
None. There is no Board in this district.

THE DISTRICT OF THE RIVER BROOM.

Protection—
1. £40.
3. Eleven. Gamekeepers and other servants of the proprietors appointed without remuneration.
4. No.

Note.—This Board was constituted in March 1897, and the keepers and other servants were then appointed bailiffs. There has been no meeting since then, and no assessment has yet been levied. The Board was constituted primarily for the purpose of vesting in the gamekeepers and other servants the powers conferred upon bailiffs under the Salmon Fishery Statutes, and this has had the effect to a great extent of stopping illegal trawling in the estuary of the Broom.

THE DISTRICT OF THE LITTLE BROOM.

Protection—
1. £100.
3. Eight. The bailiffs are gamekeepers and servants of the proprietors and do not receive any extra remuneration.
4. No.

Note.—This Board was constituted in September 1897. See note in the case of the Broom Board.

THE DISTRICT OF THE RIVERS GRUINARD AND LITTLE GRUINARD.

Protection—
1. £620.
3. Three. Gamekeepers and other servants of the proprietors appointed without extra remuneration.
4. No.

Note.—This Board was constituted in September 1897. See note in the case of the Broom district.

THE DISTRICT OF THE RIVER TORRIDON.

Take of Fish—
2. (*c*) 12 salmon, 2 grilse, 156 sea-trout.
3. (*a*) July 8th ; (*b*) September.
5. (*c*) 18 lbs.

Protection—
1. £40.
2. £2.
3. None.
4. No.

THE DISTRICT OF THE RIVER BALGAY.

Take of Fish—
1. Below the average.
3. (*c*) In July.

Protection—
1. £40.
2. £41 11s. 3d.
3. One water bailiff.
4. No.

The Salmon Disease—
3. One diseased sea-trout taken out of the River Kinloch in July last.

The Spawning Season—
1. Sea-trout begun spawning this year about the 10th October, about a week later than last year.
2. The greatest number of sea-trout spawns here in October.
3. Salmon spawns later on.
5. Far less than usual.
6. The Balgay and Kinloch rivers.

General Question—

Salmon and sea-trout are becoming scarcer in this district, for the last ten years at least, but this year both salmon and sea-trout were scarcer by far than on any of the previous years.

On looking over and examining the former spawning beds of sea-trout this year, I find that there is not one-half of the shingle or gravel turned up, and not near the number of fish on the beds as usual.

THE DISTRICT OF THE RIVERS SLIGACHAN AND SNIZORT (SKYE).

Take of Fish—
1. No return made by tenants. The supply was above the average. This applies to the River Snizort only. Grilse an improvement on last three years. Salmon much below the average in tidal waters.
2. (*a*) and (*b*) Quantity unknown ; (*c*) 134.
3. (*a*) 7th April ; (*b*) July and August ; (*c*) end of June.
4. (*a*) and (*b*) Cannot say.
5. (*a*) No net and coble fishings ; (*b*) 42 lbs. ; (*c*) 13 lbs.

Protection—
1. A sum of £33 was required by the Board to meet the current expenses for the year.
2. No assessment was levied, but instead the amount was paid by the different proprietors in proportion.
3. Fourteen.

4. Two cases at the instance of the District Fishery Board were tried before the J.P. Court at Portree as follows, viz. :—1. Widow Stewart and Malcolm MacRae—contravention 9 Geo. IV., cap. 39, secs. 3 and 7, and 8 Vict., cap. 95, sec. 1 ; fined 10s. each, or 4 days' imprisonment. 2. Frank Capel—contravention 9 Geo. IV., cap. 39, secs. 3 and 7, and 8 Vict., cap. 95, sec. 1 ; fined £5, or 14 days' imprisonment, with £5 of expenses.

Obstructions to the Passage of Fish—

1. No dykes or dams. A yare which existed in the estuary of the River Snizort was purchased from the proprietor, Mr. Lachlan MacDonald, of Skaebost, by the Fishery Board and destroyed.

Pollutions—

1 and 2. No.

The Salmon Disease—

1. Never any salmon disease in tidal waters. One case was noted this year in the Snizort River when the water was low. The fish being so numerous in tidal waters when the sea was low, people poaching for salmon in the yare above referred to (now destroyed) were supposed to trample on the fish, and this was the supposed cause of disease in the salmon found dead referred to.

The Spawning Season—

1. Salmon spawn end of November and December.
6. Snizort River.

Kelts—

1. Kelts are seldom seen.
3. March.

Smolts—

1. Never seen unless by anglers on the Snizort River.

Proportion of Male to Female Salmon—

In good seasons female salmon and grilse in the majority.

THE DISTRICT OF THE RIVERS PENNYGOWN OR GLENFORSA AND AROS (MULL).

Take of Fish—

1, 2, 3, 4, and 5. No record is kept of fish taken in the district.

Protection—

1 and 2. No roll has yet been made up for the district, nor has any assessment been levied yet.
4. No prosecutions.

THE DISTRICT OF THE RIVER LOCHY.

Take of Fish—

1. (*a*) Below the average ; (*c*) no fixed engines.
2. 226 salmon, 662 grilse, 906 sea-trout.
3. (*a*) April ; (*b*) September, 85 salmon, 202 grilse ; and (*c*) April and May.
4. (*a*) and (*b*) No change.
5. (*c*) 38 lbs.

Protection—

1. £2321.
2. None.
3. Eleven.
4. One prosecution for illegally taking salmon with net in estuary ; conviction, 15s. of penalty and expenses.

Obstructions to the Passage of Fish—
1. None.
3. No.
4. Always free passage.
5 and 6. No.

Pollutions—
1. No.

The Salmon Disease—
1. No.

The Spawning Season—
1. 21st October in tributaries.
2. 16th November and 20th December.
3. End of December.
4. High.
5. Less.
6. Roy, Cour, Spean. Lochy, Loy, Lundy, and Nevis.

Kelts—
1. Not known.
3. End of April.
4. High.

Smolts—
1. First week in April, fully three weeks earlier than usual
2. Fair.

Artificial Propagation of Salmon—
Yes ; a small hatchery on the banks of the Cour ; 100,000 ova.

Proportion of Male to Female Salmon—
About one-fourth more females than males upon actual enumeration.

THE DISTRICT OF THE RIVER AWE.

(No answers have been received from this district.)

THE DISTRICT OF THE RIVER AYR.

Take of Fish—
1. (*a*), (*b*), (*c*), and (*d*) Above the average.
2. (*a*), (*b*), and (*c*) No record kept, and tacksmen would not give information.
3. (*a*) Opening of fishings ; (*b*) in July, August, and September ; (*c*) in May, June, and July.
4. (*a*) and (*b*) Quite impossible.
5. (*a*), (*b*), and (*c*) Not known.

Protection—
1. £110.
2. 8s. per £.
3. One.
4. None.

Obstructions to the Passage of Fish—
1. None.
2. No.
3. Yes ; a salmon ladder erected at dam at Overmills.
4. Not before formation of ladder referred to.
5. No.
6. None.

Pollutions—
1 and 2. No.

The Salmon Disease—
1. No disease.

The Spawning Season—
1, 2, 3, 4, and 5. Not known.
6. The rivers Ayr and Lugar.

Kelts—
1, 2, 3, and 4. Not known.

Smolts—
1. Not known.
2. Yes.

Artificial Propagation of Salmon—
No.

Proportion of Male to Female Salmon—
No.

General Question—
The clause in the Act as to hecks at outlets of mill lades should be altered, and all such hecks should be made revolving and not removable at any time.

THE DISTRICT OF THE RIVER DOON.

Take of Fish—
1. (*a*), (*b*), (*c*), and (*d*). Above the average.
2. (*a*), (*b*), and (*c*). No record kept, and tacksmen would not give information.
3. (*a*) Opening of fishings ; (*b*) in July, August, and September ; (*c*) in May, June, and July.
4. (*a*) and (*b*). Quite impossible.
5. (*a*), (*b*), and (*c*). Not known.

Protection—
1. £437.
2. 1s. 6d. per £.
3. Two, mainly paid by proprietors.
4. No.

Obstructions to the Passage of Fish—
1. None.
2 and 3. No.
4. Yes.
5 and 6. No.

Pollutions—
1 and 2. No.

The Salmon Disease—
1. No disease.

The Spawning Season—
1, 2, 3, 4, and 5. Not known.
6. The Doon itself, and streams above Loch Doon.

Kelts—
1, 2, 3, and 4. Not known.

Smolts—
1. Not known.
2. Yes.

Artificial Propagation of Salmon—
No.

Proportion of Male to Female Salmon—
No.

General Question—
The clause in the Act as to hecks at outlets of mill lades should be altered, and all such hecks should be made revolving and not removable at any time.

THE DISTRICT OF THE RIVER GIRVAN.

Take of Fish—
1. (*a*) None ; (*b*) cannot say ; (*c*) all ; (*d*) yes.
2. (*a*) None ; (*b*) about 250 salmon, 800 grilse, 2350 trout ; (*c*) cannot say.
3. (*a*) 1st April ; (*b*) August ; (*c*) about June 12th.
5. (*a*) None ; (*b*) 38 lbs. ; (*c*) 40 lbs.

Protection—
1. £524.
2. 1s. 3d. per £.
3. One employed from 1st July until 30th November.
4. Yes. *One case*, contravention of Section 17 of Salmon Fisheries Act, 1868 (taking salmon by means of pitch-fork). Found not proven.

Obstructions to the Passage of Fish—
1. Old dam at Milton, in the Parish of Straiton, slightly altered.
2. Yes.
3. No.
4. Fish-pass at Kilkerran saw-mill dam affords at all times a free passage to salmon wishing to ascend, other dams only when the river is in flood.

5 and 6. No.

Pollutions—
1 and 2. No.

The Salmon Disease—
1. No.
3. None.

The Spawning Season—
1. End of November 1898.

Kelts—
1, 2, 3, and 4. Cannot say.

Smolts—
1. 1st May.
2. Average.

Artificial Propagation of Salmon—
No.

Proportion of Male to Female Salmon—
Cannot say.

General Question—
Pike to the number of 80 were killed on the river on Kilkerran estate.
On Dalquharran estate the river has diverted from its natural course, and it is surmised that the pike breed in the old bed and find their way into the river by a drain.

THE DISTRICT OF THE RIVER STINCHAR.

Take of Fish—
1. Below ; (*b*) good average ; (*c*) and (*d*) below.
2. (*a*) and (*b*) No ; (*c*) 158.
3. (*a*) 8th May ; (*b*) middle of August ; (*c*) July and September.
4. (*a*) and (*b*) Cannot say.
5. (*b*) Cannot say ; (*c*) 30 lbs.

Protection—
1. £400.
2. 2s. per £
3. One.
4. No.

Obstructions to the Passage of Fish—
1. None.
2. Yes.
3. No.
4. Yes.

5 and 6. No.

Pollutions—

1 and 2. No.

The Salmon Disease—
1. No disease so far as known.
4. No.

The Spawning Season—
1. 20th November.
2. 15th December.
3. Middle of January.
4. High.
5. Less.
6. Stinchar and Duisk.

Kelts—
1. Middle of February.
2. March
3. 1st May.
4. High.

Smolts—
1. 1st April.
2. Fair.

Artificial Propagation of Salmon—
No.

Proportion of Male to Female Salmon—
Based on observation—average.

THE DISTRICT OF THE RIVER CREE.

Take of Fish—
1. No special information, but the general opinion is that the take has been much below the average.
2. No.

3, 4, and 5. No information.

Protection—
1. £796.
2. £59 14s., being the assessment at 1s. 6d. per £.
3. Two.
4. No.

Obstructions to the Passage of Fish—
1. No changes.
2. Yes.
3. No.
4. Yes.
5. No.

Pollutions—
1. No.
2. In connection with the new drainage scheme of Newton-Stewart referred to last year, the filtration tanks have not yet been gone on with, but there is little pollution.

The Salmon Disease—
1. No disease.

The Spawning Season—
No information.

Kelts—
No information.

Smolts—
No information.

Artificial Propagation of Salmon—
No.

Proportion of Male to Female Salmon—
No.

General Question—
No.

THE DISTRICT OF THE RIVER DEE (SOLWAY).

Take of Fish—
1. (*a*), (*b*), (*c*), and (*d*) Below an average.
2. (*a*), (*b*), and (*c*) I cannot say the number.
3. (*a*) 1st of March; (*b*) month of July; (*c*) 1st of June.
4. (*a*) and (*b*) The run of fish in the district is about the same this number of years.
5. (*a*) The heaviest salmon with us was 29 lbs.; (*b*) and (*c*) not known.

Protection—
1. £1,603.
2. Five per cent.
3. Sixteen.
4. No.

Obstructions to the Passage of Fish—
1. None.
2. Yes.
3. No.
4. Yes.

5 and 6. No.

Pollutions—

1 and 2. No.

The Salmon Disease—

1. No salmon disease that I have seen in the district.
3. I have seen no diseased salmon this three years.
4. No remarks to make.

The Spawning Season—

1. On the 7th of November.
2. About the 24th of December.
3. About the end of December yearly.
5. Below an average.
6. The Dee, the Tarff, and the Ken.

Kelts—

1. The month of March.
2. In April.
3. Month of May.

Smolts—

1. March, April, and May.
2. Not very good.

Artificial Propagation of Salmon—

Mr. Anderson, Edinburgh, has a hatchery on the Dee at Tongland this four years, and for three years has put out about 180,000 each year.

Proportion of Male to Female Salmon—

I cannot state the proportion.

General Question—

No.

THE DISTRICT OF THE RIVER NITH.

Take of Fish—

1. (*a*), (*b*), (*c*), and (*d*) Less than in previous year.
2. (*a*) and (*b*) Cannot be given ; (*c*) about 30 in all.
3. Clean fish are caught as soon as the fishings open on 24th February ; but afterwards from about middle of March no clean fish are got till the sea-trout begin to run in April.
4. (*a*) and (*b*) Cannot be given.
5. (*a*) 31 lbs. ; (*b*) 25 lbs. ; (*c*) 21 lbs.

Protection—

1. £775 9s. 9d.
2. 2s. 6d. per £.
3. One man employed and paid by the Board, and over twenty gamekeepers sworn in as special watchers.
4. Yes. (1) Two men fishing in a fish-pass in night time fined £2, with 17s. of expenses each, or one month's imprisonment ; (2) one man using drag hooks fined £2, or 21 days ; (3) two men for contravention of Solway Act—fishing in river without leave—fined £1, with 22s. of expenses each, or 21 days' imprisonment ; (4) two men for contravention of Solway Act—ostensibly fishing for white fish by means of stake nets in estuary of river without leave—fined 1s., with 20s. of expenses each, or 14 days' imprisonment. Respondents in the last case have as a remedy raised an action of declarator against the District Board and proprietors of the district to declare a right of fishing for white sea-fish.

Obstructions to the Passage of Fish—

1. No alteration.
2. One cruive in the district is substantially in accordance with bye-law ; most of the dams are not.
3. No.
4. Yes, when the fish are running after a flood, but when the rivers are low the passes do not facilitate the passage of fish.

5 and 6. No.

Pollutions—

A new public sewer from Maxwelltown is proposed being laid into the river, and following on an opposing petition from the County Council a public inquiry ordered by the Secretary for Scotland is to be held on 10th May next under the Rivers Pollution Act.

The Salmon Disease—

1. Very few fish seen affected.
2. Low when it was seen.
3. None taken.
4. No.

The Spawning Season—

1. In October.
2. From middle of December to middle of February.
3. About end of March.
4. Fish only spawn after a flood and not when river is low.
5. Numbers getting still fewer.
6. There are spawning streams all along its course.

Kelts—

1. February and March. There were very few in river.
2. May.
3. End of March.
4. Kelts only go to the sea when the river is rising to a flood, or at least rising.

Smolts—

1. April and May.
2. No.

Artificial Propagation of Salmon—

None belonging to the Board ; but there is Mr. Armistead's private hatchery at New Abbey.

Proportion of Male to Female Salmon—

Cannot be given.

THE DISTRICT OF THE RIVER ANNAN.

Take of Fish—

1 (*a*), (*b*), (*c*), and (*d*) Below the average.

2. The occupiers of the different fishings say they do not keep a record of number caught, therefore the number cannot be given.
3. (*a*) 27th February ; (*b*) best runs of salmon during last week of July and first week in September ; (*c*) sea-trout commenced to run about the middle of April, best runs second week and last week in June (about a fortnight earlier than last year) ; grilse commenced to run in the second week of June, best run last week in July.
4. With exception of on the Newbie and Loch fisheries, no record is kept of the number caught each month, therefore this cannot be given.
5. (*a*) No net and coble fishing in this district ; (*b*) 39½ lbs. on Newbie fishery ; (*c*) 22½ lbs. in Castlemilk portion.

Protection—

1. £3,181 10s.
2. None.
3. Four (three at Annan and one at Lochmaben).
4. For offences in Annan division, proceedings were taken against persons for contravention of Section 33 of the Annan Act, 1841 ; all were convicted ; one was fined £5 18s. or a month, others 11s. each or fourteen days.

Obstructions to the Passage of Fish—

1. None have been destroyed or disused, no new ones built or old ones altered.

2. No cruives in district. Dams, yes, with following exceptions, viz.:—*On the Annan*—There is no heck at tail of mill race at Brydekirk Mill, belonging to Francis Henry Wilson, residing there. *On the Kirtle*—At Beltemont Mill, belonging to Miss Ann Beattie, 13 Church Street, Annan, there is no heck at intake or tail of race, and never were; at Kirtlebridge Mill, belonging to the trustees of the late John Irving, per Herbert Cavan Irving, Esq., Burnfoot, Ecclefechan, there is not a fish-pass nor hecks at intake or tail of mill race, and never were. *On the Mein*—At Mein Mill, belonging to the Duke of Buccleuch, there is not a fish-pass nor hecks at intake or tail of mill race, and never were.
3. One new pass has been put in dam at Beltenmount Mill (aforesaid), and one altered at Rigg dam, on the Kirtle.
4. Yes.

5 and 6. No alteration.

Pollutions—
None.

The Salmon Disease—
1. Yes; first seen on 2nd January, at its height end of January, and disappeared end of March; very few observed diseased during the season; rivers being often in flood, salmon did not remain long in the rivers after spawning.
2. Medium.
3. Yes; January, five, all male, two had spawned and three unspawned; February, one, a male, spawned; March, one, a male, spawned.
4. None.

The Spawning Season—
1. 26th November.
2. Last two weeks in January and first week in February.
3. Last week in February.
4. High.
5. Less; owing to the flooded state of the river, salmon were not easily seen on the beds, and many may have spawned that could not be seen.
6. Northfield, Mount Annan, Luce, Meinfoot, Hoddam Bridge, Mainholm, and Rotchell, on the Annan.

Kelts—
1. 12th February.
2. Last two weeks in February.
3. Last week in April.
4. Medium.

Smolts—
1. Last week in April and during May.
2. No; below the average.

Artificial Propagation of Salmon—
None in district.

Proportion of Male to Female Salmon—
This cannot be accurately given, as notes are not taken at the different fisheries.

General Question—
Nothing further than it would be well to keep in view the complicated state of the Acts of Parliament referring to the Solway Firth, and I may further state that a few years ago the proprietors of fishings in the lower portions of the river Annan stopped netting for salmon, and since then pike, roach, and skellies have become very numerous in the river, and which are very injurious to salmon spawn, smolts, and sea-trout.

Last summer, at the request of the Fishery Board, these portions of the river were netted, with the result that 16 pike and 543 roach and skellies were caught.

APPENDIX III.

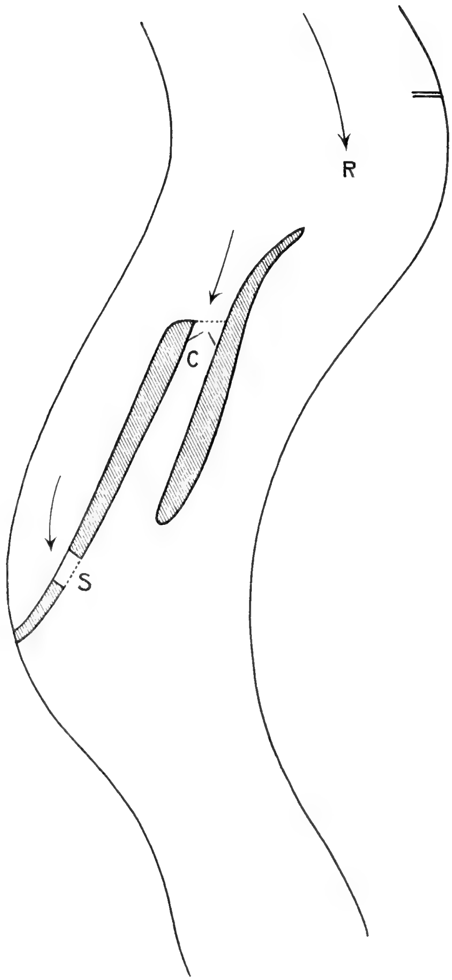
ON THE EXISTENCE, IN SCOTLAND, OF A CRUIVE WITH A "MID-STREAM" SLAP.

By W. L. Calderwood,

Inspector of Salmon Fisheries for Scotland.

In Note III. appended to the Annual Report for last year I referred to the cruive fishings of Scotland, showing that only six cruives are at present in use, although several other cruive dykes still exist. I delayed referring in detail to the first cruive mentioned in the list of six—that at Inverawe. The structure is of special interest, because, so far as I am aware, it is the only cruive in Scotland which seems to conform to the old requirements for a "mid-stream," the dykes being so constructed as to leave a gap of ample dimensions through which the main current of the river descends. On this account it may probably be said with accuracy that the Inverawe cruive is the least harmful structure of its kind.

In the Report already referred to, as in that by Mr. Archer and Messrs. Carmichael and Miller, W.S., in the 13th Annual Report, Part II., Note III., p. 67, it was pointed out that the absence of "mid-streams" in Scotland was accounted for, not by any statutory enactment repealing the provisions of the early Acts which required the existence of "mid-streams," but because in cases brought up before the Law Courts it had gradually become the custom to regard the Acts referring to "mid-streams" and their maintenance as having fallen into disuetude. Without again referring to the early Acts and their provisions (*vide* 13th Annual Report) I would state briefly that the opinion that the "mid-stream" has fallen into disuetude seems to have arisen because witnesses were unable to prove that any cruive with a "mid-stream" existed in Scotland. There seems an entire absence of argument based upon statutory law. Moreover, although the Salmon Fishery Acts of 1862 and 1868 make no reference to the necessity of keeping open the "mid-stream," any more than the Act of James VI., it seems doubtful if the powers conferred upon the Commissioners who framed those Acts made it possible for them to do more than regulate as to "the construction and use of cruives." In addition to this it is necessary to remember that by the 9th sec. of the 1868 Act, sub-sec. 4, power was given to the Secretary for Scotland, on petition by a District Fishery Board "to alter the regulations with respect to the construction and use of cruives and cruive dykes or weirs . . . . provided such alterations do not injure the supply of water to any person entitled to use any existing cruive dyke as a dam dyke." The important difference between the above quotations is that only cruives are mentioned in the first case, whereas cruive dykes or weirs are mentioned in the second. The application of the provision for a "mid-stream" slap effects the construction of the dyke, not of the cruive proper. In this way the point whether or not the absence of the "mid-stream" slap in cruive dykes is an error,



Sketch Plan of Inverawe Cruive.

although the early laws on the subject have been held to be in disuetude, seems to become a question worthy the attention of certain District Boards, in spite of the fact that the rights of cruive fishing were held at the time of the passing of the 1862 Act (*vide* sec. 6) and are held under Royal Grant or Charter. The question of disuetude seems to me to be somewhat effected by the presence of the Inverawe cruive, more especially since I am given to understand the construction of the dyke has not been materially altered since ancient times. The minimum requirement for the width of the "mid-stream" seems to have been reached in the reign of Charles II., when it was ordained "that five foot of the middle stream must be constantly free." The dykes at Inverawe project into the river from one bank only, and although the total length is more than the breadth of the river the left half of the river is left untouched.

The free passage is therefore greatly in excess of the minimum as set down in the time of Charles II. Through the kindness of A. G. H. Campbell, Esq. of Dunstaffnage, I am able to state that the Inverawe cruive dates as far back as 1480 at least—the reign of James III.—and that the dykes have never been modified since the date mentioned, the only change having taken place in 1839, when an iron heck on the cruive box was substituted for the wooden structures previously in use. Subjoined is a sketch plan of the river and cruive dykes at Inverawe made at the time of my visit in May of last year.

The cruive box measures 10ft. 10in. across, is 9ft. from its up-stream to its down-stream frames, and is 7ft. 6in. high at the heck. The gradient from the heck to the lower pool between the dykes is steep. The main current, as indicated by the arrow at R, passes between the fisher's croy or cairn on the left bank and the cruive dykes. A considerable current, however, passes through the cruive at C, and forms a good lead for fish at the lower end of the dyke, which stands in the middle of the river. The water which passes the cruive by the right bank descends to the main river below the dykes, when the river is high, by a slap marked S. It will therefore be seen that not only is the main current allowed to pass the cruive at Inverawe, but one of the dykes is provided with a slap. At a cruive such as that of Dupplin, on the Earn, the main current is caused to pass through the cruive box and no slap is provided in the dyke. At Craigforth, also, a structure which in all probability should long since have been cleared away, as indicated in my last year's report, although much water descends over the natural ledge of rock and the built structure of the dyke, the main lead for the fish is through the cruive box. In all cases some natural formation of the river is taken advantage of to increase the catching power of the cruives, but my purpose is here to show that at Inverawe there still exists a free passage or mid-stream by which the ascent of fish to the upper waters is always possible, and that in this instance we still seem to have the old requirements fulfilled, so that the cruive does not act as an insuperable barrier to the proper distribution of salmon in the river. The enforcing of the mid-stream in olden days was, without doubt, a provision for the benefit of others to whom right of salmon fishing had been granted. Nowadays salmon fishing is infinitely more valuable, and therefore a monopoly acquired by an individual through the possession of a cruive would seem still more to require its compensating condition.

APPENDIX IV.

CORRESPONDENCE BETWEEN THE CLERK TO THE DISTRICT FISHERY BOARD FOR THE RIVER BERVIE, AND THE INSPECTOR OF SALMON FISHERIES OF SCOTLAND, REGARDING FIXING THE LIMITS OF THE ESTUARY OF THE RIVER BERVIE.

97 High Street,
Montrose, 8th February 1900.

BERVIE DISTRICT BOARD.

DEAR SIR,—When recently in Edinburgh I called to consult you as to the fixing of the limits of the estuary of the Bervie during the next equinoctial spring tides . . . The Commissioners by their Bye-Law B fixed and defined the limits which divide the river Bervie including the estuary thereof from the sea to be "A portion of a circle of 150 yards radius to be drawn from a centre placed mid-channel in the river where it joins the sea at low water at equinoctial spring tides and continued shorewards by tangents to the circle drawn to the nearest points of the shore of the respective sides of the river at high water mark also of equinoctial spring tides."

The Fishings on both sides of the river belong to a local proprietor, and those to the north of them belong to the Crown. The boundary between the Fishings is so close to the river that a very little change in its mouth to the northwards would affect the interests of both proprietors and their respective tenants.

As the Clerk of the District Board, I have always been most anxious to have the limits fixed and defined as accurately as possible, and since the present march line was settled in 1896 they have been fixed by an engineer resident in Montrose.

With the foregoing explanations I will be very greatly obliged if, at your earliest convenience, you would kindly specify the *day* and *tide* when the centre of the river should be fixed during the next equinoctial spring tides.—I am, yours faithfully,

ARTHUR DICKSON,
Clerk.

Inspector of Salmon Fisheries,
Fishery Board Offices,
Edinburgh.

Fishery Board for Scotland,
19th February 1900.

SIR,—In answer to your letter of 8th inst. explaining the conditions under which, through the variation of the mouth of the river Bervie, it is necessary at intervals to determine anew the limits of the estuary, and asking me to specify the day and tide when, in accordance with the bye law of the Salmon Fisheries (Scotland) Act, 1868, the centre of the mouth of the river has to be determined, I desire to state that in referring to the bye-law in question (B) it seems to me that the intention of the Salmon Commissioners has been to have the measurements made at the time when the lowest tide occurred.

The Equinox of this year occurs at 1.39 a.m. on the morning of 21st March, and the first spring tide after the Equinox—the time when the Sun enters Aries—occurs at the time of New Moon on the 30th March.

In view of the fact, however, that the tides on the east coast of Scotland flow late as compared with the actual times of New or Full Moon, it seems to me that if my interpretation of the intention of the Salmon Commissioners is correct, the proper time to measure off the limits of the Bervie estuary is when the extreme of rise and fall of tide occurs. This maximum rise and fall occurs at Leith on 1st April, high water being at 3.11 a.m.

Low water at Leith on 1st April will therefore occur at 9.21½ a.m. The correction for Bervie being the difference between times of high water at Leith and Bervie—a correction which no doubt you will be able to ascertain—should be subtracted from the 9.21 as the figure for Leith to obtain the time when, it seems to me, the Bervie measurements should be made.—I am, Sir, your obedient servant,

W. L. Calderwood,
Inspector of Salmon Fisheries for Scotland.

Arthur Dickson, Esq.,
Montrose,
Clerk to Bervie District Fishery Board.

APPENDIX V.

FURTHER INVESTIGATIONS ON THE LIFE-HISTORY OF THE SALMON IN FRESH WATER.

By D. NOËL PATON, M.D., F.R.C.P. Ed.,
and M. I. NEWBIGIN, D.Sc.

(*From the Laboratory of the Royal College of Physicians of Edinburgh.*)

A. Further Evidence on the Factors determining the Migration of Salmon from Sea to River.

In the "Report on Investigations into the Life-History of the Salmon in Fresh Water," published in 1898, the changes which the fish undergoes between the months of May and November were dealt with, but there was no material available to enable the observations to be extended throughout the remaining five months of the year, from December to April.

The difficulty of getting an adequate supply of fish during these close months is very great, but through the energetic co-operation of Mr. Archer and his successor in the post of Inspector of Salmon Fisheries, Mr. Calderwood, a certain number of fish have been procured during these months from the estuaries of the Spey and the Dee.

To the Duke of Richmond and Gordon, through his commissioner, George Muirhead, Esq., and to the District Fishery Board of the River Dee (Aberdeenshire), our thanks are due for generously supplying us with material.

In spite of the earnest endeavours of Mr. Archer and Mr. Calderwood, it has been found impossible to get "clean"—unspawned—fish from the upper waters during these months.

The methods employed in the present investigation were those described in our previous Report, pp. 3 to 7; and in comparing fish of different sizes with one another, all weighings are expressed as for fish of uniform size—100 cm. in length—called the standard fish, S.F. Weights are given in grammes.

The following Tables give the results of the examinations and analyses of twelve female fish taken in the estuaries during February, March, and April.

Although the amount of fats was determined in every case, it has not been considered necessary to give the results of these analyses apart from the analyses of the total solids.

TABLE I.—*Showing Length, Weight, Weight of Muscles and Ovaries per Fish and per Fish of Standard Length in Female Salmon from Estuaries.*

No.	Length.	Weight.		Weight of Muscle.		Weight of Ovaries.	
		Actual.	Per S.F.	Actual.	Per S.F.	Actual.	Per S.F.
February.							
2	66	2680	9338	1680	5853	21	73
3	63	2370	9480	1494	5976	27	101
4	71	3490	9470	2230	6229	21	58
Average,	...	...	9429	...	6019	...	77
March.							
5	73	4095	10500	2654	6795	36	92
7	67	3485	11578	2140	7109	25	83
8	70	3800	11078	2350	6852	21	61
10	66	2710	9442	1638	5707	21	73
35	67	3397	11323	1676	5576	29	90
Average,	...	...	10785	...	6408	...	80
April.							
11	70	4070	11866	2560	7463	52	151·6
12	70	4170	12157	2700	7842	36	104·9
13	74	4350	10741	2844	7020	32	79·0
14	75	4680	11090	2970	7038	37	87·6
Average,	...	...	11463	...	7341	...	106

Table II.—*Showing Percentage and Total Amounts of Solids in Muscle and Ovaries in Female Fish from Estuaries.*

No.	Muscles.			Ovaries.	
	Per cent.		Total per S.F.	Per cent.	Total per S.F.
	Thick.	Thin.			
			February.		
2	30·6	35·0	1850	27·6	20
3	27·7	31·3	2443	31·1	36
4	34·4	39·0	2349	28·0	16
Average,	..	...	2214	...	24
			March.		
5	32·2	36·6	2010	31·4	28
7	32·4	38·0	2372	27·9	23
8	35·9	36·6	2471	24·2	15
10	31·6	34·4	1843	31·0	22
35	34·0	36·6	2568	32·0	31
Average,	...	...	2355	...	24
			April.		
11	32·3	39·4	2542	32·7	49
12	32·3	35·7	2657	31·6	32
13	32·8	38·0	2456	30·7	25
14	35·5	37·8	2741	30·5	28
Average,	...	...	2599	..	33

If the results of these investigations on the solids of salmon leaving the sea during February, March, and April are compared with the results previously obtained during the other months of the year, the following Table may be constructed.

Table III.—*Showing the Amount of Solids in Muscles and Ovaries of Female Salmon leaving the Sea throughout the Year.*

	Nov.	Feb.	Mar.	Apr.	May and June.	July and Aug.	Oct. and Nov.	Kelts.
Muscles, ...	2481	2214	2355	2599	2210	2270	1750	946
Overies, ...	23	24	24	33	47	72	545	9
Total, .	2504	2238	2379	2632	2257	2342	2295	955

Such a Table fully confirms the conclusion previously arrived at—That the salmon goes to the sea to feed and returns to the river when it has accumulated its full store of nourishment irrespective of the condition of the reproductive organs. The factor determining migration from sea to river is not the *nisus generativus*, but the state of nutrition.

B. Male Salmon.

The number of male salmon examined in the course of the previous investigation was so small that it was considered unsafe to form any definite conclusions.

During the past two years every effort has been made to procure a supply of male fish, but without much success. The very small number of males which have been procured seems to indicate that they must be greatly outnumbered by female fish.

The following Tables give the results of our examinations and analyses of the male salmon sent to us.

Table IV.—*Showing Length, Weight, Weight of Muscles and Testes per Fish and per Fish of Standard Length in Male Salmon.*

No.	Length.	Weight. Actual.	Weight. Per S.F.	Weight of Muscles. Actual.	Weight of Muscles. Per S.F.	Weight of Testes. Actual.	Weight of Testes. Per S.F.
Estuary.							
January.							
29	67	3112	10338	1992	6285	4	13·2
30	66	2922	10181	1900	6620	5	17·4
Average, .	...	...	10259	...	6452	...	15·3
March.							
6	75	4410	10450	2784	6597	5	11·6
33	73	3840	9846	2508	6379	4	10·2
34	67	3090	10266	1900	6312	3	9·9
Average, .	...	...	10167	...	6429	...	10·5
June.							
20	74	4245	10481	2652	6548	7	17·2
July.							
25	68	3335	10621	1980	6306	7	22·6
Upper Waters.							
June.							
21	74	3755	9270	1660	4100	27	60
22	69	3200	9756	1410	4300	15	457
24	74	3815	9420	1643	4057	53	131
Average, .	...	...	9482	...	4152	..	78

Table V.—*Showing Percentage and Total Amount of Solids in Muscles and Testes of Male Fish.*

Estuary.					
No.	Muscles.			Testes.	
	Per Cent.		Total per S.F.	Per Cent.	Total per S.F.
	Thick.	Thin.			
A. *January.*					
29	30·2	33·4	2546	16·3	2·15
30	31·4	33·9	1962	19·2	3·06
Average, . .	...	...	2254	...	2·60
B. *March.*					
6	31·4	35·4	2122	19·4	2·33
33	32·8	37·6	2200	19·5	1·96
34	32·6	36·0	2132	13·6	1·34
Average, . .	...	...	2151	...	1·87
C. *June.*					
20	31·5	36·8	2177	15·4	2·58
D. *July.*					
25	34·0	40·0	2238	18·2	3·09
Upper Waters.					
June.					
21	30·0	31·7	1686	16·7	10·3
22	31·8	34·6	1845	16·2	7·3
24	28·6	30·9	1596	16·4	21·7
Average, . .	...	...	1711	...	19·6

Comparison of the results of the present investigation with those recorded in the previous Report tend to show that the male fish leaving the sea from January to August have all about the same amount of solids in their muscles, and have testes little developed.

TABLE VI.—*Showing Solids of Muscles and Testes of Male Salmon leaving the Sea.*

	Jan.	March.	May and June.	July and Aug.	Oct. and Nov.
Muscles, . . .	2254	2151	2004	2345	1470
Testes, . . .	2·6	1·9	2·6	3·9	66
	2256·6	2152·9	2006·6	2348·9	1536

The slightly lower figure in May and June is due to the fact that the two fish examined in 1896 were much below the average as regards muscular development.

The two fish examined in October and November show a very small amount of solids in the muscles. The average figure for the total solids from January to August—2191 grms.—is based on the examination of 11 fish, and the divergence from this manifested in these two fish must be accepted with caution, and does not justify the formation of any conclusions. Further data are required.

From the Table given above it will be seen that the male salmon coming from the sea closely resemble the female fish in the amount of nourishment stored in the body.

Amount of solids in muscles and genitals in salmon leaving the sea from January to August—

Female Fish,	2434
Male Fish,	2191

In fact, the more extended examination of these male fish from the estuaries further bears out the conclusion arrived at from the examination of female fish as to the factors determining migration.

Comparing the upper-water male fish taken in 1898 with those taken in 1896, it is seen that the June fish in the former group resemble the July and August rather than the June fish in the latter group. What the explanation of this may be is not manifest. Possibly an earlier migration to the river may have induced an earlier development of the testes and a greater loss of substance from the muscles.

C. ON THE NATURE OF THE PHOSPHORUS COMPOUNDS OF THE MUSCLES OF SALMON, AND THE SYNTHESIS OF THE ORGANIC PHOSPHORUS COMPOUNDS OF TESTES AND OVARIES.

From the study of the phosphorus compounds in the muscles and in the testes and ovaries at various seasons (Report, p. 143 *et seq.*), we came to the conclusion that the nucleic acid in the testes and the ichthulin in the ovaries—both complex organic phosphorus compounds—are built up from simple inorganic phosphates stored in the muscles.

The recent reseaches carried on in Röhman's laboratory (*Berl. klin. Wochensch.*, 1898, p. 789) tend to show that, in dogs at least, inorganic phosphorus compounds are not used in the body to anything like the same extent as organic compounds; and the fact that in our previous investigation we assumed all the phosphorus extracted by acidulated water to be inorganic in nature rendered it necessary to make further observations. Especially was this the case since Siegfried (*Ztsch. f. phys. Chem.*, Bd. xxi., p. 360, 1896) has shown that in the flesh of mammals some of the phosphorus thus extracted is in organic combination, being linked to a substance which he has described as carnic acid. He states that carnic acid has the formula $C_{10}H_{15}N_3O_5$, and that it is identical with antipeptone.

If this is so, the phosphorus compound—which he calls phosphocarnic acid—must be nearly allied to the pseudo-nucleins. If such a body occurs in the muscle of the salmon in sufficient quantity to yield the phosphorus of the nucleic acid of the testes and of the ichthulin and lecithin of the ovaries, the conclusion as to the extent of synthesis may have been erroneous.

In the previous Report it was shown that the average amount of phosphorous in the muscle of the salmon is 0·215 per cent., and that of this about 0·109 is soluble in water.

To determine how much of this is in organic combination and how much in such compounds as phosphocarnic acid, the following observations were made:—

1. 100 grm. of the flesh of a fresh sea salmon in March 1899 were extracted repeatedly with over two litres of water and acetic acid. The watery extract was boiled and the precipitate well washed. The inorganic phosphorus was precipitated with ammonia and chloride of calcium. In the precipitate the phosphorus was estimated in the usual way, calcium being washed out of the molybdate precipitate with 10 per cent. nitrate of ammonia solution.

$$Mg_2P_2O_7 = {\cdot}357,\ P_2O_5 = {\cdot}228,\ P = {\cdot}099$$

The filtrate containing any phosphocarnic acid was evaporated, burned and treated with molybdate of ammonia, and P. estimated as above.

$$Mg_2P_2O_7 = {\cdot}017,\ P_2O_5 = {\cdot}011,\ P = 0{\cdot}005$$

2. 135 grm. of the flesh of a kelt (32) captured in March were analysed in the same way:—

$$Mg_2P_2O_7 = {\cdot}330,\ P_2O_5 = {\cdot}211,\ P_2O_5\% = 156,\ P = 0{\cdot}068\%$$

The filtrate, containing any phosphocarnic treated as above, gave no precipitate with ammonia-magnesia mixture.

The phosphorus extracted by water from the muscle is almost entirely in simple inorganic combination.

The evidence thus supports the view that the ovarian ichthulin and the testicular nuclein are built up from simple inorganic phosphorus compounds derived from the muscle.

D. Further Observations on the Source of the Pigment of Salmon Muscle.

By M. I. Newbigin, D.Sc.

On the Pigments of certain Crustacea.

It is well known that the salmon when in the sea feeds largely on herring, and that these in turn prey upon small free-swimming crustacea, many of which have a bright red colour. It therefore seemed of interest to compare the pigment of such crustacea with the colouring matter of the muscles and ovaries of the salmon.

During last summer, Sir John Murray sent to the Laboratory of the Royal College of Physicians collections of crustacea obtained by tow-netting in Loch Fyne, in order that the pigments might be investigated. The crustacea sent were all of a red colour, and are believed to constitute the chief food of the herring. The object of the investigation was to find what relation, if any, the pigments of these crustacea bear to those of the salmon.

When received, the crustacea were preserved in methylated spirit or in alcohol of various strengths. In no case was the preserving fluid markedly coloured, most of the pigment being still retained by the organisms. As to the crustacea sent, there were separate bottles of *Pandalus annulicornis* and *Hippolyte scutifrons*, and also large bottles labelled "contents of tow-net in Upper Loch Fyne." These last contained chiefly copepoda intermixed with colourless organisms such as *Sagitta*, and also various Euphausidæ, species of *Hippolyte*, etc. The larger crustacea were picked out from among the copepoda, and the pigments investigated in two sets —(1) those of the copepoda, (2) those of the other crustacea.

1. The copepoda contained a large amount of fat in which the pigment was dissolved. It was found possible by squeezing to extract from their bodies drops of fat deeply coloured by the reddish pigment. Both fat and pigment dissolve in boiling methylated spirit; but on cooling, the coloured fat separates out at the bottom of the vessel. Both fat and pigment dissolve readily in ether, which is thus a much better solvent for the pigment than alcohol. When the fat is saponified either by heating with an alcoholic solution of caustic soda, or by adding metallic sodium to a solution in ether, a red soap is formed from which the pigment may be obtained after treatment with acid. A small amount of a yellow pigment remains in solution in the caustic solution after saponification, as in the case of the salmon pigment.

The red pigment is a lipochrome, and exhibits the same general characters as the red pigment of the salmon, but it was not obtained in sufficient amount for detailed investigation. It especially recalls the pigment of the salmon in its close association with fat.

2. The pigments of the other crustacea sent closely resembled those of the Norway lobster. The most distinct difference from the copepoda lies in the fact that the red pigment is chiefly found in the chitinous cuticle and in the epidermis; the occurrence of a coloured oil was not obvious.

APPENDIX VI.—ABSTRACT of Sums Raised and Expended

DISTRICT BOARDS OF RIVERS.	Rateable Value of Fisheries.	RECEIPTS other than from Loans.				
		Assessments.	Pen'lties and Expenses.	Other Sources.	Total.	
	1.	2.	3.	4.	5.	
	£	£	£	£	£	
Alness,	608	181	...	...	181	1
Annan,	3,182	1	...	3	4	2
Awe,	878	110	...	...	110	3
Ayr,	100	40	...	...	40	4
Ban and Glencoilleader (Mull),	...	(a) ...	...	...	...	5
Balgay,	20	46	...	...	46	6
Bervie,	871	157	27	...	184	7
Broom,	...	(a) ...	...	...	...	8
Conon,	2,554	187	...	...	187	9
Cree,	696	52	...	8	60	10
Dee (Aberdeen),	17,468	1,135	8	10	1,153	11
Dee (Solway),	1,603	80	...	...	80	12
Deveron,	2,658	310	3	...	313	13
Don,	3,374	776	20	2	798	14
Doon,	411	62	...	...	62	15
Esk (North),	6,579	477	...	1	478	16
Esk (South),	3,507	351	6	...	357	17
Findhorn,	3,436	345	...	...	345	18
Forth,	3,738	466	6	...	472	19
Girvan,	524	...	...	...	...	20
Gruinard and Little Gruinard,	(a) ...	...	...	...	...	21
Kyle of Sutherland,	2,771	196	...	...	196	22
Lochy,	2,115	...	...	(b) 753	753	23
Little Broom,	(a) ...	...	...	...	...	24
Lussa,	(a) ...	...	...	...	...	25
Nairn,	1,136	106	...	...	106	26
Ness,	3,667	230	...	...	230	27
Nith,	781	5	13	...	18	28
Pennygown and Glenforsa,	(a) ...	...	...	...	...	29
Spey,	10,634	1,241	6	...	1,247	30
Stinchar,	...	...	...	...	...	31
Tay,	17,905	1,432	43	11	1,486	32
Torridon,	20	8		...	8	33
Tweed,	15,239	3,089	95	62	3,246	34
Ugie,	508	28	...	...	28	35
Ythan,	1,299	158	4	...	162	36
Total,	108,282	11,269	231	850	12,350	

(a) No assessment has yet been levied.
(b) Contribution from Lord Abinger.

by District Fishery Boards, during the year ending 15th May 1898.

	EXPENDITURE not defrayed out of Loans.						LOAN TRANSACTIONS.			
	Wages and Salaries of Clerks, Constables, Bailiffs, Watchers, &c.	Loans.			Other Expenses.	TOTAL.	Borrowed during the Year.	Expended out of Loans during the Year.	Loans outstanding at the Close of the Year.	Sinking Fund at the Close of the Year.
		Instalment repaid.	Payment into Sinking Fund.	Interest.						
	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
	£	£	£	£	£	£	£	£	£	£
1	139	...	...	...	60	199	...	...	...	...
2	299	...	...	..	(*c*) 314	613	...	...	...	...
3	68	...	...	...	8	76	...	...	...	...
4	38	...	...	...	2	40	...	...	...	...
5	...	...	...	...	...	..	...	...	...	...
6	31	...	...	...	15	46	...	...	...	...
7	118	...	...	...	28	146	...	...	...	...
8	...	...	...	...	...	...	...	...	...	...
9	145	...	...	...	51	196	...	...	...	...
10	58	...	...	...	...	58	...	...	...	...
11	927	...	...	...	298	1,225	...	...	...	...
12	83	...	..	...	...	83	...	...	...	...
13	313	...	...	36	68	417	5,276	5,275	5,276	...
14	599	...	...	...	121	720	...	...	...	...
15	50	...	...	...	12	62	...	...	...	...
16	404	...	...	...	10	414	...	...	...	...
17	294	...	...	...	89	383	...	...	...	...
18	323	...	...	...	5	328	...	...	...	...
19	428	...	...	...	12	440	...	...	...	...
20	5	...	...	...	...	5	...	...	...	...
21	...	...	...	...	...	...	...	...	...	...
22	223	...	...	...	19	242	...	...	...	...
23	758	...	...	...	...	758	...	...	..	...
24	...	...	...	...	...	...	...	...	...	...
25	...	...	...	...	...	...	...	...	...	...
26	77	...	...	...	10	87	...	...	...	...
27	284	...	...	...	32	316	...	...	...	...
28	90	...	...	...	22	112	...	...	...	
29	...	...	...	...	...	...	...	...	...	...
30	1,082	...	...	...	(*d*) 268	1,350	...	...	...	...
31	...	...	...	...	...	...	...	...	...	...
32	895	...	...	...	499	1,394	...	...	...	...
33	8	...	...	...	...	8	...	...	...	...
34	2,870	...	...	...	517	3,387	...	...	...	...
35	25	...	...	...	3	28	...	...	...	...
36	146	...	...	...	17	163	...	...	...	...
	10,780	...	...	36	2,480	13,296	5,276	5,275	5,276	...

(*c*) Includes expenses in connection with Brydekirk Caul, £306.
(*d*) Includes contribution of £200 towards cost of re-opening cut in channel at mouth of Spey.

APPENDIX VII.

Rateable Value of Salmon Fisheries, in Districts where Boards have been formed, for the Years 1881 to 1898 inclusive.

Year.	Alness. Annual value.	Alness. Average value for each period of 5 years.	Annan. Annual value.	Annan. Average value for each period of 5 years.	Awe. Annual value.	Awe. Average value for each period of 5 years.	Ayr. Annual value.	Ayr. Average value for each period of 5 years	Balgay. Annual value.	Balgay. Average value for each period of 5 years.	Bervie. Annual value.	Bervie. Average value for each period of 5 years.	Conon. Annual value.	Conon. Average value for each period of 5 years.
	£	£	£	£	£	£	£	£	£	£	£	£	£	£
1881	..	..	1,391	..	..	..	..	..	..	..	..	..	..	..
1882	..	..	1,719	..	..	..	..	..	..	..	..	..	..	..
1883	..	..	1,720	..	..	..	..	..	..	..	..	..	..	..
1884	..	..	1,864	..	..	..	..	..	..	..	..	..	..	..
1885	..	..	1,933	**1,725**	..	..	..	..	..	..	..	..	..	..
1886	..	..	1,998	..	..	..	..	..	..	..	..	..	..	..
1887	..	..	1,993	..	..	..	..	..	..	..	..	..	..	..
1888	..	..	2,007	..	..	..	..	..	..	..	..	..	..	..
1889	..	..	2,007	..	..	..	..	..	..	..	..	..	..	..
1890	..	..	2,107	**2,022**	701	..	..	..	40	..	585	..	2,624	..
1891	..	..	2,112	..	701	..	..	..	40	..	586	..	2,560	..
1892	..	..	2,099	..	718	..	..	..	40	..	586	..	2,756	..
1893	..	..	2,165	..	723	..	..	..	40	..	586	..	2,975	..
1894	579	..	2,778	..	723	..	..	..	40	..	536	..	2,944	..
1895	584	..	2,793	**2,389**	896	752	..	..	20	36	536	566	2,540	2,755
1896	584	..	3,182	..	896	..	..	..	20	..	1,071	..	2,455	..
1897	614	..	3,182	..	878	..	..	..	20	..	1,071	..	2,590	..
1898	608	..	3,182	..	878	..	100	..	20	..	871	..	2,554	..

Year.	Cree. Annual value.	Cree. Average value for each period of 5 years.	Dee (Aberdeen). Annual value.	Dee (Aberdeen). Average value for each period of 5 years.	Dee (Solway). Annual value.	Dee (Solway). Average value for each period of 5 years.	Deveron. Annual value.	Deveron. Average value for each period of 5 years.	Don. Annual value.	Don. Average value for each period of 5 years.	Esk (North). Annual value.	Esk (North). Average value for each period of 5 years.	Esk (South). Annual value.	Esk (South). Average value for each period of 5 years.
	£	£	£	£	£	£	£	£	£	£	£	£	£	£
1881	501	..	9,857	..	1,175	..	2,354	..	3,303	..	6,385	..	2,045	..
1882	522	..	9,556	..	1,195	..	2,575	..	3,025	..	5,942	..	2,200	..
1883	532	..	9,931	..	1,200	..	2,569	..	3,016	..	5,624	..	2,475	..
1884	530	..	10,504	..	1,200	..	2,549	..	3,499	..	6,349	..	2,546	..
1885	645	**546**	10,791	**10,127**	1,235	**1,201**	2,340	**2,477**	3,395	**3,247**	6,757	**6,211**	2,889	**2,431**
1886	530	..	10,805	..	1,565	..	1,790	..	3,588	..	7,216	..	2,934	..
1887	540	..	11,220	..	1,615	..	1,834	..	3,703	..	6,400	..	3,104	..
1888	530	..	12,532	..	1,517	..	1,865	..	3,908	..	6,419	..	3,124	..
1889	530	..	12,036	..	1,517	..	1,748	..	3,929	..	6,608	..	3,104	..
1890	530	**532**	12,274	**11,773**	1,627	**1,568**	1,800	**1,807**	3,905	**3,806**	6,725	**6,673**	3,012	**3,055**
1891	530	..	11,968	..	1,463	..	2,047	..	3,646	..	6,476	..	3,012	..
1892	530	..	12,336	..	1,463	..	2,071	..	3,623	..	6,519	..	3,012	..
1893	544	..	13,911	..	1,463	..	2,073	..	3,964	..	6,609	..	3,012	..
1894	554	..	14,489	..	1,463	..	2,138	..	3,743	..	6,812	..	3,002	..
1895	554	**542**	14,593	**13,461**	1,633	**1,497**	2,383	**2,142**	3,583	**3,711**	6,812	**6,645**	3,149	**3,037**
1896	571	..	15,820	..	1,603	..	2,360	..	3,390	..	6,519	..	3,149	..
1897	571	..	16,176	..	1,633	..	2,469	..	3,383	..	6,540	..	3,149	..
1898	696	..	17,468	..	1,603	..	2,658	..	3,374	..	6,579	..	3,507	..

APPENDIX VII.—*continued.*

Rateable Value of Salmon Fisheries, in Districts where Boards have been formed, for the Years 1881 to 1898 inclusive.

Year.	Findhorn.		Forth.		Girvan.		Kyle of Sutherland.		Lochy.		Nairn.		Ness.		Nith.		Spey.		Tay.		Torridon.		Tweed.		Ugie.		Ythan.	
	Average value.	Average value for each period of 5 years.	Annual value.	Average value for each period of 5 years.	Annual value.	Average value for each period of 5 years.	Annual value.	Average value for each period of 5 years.	Annual value.	Average value for each period of 5 years.	Annual value.	Average value for each period of 5 years.	Annual value.	Average value for each period of 5 years.	Annual value.	Average value for each period of 5 years.	Annual value.	Average value for each period of 5 years.	Annual value.	Average value for each period of 5 years.	Annual value.	Average value for each period of 5 years.	Annual value.	Average value for each period of 5 years.	Annual value.	Average value for each period of 5 years.	Annual value.	Average value for each period of 5 years.
	£	£	£	£	£	£	£	£	£		£	£	£	£	£	£	£	£	£	£	£	£	£	£	£	£	£	£
1881	4,055	..	3,793	..	574	..	2,762	..	1,582	..	..	..	3,075	..	568	..	10,563	..	21,698	..	..	..	13,477	..	322	..	746	..
1882	3,493	..	3,862	..	571	..	2,828	..	1,484	..	..	..	3,198	..	478	..	9,724	..	19,630	..	..	..	13,563	..	343	..	746	..
1883	3,493	..	3,896	..	571	..	2,388	..	1,873	..	..	..	3,285	..	499	..	8,654	..	19,223	..	..	..	13,745	..	339	..	790	..
1884	3,501	..	3,862	..	571	..	2,280	..	1,677	..	..	..	2,924	..	505	..	8,454	..	17,773	..	..	..	13,658	..	339	..	726	..
1885	3,546	**3,617**	3,931	**3,868**	571	**571**	2,222	**2,496**	1,667	**1,658**	..	..	3,030	**3,093**	553	**520**	8,430	**9,165**	19,656	**19,596**	..	..	13,557	**13,600**	334	**335**	726	**746**
1886	3,546	..	4,240	..	571	..	2,545	..	1,682	..	..	..	3,225	..	534	..	9,483	..	20,447	..	..	..	13,681	..	301	..	726	..
1887	3,661	..	4,382	..	542	..	2,558	..	1,749	..	..	..	3,239	..	515	..	9,559	..	22,542	..	..	..	14,382	..	290	..	816	..
1888	3,551	..	4,241	..	542	..	2,585	..	1,628	..	..	..	3,291	..	447	..	10,663	..	22,103	..	..	..	14,199	..	284	..	876	..
1889	3,551	..	4,187	..	542	..	2,610	..	1,866	..	..	..	3,185	..	402	..	10,663	..	19,701	..	..	..	14,254	..	351	..	876	..
1890	3,541	**3,570**	4,257	**4,261**	542	**547**	2,693	**2,598**	1,674	**1,719**	1,542	..	3,079	**3,203**	423	**464**	10,669	**10,207**	17,731	**20,504**	..	..	14,278	**14,158**	348	**314**	876	**834**
1891	3,541	..	3,890	..	542	..	2,640	..	1,895	..	1,543	..	3,366	..	443	..	9,669	..	17,820	..	40	..	14,414	..	358	..	931	..
1892	2,501	..	3,704	..	542	..	2,665	..	1,961	..	1,343	..	3,254	..	423	..	9,687	..	17,227	..	40	..	14,746	..	358	..	1,004	..
1893	3,491	..	3,765	..	542	..	2,613	..	1,961	..	1,343	..	3,253	..	756	..	9,687	..	19,008	..	40	..	14,573	..	358	..	1,004	..
1894	3,501	..	3,806	..	554	..	2,658	..	2,122	..	1,343	..	3,468	..	775	..	9,316	..	21,763	..	40	..	15,583	..	356	..	1,004	..
1895	3,501	**3,507**	3,766	**3,786**	544	**544**	2,611	**2,637**	2,122	**2,012**	1,136	1,341	3,209	**3,310**	771	**633**	9,588	**9,589**	19,587	**19,079**	20	36	15,803	**15,023**	402	**366**	1,024	**993**
1896	3,446	..	3,617	..	500	..	2,634	..	2,094	..	1,136	..	3,085	..	815	..	8,671	..	17,091	..	20	..	15,084	..	503	..	1,024	..
1897	3,436	..	3,616	..	524	..	2,731	..	2,115	..	1,135	..	3,503	..	780	..	9,638	..	17,211	..	20	..	15,444	..	504	..	1,294	..
1898	3,436	..	3,738	..	524	..	2,771	..	2,115	..	1,136	..	3,667	..	781	..	10,634	..	17,905	..	20	..	15,239	..	508	..	1,299	..

APPENDIX VIII.

ANNUAL CLOSE TIME APPLICABLE TO THE SALMON RIVERS IN SCOTLAND.

N.B.—Observe that, in the following List, the days fixing the commencement and termination of the Annual Close Time for Net-fishing and for Rod-fishing, respectively, are in all cases inclusive, as in the case of the Add, the first river in the List.

Name of River.	Annual Close Time for Net-fishing.	Annual Close Time for Rod-fishing.
Add,	From Sept. 1 to Feb. 15, both days inclusive.	From Nov. 1 to Feb .15, both days inclusive.
Aline,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Alness,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Annan,	From Sept. 10 to Feb. 24.	From Nov. 16 to Feb. 24.
Applecross,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Arnisdale (*Loch Hourn*),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Awe,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Aylort (*Kinloch*),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Ayr,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Baa and Goladoir,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Badachro and Kerry (*Gairloch*),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Balgay and Shieldag,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Beauly,	From Aug. 27 to Feb. 10.	From Oct. 16 to Feb. 10.
Berriedale,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Bervie,	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Bladenoch,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Broom,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Brora,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Carradale (*in Cantyre*),	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Carron,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Clayburn, Finnisbay, Avennangeren, Strathgravat, North Lacastile, Scalladale and Mawrig (*East Harris*),	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Clyde and Leven,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Conon,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Cree,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Creed or Stornoway, and Laxay (*Island of Lews*),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Creran (*Loch Creran*),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Croe and Shiel (*Loch Duich*),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Dee (*Aberdeenshire*),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Dee (*Kirkcudbright*),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Deveron,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Don,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Doon,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Drummachloy or Glenmore (*Isle of Bute*),	From Sept. 1 to Feb. 15.	From Oct. 16 to Feb. 15.
Dunbeath,	From Aug. 27 to Feb. 10.	From Oct. 16 to Feb. 10.
Earn,	From Aug. 27 to Feb. 10.	From Nov. 1 to Jan. 31.
Eckaig,	From Sept. 1 to Feb. 15.	From Nov. 1 to Feb. 15.
Esk, North,	From Sept. 1 to Feb. 15.	From Nov. 1 to Feb. 15.
Esk, South,	From Sept. 1 to Feb. 15.	From Nov. 1 to Feb. 15.
Ewe,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.

Name of River.	Annual Close Time for Net-fishing.	Annual Close Time for Rod-fishing.
Fincastle, Meaveg, Ballanachist South Lacastile, Borve, and Obb (*West Harris*), . . .	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Findhorn, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Fleet (*Sutherlandshire*), .	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Fleet (*Kirkcudbrightshire*),	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Forss, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Forth, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Fyne, Shira, and Aray (*Loch Fyne*), . . .	From Sept. 1 to Feb. 15.	From Nov. 1 to Feb. 15.
Girvan, ...	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Glenelg, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Gour, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Greiss, Laxdale, or Thunga,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Grudie or Dionard, . .	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Gruinard and Little Gruinard, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Halladale, Strathy, Naver, and Borgie, . . .	From Aug. 27 to Feb. 10.	From Oct. 1 to Jan. 10.
Helmsdale, . . .	From Aug. 27 to Feb. 10.	From Oct. 1 to Jan. 10.
Hope and Polla or Strathbeg,	From Aug. 27 to Feb. 10.	From Sept. 11 to Jan. 10.
Howmore, ...	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Inchard, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Inner (*in Jura*), . .	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Inver, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Iorsa (*in Arran*), . .	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Irvine and Garnock, . .	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Kennart, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Kilchoan or Inverie (*Loch Nevis*), ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Kinloch (*Kyle of Tongue*), .	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Kirkaig, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Kishorn, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Kyle of Sutherland, . .	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Laggan and Sorn (*Island of Islay*), ...	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Laxford, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Leven, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Little Loch Broom, . .	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Lochy, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Loch Duich, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Loch Luing, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Loch Roag, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Lossie, ...	From Aug. 27 to Feb. 10.	From Oct. 16 to Feb. 10.
Luce, ...	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Lussa (*Island of Mull*), .	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Moidart, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Morar, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Mullanageren, Horasary, and Lochnaciste (*North Uist*), ...	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Nairn, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Nell, Feochan, and Euchar,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Ness, ...	From Aug. 27 to Feb. 10.	From Oct. 16 to Feb. 10.
Nith, ...	From Sept. 10 to Feb. 24.	From Nov. 15 to Feb. 24.
Orkney Islands (*River from Loch of Stenness, &c.*), .	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Ormsary (*Loch Killisport*), Loch Head, and Stornoway (*Mull of Cantire*),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Pennygowan or Glenforsa, and Aros, . . .	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Resort, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Ruel, ...	From Sept. 1 to Feb. 15.	From Nov. 1 to Feb. 15.

Name of River.	Annual Close Time for Net-fishing.	Annual Close Time for Rod-fishing.
Sanda, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Scaddle, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Shetland Islands (*River of Sandwater, &c.*), . .	From Sept. 10 to Feb. 24.	From Nov. 16 to Jan. 31.
Shiel (*Loch Shiel*), . .	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Sligachan, Broadford, and Portree (*Isle of Skye*), .	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Snizort, Orley, Oze, and Drynoch (*Isle of Skye*) .	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Spey, ...	From Aug. 27 to Feb. 10.	From Oct. 16 to Feb. 10.
Stinchar, ...	From Sept. 10 to Feb. 24.	From Nov. 16 to Feb. 24.
Tay, ...	From Aug. 27 to Feb. 10.	From Oct. 16 to Jan. 14.
Thurso, ...	From Aug. 27 to Feb. 10.	From Sept. 15 to Jan. 10.
Torridon, Balgay, and Shieldag, . . .	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Ugie, ...	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Ullapool (*Loch Broom*) .	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Urr, ...	From Sept. 10 to Feb. 24.	From Dec. 1 to Feb. 24.
Wick, ...	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Ythan, ...	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.

APPENDIX IX.

LIST OF CHAIRMEN AND CLERKS OF SALMON FISHERY DISTRICT BOARDS IN SCOTLAND.

DISTRICT.	Name and Address of Chairman.	Name and Address of Clerk.
Alness, . . .	Col. Alex. J. C. Warrand, Ryefield House, Conon Bridge, Dingwall.	William J. Duncan, Solicitor, Dingwall.
Annan, . . .	A. Johnstone Douglas, Esq., Comlongan Castle, Ruthwell.	John F. Cormack, Solicitor, Lockerbie.
Awe, ...	The Marquess of Breadalbane, Taymouth Castle, Perthshire.	Alex. MacArthur, Solicitor, Oban.
Ayr, ...	Richard A. Oswald, Esq. of Auchincruive, Ayr.	William Macrorie, Commercial Bank, Ayr.
Baa & Glencoilleader (Mull),	The Duke of Argyll, Inveraray Castle, Inveraray.	Alex. MacArthur, Solicitor, Oban.
Balgay, . . .	C. R. Manners, Esq., C.E., 12 Lombard Street, Inverness.	Duncan Shaw, W.S., 15 High Street, Inverness.
Bervie, . . .	David Scott Porteous, Esq. of Lauriston, as mandatory of the Commissioners of Woods and Forests.	Arthur Dickson, Solicitor, Montrose.
Broom, . . .	Sir Arthur George Ramsay Mackenzie of Coul, Bart., Coul House, Strathpeffer.	W. R. T. Middleton, Solicitor, Dingwall.
Conon, . . .	John Little Mounsey, Esq., W.S., 5 Thistle Street, Edinburgh, Commissioner for Col. J. A. F. H. Stewart Mackenzie of Seaforth.	W. R. T. Middleton, Solicitor, Dingwall.
Cree, ...	The Earl of Galloway, Cumloden, Newton-Stewart.	A. B. Matthews, Solicitor, Newton-Stewart.
Dee (Aberdeen),	The Lord Provost of Aberdeen.	Alex. Duffus, Advocate, Aberdeen.
Dee (Solway), .	H. G. Murray Stewart, Esq. of Broughton, Gatehouse.	W. Nicholson, Sheriff-Clerk, Kirkcudbright.
Deveron, . .	A. F. Leslie, Esq. of Montcoffer, Banff.	Francis George, Solicitor, Banff.
Don, ...	George Falconer, Esq., as mandatory for the Aberdeen Shipmasters' Society.	Alex. Duffus, Advocate, Aberdeen.
Doon, . . .	Marquis of Ailsa, Culzean Castle, Maybole.	W. Macrorie, Solicitor, Ayr.
Esk (North), .	The Rev. J. S. More Gordon of Charleton and Kinnaber, per George More Gordon, Esq., Charleton, Montrose.	Arthur Dickson, Solicitor, Montrose.
Esk (South), .	James Johnston, Esq., Montrose.	James Don and David G. Shiell, Solicitors, Brechin.
Findhorn, . .	J. J. Meiklejohn, Esq., Novar, Ross-shire, factor for R. C. Munro Ferguson, Esq., M.P.	Wm. Grant, National Bank Buildings, Forres.
Forth, . . .	Mandatory of Commissioners of Woods and Forests.	Thomas L. Galbraith, Town-Clerk, Stirling.
Girvan, . . .	John Campbell Kennedy, Esq. of Dunure.	T. Gerald Tait, Solicitor, Girvan.
Gruinard and Little Gruinard,	Alfred N. G. Aitken, Esq., S.S.C., Edinburgh, Factor and Commissioner for Hugh Mackenzie, Esq., of Dundonnell.	W. R. T. Middleton, Solicitor, Dingwall.
Kyle of Sutherland,	Sir Charles Lockhart Ross, Bart. of Balnagowan.	John Leslie, Solicitor, Dornoch.
Little Broom, .	Alfred N. G. Aitken, Esq., S.S.C., Edinburgh, Factor and Commissioner for Hugh Mackenzie, Esq. of Dundonnell.	W. R. T. Middleton, Solicitor, Dingwall.
Lochy, . . .	Lord Abinger, Inverlochy Castle, Fort-William.	N. B. Mackenzie, Solicitor, Fort-William.
Lussa (Mull) and River from Loch Uisk to Loch Buie,	Maclaine of Lochbuie, Mull.	Alex. MacArthur, Solicitor, Oban.
Nairn, . . .	Brodie of Brodie, Brodie Castle, Forres.	H. T. Donaldson, Solicitor, Nairn.
Ness, ...	George Malcolm, Esq., Factor, Invergarry, Fort-Augustus.	Anderson & Shaw, Solicitors, Inverness.
Nith, ...	John Henderson, Esq., Solicitor, Dumfries.	C. Stuart Phyn, Procurator-Fiscal, Dumfries.
Pennygowan or Glenforsa, and Aros (Mull),	Vacant.	Alex. MacArthur, Solicitor, Oban.

APPENDIX IX. (*continued*)—LIST OF CHAIRMEN AND CLERKS OF SALMON FISHERY DISTRICT BOARDS IN SCOTLAND.

DISTRICT.	Name and Address of Chairman.	Name and Address of Clerk.
Sligachan, Broadford, and Portree (Skye), . .	Kenneth Macdonald, Esq., as mandatory for L. Macdonald, Esq., of Skeabost.	Kenneth Macrae, Sheriff-Clerk, Portree.
Snizort, Orley, Oze, and Drynock (Skye), .	Kenneth Macdonald, Esq., as mandatory for L. Macdonald, Esq., of Skeabost.	Kenneth Macrae, Sheriff-Clerk, Portree.
Spey, . . .	The Duke of Richmond and Gordon, Gordon Castle, Fochabers.	John Wink and George A. Cooper, Solicitors, Elgin.
Stinchar, . .	The Earl of Stair, Lochinch, Wigtownshire.	Thomas C. Greig, Rephad, Stranraer.
Tay, ...	Lt.-Col. Hon. F. J. Stuart Gray, Kinfauns Castle, Perth.	Mackenzie & Dickson, Solicitors, Perth.
Torridon, . .	C. R. Manners, Esq., C.E., 12 Lombard Street, Inverness.	Duncan Shaw, W.S., 42 High Street, Inverness.
Ugie, . . .	Lieut.-Col. Ferguson, of Pitfour, Mintlaw.	Robert Gray, Solicitor, Peterhead.
Ythan, . . .	Earl of Errol, Slains Castle, Aberdeenshire.	D. M. A. Chalmers, Advocate, Aberdeen.
Tweed (Police Committee of the Commissioners),	Sir William Crossman, Cheswick, Beal, Northumberland.	James and David W. B. Tait, W.S., Kelso.

Note.—In addition to the districts specified above, the Duke of Sutherland is sole proprietor of the districts of the following rivers, viz.:—Helmsdale, Brora, Fleet, Kirkaig, Inver, Laxford, and Inchard (under the charge of his factor, Mr Donald M'Lean, Dunrobin Office, Golspie); and the Halladale, Strathy, Naver, Borgie, Kinloch, Hope, Polla or Strathbeg, and Dionard or Grudie (under the charge of his factor, Mr John Box, Tongue); and the Countess of Cromartie is sole proprietrix of the district of the river Kennart (under the charge of her factor, Mr William Gunn, Cromartie Estate Office, Strathpeffer).

Fishery Board for Scotland,
Edinburgh, 3rd April 1899.

GLASGOW: PRINTED BY JAS. HEDDERWICK & SONS
FOR HER MAJESTY'S STATIONERY OFFICE.

The following appear periodically, and can be subscribed for :—

TRADE OF THE UNITED KINGDOM WITH BRITISH POSSESSIONS AND FOREIGN COUNTRIES, showing the Quantities and the Declared Value of the Articles.

The Proceedings of Parliament in Public and Private Business are published daily—House of Lords, price 1*d*. per 4 pp. ; House of Commons, 1*d*. per 8 pp.

TRADE REPORTS of the several British Colonies, with information relative to their population and general condition.

TRADE REPORTS by Her Majesty's Representatives in Foreign Countries, and Reports on Commercial and General Interests.

State Trials, being Reports of the Chief State Trials which have taken place between 1820 and the present time, published under the supervision of a Committee appointed by the Lord Chancellor. 1820-1823 to 1850-1858. 8 vols. Roy. 8vo. Price 10*s*. each.

Challenger, H.M.S. A Report on the Scientific Results of the voyage of, during the years 1873-76, under the command of Captain George S. Nares, R.N., and Captain Frank Turle Thomson, R.N. Prepared under the superintendence of the late Sir C. Wyville Thomson, Knt., F.R.S.; and now of Sir John Murray, K.C.B. Fifty Volumes. Price 101*l*. 15*s*.

Military :—

AFRICA. BRITISH CENTRAL PROTECTORATE. Précis of information concerning. Price 3*s*. 6*d*.

ARTIFICERS. MILITARY. Handbook for. Price 1*s*.

ELECTRICITY AND MAGNETISM. Text-book. By Capt. W. P. Bull, R.S. Price 9*s*.

FIELD SERVICE MANUAL. CAVALRY. 1899. Price 4*d*. MOUNTED INFANTRY. 1899. Price 3*d*.

INFANTRY. Mounted. Regulations. 1899. Provisional issue. Price 3*d*.

NILE, AND COUNTRY BETWEEN DONGOLA, SUAKIM, KASSALA, AND OMDURMAN. Report on the. Price 4*s*. 6*d*.

RHODESIA. SOUTHERN. Précis of information concerning. By Major C. T. Dawkins, C.M.G. January 1899. Price 2*s*.

SMALL WARS. Their Principles and Practice. New edition. Price 5*s*.

SUDAN. Handbook of the. Part I., Geographical. Part II., Historical. Price 2*s*.

DITTO. Supplement to. July 1899. Price 2*s*. 6*d*.

VOLUNTEER CAMPS. Pay, &c. Instructions relating to. Price 1*d*.

Naval :—

NAVAL PRIZE COURTS. Rules of Court. Table of Fees, &c., &c. Price 3*s*.

Geological :—

BELFORD, HOLY ISLAND AND THE FARNE ISLANDS. By W. Gunn, F.G.S. Price 2*s*. 6*d*.

SOUTH WALES COAL FIELD. Part I. Country round Newport, Mon. By Aubrey Strahan. Price 2*s*.

Local Government Board :—

DAIRIES, COWSHEDS AND MILK SHOPS. Model Regulations. Price 1*d*.

ENTERIC FEVER IN THE CITY OF CHICHESTER. Report on. Price 4*s*. 6*d*.

BOARDING-OUT OF PAUPER CHILDREN. 1898–99. Report of Miss H. Mason and of Miss F. M. Chapman. Each 2*d*.

Emigrants' Information Office, 31 Broadway, Westminster, viz. :—

COLONIES, HANDBOOKS FOR. April 1900. 8vo. Wrapper.

No. 1. Canada. 2. New South Wales. 3. Victoria. 4. South Australia 5. Queensland. 6. Western Australia. 7. Tasmania. 8. New Zealand. 9. Cape Colony. 10. Natal. Price 1*d*. each.

No. 11. Professional Handbook dealing with Professions in the Colonies. 12. Emigration Statutes and General Handbook. Price 3*d*. each.

No. 13 (viz., Nos. 1 to 12, in cloth). Price 2*s*.

CONSULAR REPORTS, SUMMARY OF. America, North and South. June 1899. Price 2*d*.

INTENDING EMIGRANTS, INFORMATION FOR :—Argentine Republic, price 2*d*. California, price 1*d*. Ceylon, price 1*d*. Federated Malay States, Jan. 1900, price 4*d*. Maryland, price 1*d*. Newfoundland, price 1*d*. South African Republic, price 3*d*. West Indies, price 6*d*.

Excise Laws. PRACTICAL ARRANGEMENT OF THE LAWS RELATIVE TO THE EXCISE, &c., &c. By Nath. J. Highmore, Assist. Solicitor of Inland Revenue. 2nd Edition. 2 Vols. Price 30*s*.

Foreign Office :—

AFRICA BY TREATY. The Map of. By Sir E. Hertslet, K.C.B. 3 Vols. Price 31*s*. 6*d*.

COMMERCIAL TREATIES. (Hertslet's.) A complete collection of Treaties, &c., between Great Britain and Foreign Powers so far as they relate to Commerce and Navigation, &c. By Sir E. Hertslet, K.C.B., &c. Vols. I. to XX. Price 15*s*. each.

STATE PAPERS. British and Foreign. Vol. 80. General Index (chronologically and alphabetically arranged) to Vols. 65 to 79 (1873 to 1888). Vol. 81 (1888-1889). Vol. 82 (1889-1890). Vol. 83 (1890-1891). Vol. 84 (1891-1892). Vol. 85 (1892-1893). Vol. 86 (1893-1894). Vol. 87 (1894-1895). Price 10*s*. each.

Board of Trade Journal, of Tariff and Trade Notices and Miscellaneous Commercial Information. Published weekly. Price 1*d*.

Index to Vols. 1 to 14. Price 2*s*. And to Vols. XV. to XX. July 1893 to June 1896. Price 1*s*. 6*d*.

Kew : Royal Botanic Gardens. Bulletins of Miscellaneous Information. Volume for 1898, price 3*s*.; and Monthly parts, 1899, price 4*d*.

H. & S.—750—6/1900.

EIGHTEENTH

ANNUAL REPORT

OF THE

FISHERY BOARD FOR SCOTLAND,

Being for the Year 1899.

IN THREE PARTS.

PART I.—GENERAL REPORT.
PART II.—REPORT ON SALMON FISHERIES.
PART III.—SCIENTIFIC INVESTIGATIONS.

PART II.—REPORT ON SALMON FISHERIES.

Presented to Parliament by Command of Her Majesty.

GLASGOW:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE
BY JAMES HEDDERWICK & SONS,
AT THE "CITIZEN" PRESS, ST. VINCENT PLACE.

And to be purchased, either directly or through any Bookseller, from
JOHN MENZIES & CO., 12 HANOVER STREET, EDINBURGH, and
90 WEST NILE STREET, GLASGOW; or
EYRE & SPOTTISWOODE, EAST HARDING STREET, FLEET STREET, E.C., and
32 ABINGDON STREET, WESTMINSTER, S.W.; or
HODGES, FIGGIS, & CO., LIMITED, 104 GRAFTON STREET, DUBLIN.

1900.

[Cd. 200.] *Price 6½d.*

EIGHTEENTH

ANNUAL REPORT

OF THE

FISHERY BOARD FOR SCOTLAND,

Being for the Year 1899.

IN THREE PARTS.

PART I.—GENERAL REPORT.
PART II.—REPORT ON SALMON FISHERIES.
PART III.—SCIENTIFIC INVESTIGATIONS.

PART III.—SCIENTIFIC INVESTIGATIONS.

Presented to Parliament by Command of Her Majesty.

GLASGOW:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE
BY JAMES HEDDERWICK & SONS,
AT "THE CITIZEN" PRESS, ST. VINCENT PLACE.

And to be purchased, either directly or through any Bookseller, from
JOHN MENZIES & CO., 12 HANOVER STREET, EDINBURGH, and
90 WEST NILE STREET, GLASGOW; or
EYRE & SPOTTISWOODE, EAST HARDING STREET, FLEET STREET, E.C., and
32 ABINGDON STREET, WESTMINSTER, S.W.; or
HODGES, FIGGIS, & CO., LIMITED, 104 GRAFTON STREET, DUBLIN.

1900.

[Cd. 211.] *Price 3s. 9d.*

SALE OF GOVERNMENT PUBLICATIONS.

The under-mentioned Firms have been appointed sole Agents for the sale of Government Publications, including Parliamentary Reports and Papers, Acts of Parliament, Record Office Publications, &c., &c., and all such works can be purchased from them either directly or through retail booksellers, who are entitled to a discount of 25 per cent. from the selling prices :—

IN ENGLAND :—

For all publications *excepting* Ordnance and Geological Maps, the Hydrographical Works of the Admiralty, and Patent Office Publications :—Messrs. EYRE AND SPOTTISWOODE, East Harding Street, E.C.
For Geological Maps :—Mr. E. STANFORD, Cockspur Street, S.W.
For Hydrographical Works of the Admiralty :—Mr. J. D. POTTER, 31 Poultry, E.C.
Patent Office Publications are sold at the Patent Office.

For all Publications *excepting* the Hydrographical Works of the Admiralty and Patent Office Publications :—

IN SCOTLAND :—Messrs. JOHN MENZIES & Co., 12 Hanover Street, Edinburgh, and 90 West Nile Street, Glasgow.

IN IRELAND :—Messrs. HODGES, FIGGIS, & Co., LIMITED, 104 Grafton Street, Dublin.

ORDNANCE SURVEY MAPS OF GREAT BRITAIN AND IRELAND :—There are Agents for the sale of these Maps in most of the chief towns. Copies can also be ordered at many Head Post Offices, and through any Bookseller, or from the Director-General Ordnance Survey, Southampton ; or, in the case of Ireland, from the Officer in Charge Ordnance Survey, Dublin.

The following is a list of some of the more important Parliamentary and Official Publications recently issued :—

Parliamentary :

Statutes—

Public General, Session 1899. With Index, Tables, &c. Cloth. Price 3s.
Second Revised Edition. A.D. 1235-1713 to A.D. 1872-1883. XV. Vols. Price 7*s*. 6*d*. each.
Revised Editions. Tables showing subsequent Repeals, effected by Acts of Session 62 & 63 Vict. 1899. Price 6*d*.
Statutes in Force. Index to. 15th Edition. To end of 62 & 63 Vict. 2 Vols. Price 10*s*. 6*d*.
The Statutory Rules and Orders revised. Statutory Rules and Orders, other than those of a Local, Personal, or Temporary Character, issued prior to 1890, and now in force. Vols. I. to VIII. Price 10*s*. each.
Statutory Rules and Orders, other than those of a Local, Personal, or Temporary Character. With a List of the more important Statutory Orders of a Local Character arranged in classes ; and an Index. Roy. 8vo. Boards. Issued in the years 1890, 1891, 1892, 1893, 1894, 1895, 1896, 1897, 1898, and 1899. Price 10*s*. each.
Statutory Rules and Orders in force on 31st December 1899. Index to. Price 10*s*.
Statutory Rules and Orders, 1900. Registered under the Rules Publication Act, 1893. In course of issue.

Acts of Parliament, Public and Local and Private, Session 1900. In course of issue.

[H.C. No. 97/1900.] LIFE ASSURANCE COMPANIES. Statement of Account, 1899. Price 2*s*. 10*d*.
[H.C. No. 134/1900.] COAL. Tables showing Production, &c., 1883 to 1898. Price 6*d*.
[Cd. 46.] AGRICULTURAL RETURNS. Great Britain. 1899. Price 1*s*. 4*d*.
[Cd. 67.] AGED DESERVING POOR. Report of Departmental Committee on the Financial Aspects of Proposals ; with Appendices. Price 1*s*. 3*d*.
[Cd. 167.] MINES AND QUARRIES. General Report and Statistics, 1899. Part I. Persons employed, output, accidents, &c. Price 8*d*.
[Cd. 169.] RAILWAY ACCIDENTS RETURNS FOR THE YEAR 1899. Price 3*s*. 3*d*.
[Cd. 120.] INDUSTRIAL ASSOCIATIONS OF THE UNITED KINGDOM. Labour Department Directory. Price 7½*d*.
[Cd. 134, 134I 10 and 11.]
[Cd. 190.] EDUCATION. Directory with Regulations for establishing and conducting Science and Art Schools and Classes. 1900-1901. Price 6*d*.
[Cd. 196.] WAR RELIEF FUNDS COMMITTEE. Report and Treasury Minute. Price 2*d*.
MINES. Reports of Her Majesty's Inspectors for 1899, with Summaries of the Statistical portion under the provisions of the Coal Mines Regulation Act, 1887 ; Metalliferous Mines Regulation Acts, 1872-1875 ; Slate Mines (Gunpowder) Act, 1882, Districts Nos. 1 to 13. Complete. Price 7*s*. 7*d*.
MINES in the United Kingdom and the Isle of Man. List of, for 1898. Price 3*s*.
QUARRIES Ditto. ditto. ditto. 1898. Price 3*s*. 8*d*.
MINES ABANDONED. List of the Plans of. Corrected to 31st December 1898. Price 10*d*.

EIGHTEENTH

ANNUAL REPORT

OF THE

FISHERY BOARD FOR SCOTLAND,

Being for the Year 1899.

IN THREE PARTS.

Part I.—GENERAL REPORT.
Part II.—REPORT ON SALMON FISHERIES.
Part III.—SCIENTIFIC INVESTIGATIONS.

PART III.—SCIENTIFIC INVESTIGATIONS.

Presented to Parliament by Command of Her Majesty.

GLASGOW:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE
By JAMES HEDDERWICK & SONS,
At "The Citizen" Press, St. Vincent Place.

And to be purchased, either directly or through any Bookseller, from
JOHN MENZIES & CO., 12 Hanover Street, Edinburgh, and
90 West Nile Street, Glasgow; or
EYRE & SPOTTISWOODE, East Harding Street, Fleet Street, E.C., and
32 Abingdon Street, Westminster, S.W.; or
HODGES, FIGGIS, & CO., Limited, 104 Grafton Street, Dublin.

1900.

[Cd. 211.] *Price 3s. 9d.*

CONTENTS.

APPENDICES.

SCIENTIFIC REPORTS.

EIGHTEENTH ANNUAL REPORT.

TO THE RIGHT HONOURABLE

LORD BALFOUR OF BURLEIGH.

Her Majesty's Secretary for Scotland.

OFFICE OF THE FISHERY BOARD
FOR SCOTLAND,
EDINBURGH, 1*st May* 1900.

MY LORD,

In continuation of our Eighteenth Annual Report, we have the honour to submit—

PART III.—SCIENTIFIC INVESTIGATIONS.

GENERAL STATEMENT.

In this part of the Eighteenth Annual Report an account is given of the results of the principal scientific investigations conducted by the Board during the year 1899 in connection with the sea fisheries. Besides the researches related to the life-history and habits of the food fishes and on the invertebrate fauna described in the following pages, a number of other inquiries have been in progress but are not yet completed, among which may be mentioned the rate of growth and migration of fishes, the distribution of spawning fishes and of immature fishes, and on the fauna of the Moray Firth. An investigation was also made in the spring on the condition of the clam-bait bed in the Firth of Forth.

The scientific researches are being conducted at the Board's Marine Laboratory at the Bay of Nigg, Aberdeen, where it is hoped the tanks and apparatus which are necessary for such investigations may be provided in the course of the present year. A considerable part of the work has also been carried on by the small steamer the *Garland*, but, as has been fully explained in preceding Reports, this vessel is not well adapted for the purpose, owing to her small size and considerable age. In consequence of these disabilities, the observations are frequently interrupted by stormy weather and the necessity of repairs, so that they cannot be carried out with regularity. This has prejudicially affected, and continues to affect, the trawling experiments, and it has prevented any systematic investigation of the spawning grounds off the coast, as well as others of importance. The inefficiency of the *Garland* in this department may be understood from the fact that it is not possible with it to follow up the life-history and movements of the principal food fishes from the inshore to the offshore waters, or *vice versa*, or to make observations on the great fishing grounds where fishermen mostly pursue their industry, and where the greater part of the fish supply is obtained.

The Influence of Trawling.

The results of the trawling operations carried on in the course of the year, together with the various Tables embodying the observations in detail, are given in a separate report (p. 19). During the year the investigations were conducted in the Firth of Clyde, where the stations were examined in January, May, June, July, September, October, November, and December. The work was considerably interrupted by stormy weather and the necessity of taking the vessel into harbour for repairs. The number of fishes captured with the ordinary trawl at the Clyde stations was close upon 20,000, of which the majority were flat-fishes. A feature of contrast with the condition on the East Coast is the scarcity of plaice, the most abundant flat-fishes being witches and long rough dabs, which formed over 80 per cent. of all the flat-fishes caught. The statistics for the various kinds of fish caught at the twelve stations show that the average for the year for all kinds together was 176·9 per haul; the average for flat-fishes was 103·7; and that for round-fishes (cod, haddock, whiting, and gurnard), 34·7. Among flat-fishes the average for plaice was only 1·5; that for lemon soles was 7·2; while witches had the high average of 41·7. The dabs had also high averages—for the common dab, 14·9, and for the long rough dab, 36·5. Other species of flat-fishes were taken in small numbers, including, for all the hauls, a total of 60 black or common soles. Among round-fishes, gurnards headed the list with an average of 22·3; the average for cod was only 1; for whitings, 9·4; and for haddocks, 2.

Comparison of the results obtained in the years in which the investigations have been made in the Clyde show that the general average has increased over the period. In 1888 it was 109·7 per haul; in 1890, 99·5; in 1895, 113·4; in 1896, 120·7; in 1897, 112·5; in 1898, 189·3; and last year, 176·9. The statistics for flat-fishes and round-fishes indicate a fairly steady rise in the former and considerable fluctuation in the latter. The figures are as follows:—

	1888.	1890.	1895.	1896.	1897.	1898.	1899.
Flat-Fishes .	61·2	61·1	64·7	75·5	84·8	94·7	103·7
Round-Fishes .	44·7	35·1	43·6	35·1	27·8	49·9	34·7

When the statistics relating to the various species are considered, it is found that the increase among the flat-fishes has been principally in witches and long rough dabs, as shown by the following averages:—

	1888.	1890.	1895.	1896.	1897.	1898.	1899.
Plaice . .	5·3	3·4	2·3	2·1	2·5	3·0	1·5
Lemon Soles .	7·4	5·6	2·8	7·2	5·3	4·1	7·2
Witches . .	12·7	19·7	25·7	35·9	47·1	36·5	41·7
Common Dabs .	23·8	13·8	14·0	15·7	12·7	13·6	14·9
Long Rough Dabs	5·3	17·7	20·0	15·1	16·8	37·3	36·5

The same general result is shown when the averages for the comparable months are considered, with the exception of December 1898, witches and long rough dabs exhibiting a substantial increase, and plaice a diminution.

The trawling investigations begun in Loch Fyne in 1896 show that, within the period, witches and long rough dabs have also given an increased average, while plaice do not indicate the same diminution as at the outer stations. Inasmuch as the observations hitherto made in the Clyde comprise a comparatively small number of hauls, especially in the earlier years, inferences as to changes in the abundance of the fishes in the closed area must be provisional.

The special statistics which have been collected for the past six years, showing the quantities of fish caught in the closed waters of the Moray Firth by line-fishermen, are appended to the Report. The following figures indicate the quantities landed in each district in each of the years, as well as the average weight taken per "shot" of the line:—

District.	1894.		1895.		1896.		1897.		1898.		1899.	
	Cwts.	Average.	Cwts.	Average.	Cwts.	Average.	Cwts.	Average.	Cwts.	Average.	Cwts.	Average.
Wick . .	19,008	2·47	23,009	4·03	31,556	5·40	44,258	6·16	31,383	6·49	26,116	5·106
Lybster .	4,408	4·91	3,977	3·77	4,241	2·87	7,118	4·22	4,438	3·26	4,309	1·398
Helmsdale .	15,826	3·52	16,669	4·15	18,360	4·71	17,148	4·93	13,143	3·84	12,752	3·85
Cromarty .	21.346	3·07	19,193	2·93	15,317	2·51	14,736	2·48	12,428	2·065	11,183	1·815
Findhorn .	60,074	4·04	68,761	4·86	63,521	4·46	46,694	2·66	30,770	2·088	31,825	1·957
Buckie .	48,540	4·21	50,489	4·66	57,450	5·05	50,067	4·77	41,102	4·24	34,915	3·357
Banff . .	49,292	2·94	76,491	4·77	66,471	3·82	61,329	3·70	36,057	2·13	26,675	2·406
	218,494	3·05	258,589	4·43	256,916	4·26	241,350	3·83	169,321	3·244	147,775	2,666

When these quantities are compared with those given in the Tables in Part I. of the Board's Report, showing the gross quantities landed, irrespective of the place of captnre, it will be found that by far the greater part of the line-caught fish in each district is taken from the Moray Firth. Last year 147,775 cwts. out of a gross quantity of 180,649 cwts. were so derived. In all the districts, indeed, except Wick, all the fish caught by line are returned as derived from the closed waters. In previous years this was the case with only a few of the districts, and the circumstance seems to point to a greater restriction of line fishing in this area.

The gross quantity taken from the Moray Firth by line-fishermen in 1899 was less than in any preceding year. As compared with the previous year, the decrease amounted to 21,546 cwts.; as compared with 1895 the decrease was 110,814 cwts., and each year since that named has exhibited a progressive decline. The average catch per "shot" of the line has also decreased during the same period. In 1895 it was 4·43 cwts.; in 1898, 3·24 cwts.; and last year only 3·66 cwts. The diminution was not, however, confined to the Moray Firth. The general statistics for the rest of the East Coast and for the whole of the coasts of Scotland show a corresponding change, and in the same kinds of fishes.

With respect to the various kinds of fishes caught by line in the closed waters, the following Table shows the quantities and the average weight per "shot" for each of the six years:—

FISH.	1894.		1895.		1896.		1897.		1898.		1899.	
	Cwts.	Average.	Cwts.	Average.	Cwts.	Average.	Cwts.	Average.	Cwts.	Average.	Cwts.	Average.
Cod - -	32,571	0·52	47,646	0·81	64,663	1·07	79,731	1·26	56,208	1·07	52,753	0·95
Ling - -	2,169	0·035	2,937	0·005	3,868	0·062	3,544	0·056	2,567	0·049	2,883	0·052
Torsk - -	25	0·002	24	—	94	—	25	—	43	—	82	—
Saithe - -	6,120	0·09	5,083	0·087	10,636	0·17	11,761	0·18	14,881	0·28	9,375	0·169
Haddock -	153,529	2·47	178,370	3·056	156,703	2·6	126,031	2·004	81,098	1·554	68,075	1·229
Whiting -	5,845	0·094	5,114	0·087	4,836	0·08	3,319	0·052	1,535	0·029	1,323	0·023
Turbot - -	5	—	—	—	15	—	16	—	13	—	60	—
Halibut -	254	0·004	403	0·007	691	0·011	707	0·011	730	0·013	762	0·013
Lemon Sole -	—	—	—	—	19	—	14	—	1	—	6	—
"Flounder, Plaice, and Brill" - -	5,477	0·088	5,765	0·09	3,402	0·056	3,978	0·063	3,425	0·065	5,005	0·09
Conger - -	1,244	0·02	777	0·013	823	0·013	1,533	0·024	826	0·015	741	0·013
Skate - -	3,281	0·053	3,014	0·051	3,683	0·061	3,999	0·063	3,273	0·062	3,584	0·064
Other kinds of White Fish -	7,976	0·128	9,456	0·16	7,483	0·12	6,663	0·105	4,574	0·087	3,116	0·056

The most important of the fishes are cod and haddocks, and both show a decrease from the previous year. That in cod was comparatively slight, amounting for the year to 3405 cwts., the average per "shot" also falling from 1.07 to 0·95 cwts. The total and the average were, however, both lower in the years 1894 and 1895; since 1897 the gross quantity and the average have diminished.

The decrease in the quantity of haddocks caught by line in the Moray Firth is more noteworthy. In 1898 the amount landed was 81,098 cwts., while last year it was 68,075 cwts., or nearly 14,000 cwts. less. The average catch per "shot" also declined from 1·554 to 1·229 cwts., the lowest since the statistics began to be collected. Since 1895 both the gross quantity landed and the average weight taken per "shot" of the line have fallen in each successive year. In 1895 the total was 178,370 cwts., and the average per "shot" 3·06 cwts.

There was also a decrease last year in the quantity and average catch of saithe or coal-fish landed. Unlike the cod or haddock, the saithe had been gradually increasing from 1895. Throughout the whole period of six years whitings have shown a gradual and continuous decline. In 1894 the quantity amounted to 5,845 cwts., and the average per "shot" was 0·09; last year the quantity was 1323 cwts., and the average 0·02. Conger also slightly diminished, while skate slightly increased, the average per "shot" remaining the same.

Among flat-fishes, on the other hand, an increase occurred as compared with the previous year; but the quantity caught by lines in the Moray Firth is not very large. The total weight landed in 1898 was 4169 cwts., while 5833 cwts. were landed in 1899. The quantities landed in each of the years, and the percentage of the total catch are as follows:—

	1894	1895	1896	1897	1898	1899
Cwts.	5,736	6,170	4,127	4,715	4,169	5,833
Percentage of Total Catch	2·6	2·3	1·6	1·9	2·5	3·9

Very few lemon soles were taken by lines, only six cwts. during the year; turbot increased from 13 cwts. in 1898 to 60 cwts. last year, and halibut from 730 to 762 cwts. The increase in the group comprised under the heading "flounder, plaice, and brill" was more considerable, namely, from 3425 cwts. in 1898 to 5005 cwts. in 1899, the respective averages being 0·06 and 0·09, and the increase took place almost entirely in the three districts of Helmsdale, Cromarty, and Findhorn.

The statistics dealing with the number of "shots" of the line-fishing boats, or the number of visits made to the fishing gronnds, show that an increase occurred last year as compared with 1898. The figures for the whole of the Moray Firth in each of the years are as follows:—

	1894	1895	1896	1897	1898	1899
Large Boats .	7,082	7,710	11,915	14,039	10,330	12,665
Small Boats .	54,866	50,643	48,3 6	48,836	41,853	42,808
	61,948	58,353	60,261	62,875	52,183	55,473

It will be observed that while the number of "shots" of the small-line boats has declined over the period, the number of "shots" of the great-line boats has increased. On the whole, however, line-fishing in the Moray Firth has declined during the last two years.

As has been said, the fluctuations in the abundance of the fish caught by line in the closed waters in the various years, have been part of a general change along the coast, and cannot therefore be ascribed to a special cause. At the same time it is evident that the operations of the foreign trawlers, which have frequented the Firth in considerable numbers during the past few years cannot be without influence; and their presence must materially interfere with the results of the trawling investigations which were initiated after the Firth was closed.

The Hatching and Rearing of Food Fishes.

As explained in last year's Report, it was found necessary to continue the hatching operations at Dunbar during the season of last year, since the construction of the large tank at the new site at the Bay of Nigg had been suspended in the preceding September. The work consisted, as in preceding years, in the hatching of the eggs of the plaice, and the same methods were adopted. Adult plaice to serve as spawners for the supply of fertilised eggs were procured from trawlers in February and March, a little over 400 males and females being thus obtained. As in preceding years a considerable number of the fishes subsequently died owing to injuries received while being captured, and others remained in an egg-bound condition.

The collection of the fertilised eggs from the spawning-pond commenced early in March, and continued until the end of April, the total number procured being 18,700,000, from which 16,470,000 fry were obtained. These were transferred in batches to the upper waters of Loch Fyne ,off Inveraray,at various dates in April and May, and there liberated.

The numbers of fry of the various species of marine food fishes, whose eggs have been hatched at Dunbar since the work was commenced, are as follows:—

	Plaice.	Cod.	Lemon Soles.	Turbot.	Others.	Total.
1894	26,060,000	500,000	...	...	...	26,560,000
1895	38,615,000	2,760,000	4,145,000	3,800,000	1,050,000	50,370,000
1896	11,350,000	750,000	1,580,000	1,360,000	950,000	15,990,000
1897	24,370,000	...	...	...	...	24,370,000
1898	19,200,000	...	...	...	...	19,200,000
1899	16,470,000	..	...	...	...	16,470,000
	136,065,000	4,010,000	5,725,000	5,160,000	2,000,000	152,960,000

At the close of the season's work the hatchery was dismantled and transferred, with the apparatus, pumps, and plant, to the new site at the Bay of Nigg, Aberdeen, and re-erected there. The large concrete tank, referred to in the preceding Report, was completed towards the close of the year. It was found to work satisfactorily, and as it has a capacity of about 160,000 gallons, and is so sunk in the ground as to admit the sea, through a twelve-inch pipe, at half-tide, it ought to be able to contain a large number of spawners, and will form a valuable adjunct to the establishment. The collection of adult plaice for the ensuing hatching season was begun in December. An additional concrete tank to contain about 60,000 gallons of water was built on an elevated part of the site, to act as a reservoir to supply the hatching apparatus in the night during the hatching season, and the tanks in connection with the laboratory at other times of the year.

The Life History of the Edible Crab.

In the present Report will be found a paper by Mr. H. C. Williamson, describing the results of an investigation into the life-history of the edible crab, which he has conducted during the past two years. The edible crab is one of the shell-fish which have formed the subject of legislation, the Fisheries (Oyster, Crab, and Lobster) Act of 1877 having prohibited the sale or possession of any crab of less than 4¼ inches across the back, of any soft crab, or of any crab with the spawn attached; and since then the District Fisheries Committees in England have made many bye-laws still further regulating the fishery in that country. At the same time it has been felt that much fuller information than existed concerning the life-history and habits of the crab is required in order to follow the operations of these regulations; and it was principally with this object in view that the research was begun.

The result of this research is to throw a considerable amount of light upon such important problems as the size at maturity, the seasonal migrations, distribution, and the season of casting. It was found that a female crab may be potentially mature when it measures about 4⅛ inches across the broadest part of the back; many between this size and 5⅜ inches, probably about a half, are functionally immature; all those above $5\frac{3}{8}$ inches were found to be mature and fertilised. The male crab becomes ripe at a smaller size, and all those above $4\frac{1}{8}$ inches are probably mature. The males and females are in almost equal abundance, the examination of several thousands of specimens showing that 98 males exist to every 100 females.

The crab spawns its eggs, which may number several millions, from November to January, in deep water, and they are hatched inshore in July and August, the period of incubation being seven or eight months, batches of eggs, as a rule, being carried in two successive years, at least, before the crab casts its shell. With regard to casting—an important subject from the point of view of close-times which have been proposed—it was found that while it may occur during a large part of the year—namely, from May to November inclusive—it takes place principally in July, August, and September. The largest numbers of soft crabs are obtained from August to November inclusive, and principally in September. Experiments showed that the time taken for a soft crab to harden, and therefore to become legally marketable, varied considerably. The great majority take from three and a half to four months, and large numbers remain "soft" in the legal sense from 90 to 100 days after casting. When the crab is approaching the mature size casting probably occurs once a year, but mature crabs above $4\frac{1}{8}$ inches do not cast every year, and the female not oftener than once in two years. With regard to distribution, it appears that the post-larval and earliest young stages, up to $\frac{7}{8}$ of an inch in breadth, are probably restricted to the shallow shore waters; those from this size up to $2\frac{1}{4}$ inches are to be found between tide-marks; a little larger (up to 4 inches) they are littoral, outside low-water mark; and those of 4 inches and upwards, or the mature group, are found in winter offshore, beyond the twenty-fathom line at Dunbar, and in the spring and summer in the inshore waters.

Numerous experiments were made, with interesting results, regarding the seasonal migrations, and the movement of those which were marked and recovered are indicated on a chart accompanying the paper. The migration seawards appears to occur during August and September, and the inshore migration begins usually in February. The statistics of the crab fishery and its regulation are also considered. In connection with this investigation it was discovered that the Board had not the power, which is possessed by the District Fishery Committees in England, to permit the possession of berried crabs for scientific research, or for any purpose except for use as bait, in terms of the Act of 1877. A number of berried crabs had been obtained in ignorance of this difficulty, but the provision referred to greatly restricted the investigation, and it would be advantageous if the Board obtained the same powers as the English Committees have to allow the use of such crabs for scientific investigations.

The Parasites of Fishes.

In a paper by Mr. Thomas Scott the results of his investigation on the crustacean parasites of fishes are described. Scarcely any part of a fish is free from such parasites; they are found running over the skin, they adhere to the fins, the gills, and gill-covers, they are found on the lips, the tongue, and the roof and sides of the throat, in the nasal fossæ, and even attached to the eye. For this research a very large number of fishes were examined, belonging to forty-seven species, and obtained for the most part by the *Garland* at various parts of the coast or at the Fish Market, Aberdeen. The majority yielded one or two kinds of parasites only, while on a few as many as four or five different species were obtained. The grey skate furnished the largest number, six different kinds having been found on specimens of this species. The saithe and torsk came next with five species each; the hake and toper yielded four, while three each were obtained on the common gurnard, the halibut, the turbot, the plaice, the conger, and the sun-fish. Eleven fishes yielded two, and twenty-six only one species of parasite each.

The number of species of parasites which are described in the paper is 66, of which 59 belong to the Copepoda, 5 to the Isopoda, and 2 to the Amphipoda. Of the Copepod species, a group in which Mr. Scott is one of the leading authorities, six of the species described are new to science. Some of these parasitic crustaceans are so strangely abnormal and grotesque in form that the most experienced naturalists have failed to recognise their relationship to the Crustacea until the study of their development and life-history revealed their true affinity. The paper is illustrated by numerous figures.

Seine-Net Fishing for Herrings.

The alleged injurious action of the seine-net in the herring fishery has been for some time under investigation with the view of ascertaining whether the two principal objections which have been urged against this mode of fishing—namely, the wasteful destruction of the herring-spawn deposited on the bottom, and of immature herrings—are well founded. For several years, as stated in previous Reports, arrangements were made to conduct investigations at the well-known spawning ground, Ballantrae Bank, off the Ayrshire coast, but owing to the failure of the fishing in successive seasons seine-net boats scarcely took part in it, and the observations could not be made. Last year, however, and still more markedly in the present season, the herrings reappeared on the bank in considerable numbers, and an investigation was made by the assistance of the *Garland*. The results of this enquiry and of the corresponding enquiry made in Loch Fyne are given in a paper in the present Report by Dr. T. Wemyss Fulton, the Scientific Superintendent.

It was found that while the seine-net may capture considerable quantities of small herrings which would escape capture by the drift-net or the trammel-net, and may be the means of occasionally destroying quite immature herrings, the evidence shows that the action of the seine-net in Loch Fyne has not been unnecessarily wasteful, or injurious to the permanence of the supply of herrings from the loch. Statistics prove that while the number of seine-net boats in relation to the number of drift-net boats has increased, the quantity of herrings captured has not only not diminished, but has been steadily augmented over a period. During the five years 1889 to 1893 the gross quantity of herrings taken from Loch Fyne was 213,068 cwts., or an annual average of 42,613 cwts., while during the five years 1894 to 1898 the gross quantity was 573,415 cwts., and the annual average 114,683 cwts.

At Ballantrae Bank the investigation showed that the seine-net, which drags upon the bottom in the comparatively shallow water there, occasionally brings up deposited herring-spawn attached to the fronds of seaweeds, or coating the stones and gravel. Of 79 nets examined immediately after they were hauled, 63 showed no trace of deposited spawn, while in 16 cases spawn was found. The quantity, however, was small, and the amount of injury caused in this way by the seine-net is probably inconsiderable. At the same time, the conditions of the fishery at Ballantrae Bank are very different from what they are in Loch Fyne, where the water is very deep, and fishing operations are confined to the surface stratum. At the former place the water is only from seven to twelve fathoms in depth, and the seine-net extends quite from the surface to the bottom, taking everything within its reach. The herrings caught are spawning fish from which the eggs are running, the area of the bank is limited, and it is admitted that by an excessive use of the seine-net the herrings could be practically cleared from it in a short time. The statistics show a great decline in the fishery following the years of abundance, when hundreds of seine-boats frequented the ground; and while this may be due merely to natural fluctuation, the view that it may have been caused by excessive use of the seine is not inconsistent with the evidence. It is considered desirable, however, to continue the investigations for another year or two.

In the Clyde generally seine-net fishing is now the means of supplying the greater part of the herrings for the consumer. Last year the 328 seine-boats, manned by 1382 men, landed 54,059 crans of herrings of the value of £70,325; while the 404 drift-boats, with 1262 men, landed only 15,965 crans, valued at £18,009.

The Mackerel of the East and West Coasts of Scotland.

Some years ago experiments were made at Barra with the view of ascertaining whether or not there was a likelihood of establishing a mackerel fishery in the adjoining seas, the results of which were described in a previous Report. In the present Report an account is given of an investigation by Mr. H. C. Williamson, made with the object of discovering whether the mackerel of the East and West Coasts were of the same or of different races. The mackerel examined were obtained from Barra, Stornoway, Lower Loch Fyne, Kilbrennan Sound, and off the coast of Aberdeen. A large number of measurements and observations were made on each of the fishes, and the means and their deviation calculated, and the results are set forth in a series of Tables appended to the paper. The general conclusion is that the differences in the length of the head, skull, and pectoral fin in the mackerel from the two coasts may with some probability be granted racial distinction ; while the remaining characters do not prove such differentiation.

The Fishes of the Firth of Clyde.

Mr. T. Scott furnishes in the present Report a list of the fishes which have been found within the limits of the Firth of Clyde, the information being derived from the investigations of the *Garland* and from several other sources. The number of species comprised in the list is 113, but the recorded occurrence of one or two of those appears to the author to be somewhat doubtful, and in the case of one or two other species, though their presence in the Clyde seems to be fairly well attested, further information is desirable. By the use of fine-meshed nets on the *Garland*, it has been shown that some forms, such as the Argentine and Lumpenus, which were previously considered to be rare, are not uncommon in certain localities.

The Surface-Currents of the North Sea.

In the Fifteenth Annual Report a description was given of the experiments made for the purpose of determining the direction and rate of the currents in the North Sea, with reference specially to the transport of the pelagic eggs and larvæ of fishes. Similar experiments have since been undertaken in the English Channel and neighbourhood by the Marine Biological Association, and also by the Belgian authorities. In the present Report a further statement is given by Dr. Wemyss Fulton of the results derived from a study of the additional drift floats, amounting to 132, which have been recovered at later dates since the time mentioned. They were found on the coasts of Schleswig, Denmark, Sweden, and Norway, to as far north as the North Cape, the extreme point of Norway, and extending over 17 degrees of latitude.

The results confirm the conclusion previously reached that the current passes southwards along the east coasts of Scotland and England as far as the Wash, and then passes over to the Schleswig and Danish coasts and northwards to the Skagerack and the western coast of Norway.

The Natural History of the Plaice.

In this Report will be found a paper by Mr. H. M. Kyle dealing with certain problems connected with the natural history of the plaice. The research has been conducted by means of a large number of specimens from various parts of the North Sea, and it was specially directed to discover the variations and variability of the species. With respect to the average size of the plaice when first mature, it appears that in the southern part of the North Sea the female plaice first reaches maturity at a size between thirteen and fourteen inches, while the males reach maturity when between ten and eleven inches in length. In the northern part of the North

Sea the female does not reach maturity, on an average, until attaining a length of about $15\frac{1}{2}$ inches, and the male on the average at a length of twelve to thirteen inches. The variability of the sexes, and variations due to growth are considered in detail; and with regard to the question of race-variability, it is shown that the North Sea plaice are divided into at least two groups by definite and distinct differences in structure. The plaice of the southerly North Sea are relatively more elongated and narrower, while those of the northern parts of the North Sea are relatively broader and shorter. The causes of their difference and variability are discussed, and the paper is illustrated by a number of tables and diagrams.

The Classification of Flat-Fishes.

A paper on this subject is also furnished by Mr. Kyle, in which the affinities and classification of the various species and genera of flat-fishes are considered in great detail. The species examined included the majority of the European forms, representatives of the chief genera of the American flat-fishes, and of the Indian, China, and Australasian seas. Their structure and distribution are described, and their natural affinities, as far as possible, determined. The paper, which is illustrated by two plates, embodies the results of a large amount of work, and forms a valuable addition to our knowledge of the subject with which it deals.

The Invertebrate Fauna.

Another paper is furnished by Mr. Thomas Scott, in which he gives additional observations on the crustacean fauna, and describes a number of species belonging to the various groups, which were for the most part obtained by the *Garland* in the seaward part of the Firth of Clyde and in Loch Fyne. Some of the Copepoda are new to science, and with regard to those previously recorded, further information has been obtained regarding their structure and distribution. The paper is illustrated by two plates.

ANGUS SUTHERLAND, *Chairman.*
D. CRAWFORD, *Deputy-Chairman.*
D'ARCY W. THOMPSON.
J. RITCHIE WELCH.
W. R. DUGUID.
L. MILLOY.
D. MEARNS.

WM. C. ROBERTSON, *Secretary.*

SCIENTIFIC REPORTS.

I. REPORT ON THE TRAWLING EXPERIMENTS OF THE "GARLAND," AND ON THE FISHERY STATISTICS RELATING THERETO.

INTRODUCTORY.

During last year the trawling investigations of the "Garland" were conducted in the Firth of Clyde and Loch Fyne, where the stations were examined in each month, except in February, March, April, and August. The work at each station consists in—(1) trawling along a selected line for a specified distance, determined usually by cross-bearings, all the fish caught being enumerated, measured, and recorded; (2) observations on the temperature, density, and transparency of the water, on the condition of the weather, &c.: (3) collections of the pelagic organisms floating in the water. The Tables relating to the chief of these investigations will be found appended to this Report. In addition, special observations were made on the occurrence and distribution of pelagic fish eggs and larvæ, on the distribution of immature and spawning fishes, on the migrations of fishes, and on various other questions.

The "Garland" was also employed in February, March, and a portion of April in procuring live plaice for the sea-fish hatchery at Dunbar, and in conducting an investigation into the condition of the clam bait beds in the Firth of Forth.

The fishery statistics which have been collected in the districts of the Moray Firth in connection with the trawling experiments there, and which show the quantities of the various kinds of fish caught by line fishermen within the closed waters in each month of the year, and for the whole year, with the respective averages per "shot" of the lines, are appended to this Report, and are discussed below. These statistics were collected by the Fishery Officers of the various districts, or by their correspondents. The trawling records were made by Mr. F. G. Pearcey, the naturalist on board the "Garland."

The Firth of Clyde.

The trawling stations in the Firth of Clyde were examined last year in January, May, June, July, September, October, November, and December, 117 hauls being made with the ordinary trawl-net. In addition to these, several hauls were made at night, and 117 with a fine-meshed shrimp trawl, partly at the ordinary stations and partly in other localities, for the purpose mainly of determining the distribution of immature fish. The Clyde stations are seventeen in number, and are situated as follows:—

Station I. lies off the east coast of Cantyre, in from about twelve to twenty fathoms of water, and extends from Davaar Island to near Ru Staffnage.

Station II. is placed further north in the Sound of Kilbrennan, in from nine to over twenty fathoms, between Pluck Point and Carradale Point.

Station III. is situated opposite to Station II., in Machry Bay, Arran, where the water ranges from about ten to over twenty fathoms in depth.

Station IV. lies off Pirn Mill, Arran, to the north of Station III., in from twenty-seven to thirty fathoms.

Station V. is placed in Whiting Bay, on the other side of Arran, in water from ten to twenty fathoms.

Station VI. lies to the south of Station I., beginning off Rhuad Point, Cantyre, and has a depth of from twenty to thirty fathoms.

Station VII. is placed off the Ayrshire Coast, opposite the village of Ballantrae, in water of from sixteen to twenty-four fathoms deep.

Station VIII. is situated to the south-west of Ailsa Craig, about midway between Sanda Island, Cantyre, and Bennan Head, and the depth of water is from about twenty-seven to thirty-three fathoms.

Station IX. lies to the north of the last station and to the west of Ailsa Craig, in from twenty-five to twenty-eight fathoms.

Station X. lies between Station IX. and the coast of Cantyre, in water about twenty-six fathoms deep.

Station XI. passes round Ayr Bay, and has a depth of about twenty fathoms.

Station XII. lies midway between Arran and the coast of Ayr, in water from about thirty-three to forty-four fathoms deep.

Stations XIII.–XVII. are situated in Upper Loch Fyne. XIII. extends from near Otter Spit to Gortans, and has a depth of from twenty-five to thirty fathoms; XIV. extends from near Gortans to Minard Castle, the depth being about the same as the last; XV. extends from Inverawe to Furnace, with a depth of thirty-three to forty fathoms; XVI. passes from near Strachur to Inveraray, the depth varying from about sixty to seventy fathoms; and Station XVII. lies at the head of the loch from Dunderawe to above Cairndow, in from ten to thirty-five fathoms.

The number of fishes captured in the regular hauls of the ordinary trawl at these stations last year numbered close upon 20,000, of which over 12,000 were flat-fishes. A feature of contrast with the condition in the East Coast areas is the comparative scarcity of plaice, and the great abundance of witches, which are most numerous at Stations XV., XII., and VIII. They comprised very nearly half of all the flat-fishes caught. Long rough dabs were also abundant; so that these two species combined formed about 81 per cent. of the total flat-fishes. The statistics of the various kinds of fish caught at the twelve stations in the Firth of Clyde during the year show that the average number of flat-fishes per haul of the net was 103·7, the average number of round-fishes (cod, haddock, whiting, and gurnard) 34·7, and the average of fishes of all kinds 176·9. Among flat-fishes the average for plaice was 1·5, for lemon soles 7·2, for witch soles 41·7. Common dabs gave an average of 14·9, and long rough dabs an average of 36·5. Other species of flat-fishes were taken in small numbers, including, for all the hauls, a total of 60 black soles. Among round-fishes gurnards were most numerous, giving an average of 22·3 per haul. The average for cod was only 1, and for haddocks 2; whiting were somewhat more abundant, the average being 9·4. The average for skates of the various species was 6.

Comparison of the results obtained in the various years in which trawling investigations have been conducted in the Clyde shows that, taking all the stations together and all the kinds of fish, the average number per haul of the net has generally increased over the period comprised. In 1888 the general average was 109·7 per haul; in 1890 it was 99·5 per haul; in 1895 it was 113·4; in 1896 it was 120·7; in 1897, 112·5; in 1898, 189·3; and in 1899, 176·9. The averages for the two groups of flat-fishes and round-fishes show that there has been a fairly steady rise in the former and considerable fluctuation in the latter. The figures are as follows:—

	1888.	1890.	1895.	1896.	1897.	1898	1899.
Flat-Fishes, -	61·2	61·1	64·7	75·5	84·8	94·7	103·7
Round-Fishes,	44·7	35·1	43·6	35·1	27·8	49·9	34·7

The increase in the average number of flat-fishes appears whether the figures for the whole year are taken or the comparison is restricted to the same months, with one exception, namely, December, when more fishes of all kinds, except common dabs, were taken in 1898 than in 1899.

Comparison of the statistics relating to the various species of flat-fishes shows that the increase over the period has been principally in witches and long rough dabs. The averages are as follows:—

	1888.	1890.	1895.	1896.	1897.	1898.	1899.
Plaice, - -	5·3	3·4	2·3	2·1	2·5	3·0	1·5
Lemon Soles, -	7·4	5·6	2·8	7·2	5·3	4·1	7·2
Witches,- -	12·7	19·7	25·7	35·9	47·1	36·5	41·7
Common Dabs,	23·8	13·8	14·0	15·7	12·7	13·6	14·9
Long Rough Dabs	5·3	17·7	20·0	15·1	16·8	37·3	36·5

The same result is shown when the averages of the comparable months are considered, with the exception of December 1898, witches and long rough dabs indicating a substantial increase and plaice a diminution. Common dabs appear also to have diminished in abundance.

The trawling investigations in Upper Loch Fyne were not commenced until 1896, and there is not, therefore, the same material for comparison as with the Firth of Clyde. Among flat-fishes the predominant species are, as at the outer stations, witches and long rough dabs. Plaice, although not abundant, are found in greater numbers than in the Firth of Clyde; cod are also more numerous in the loch, while whitings and gurnards are less numerous. The general averages for flat-fishes, round-fishes, and the total of all kinds in the various years are as follows:—

	1896.	1897.	1898.	1899.
Flat-Fishes, - - -	70·5	83·1	81·4	129·9
Round-Fishes, - - -	8·2	9·8	12·7	14·1
Totals, - - -	81·1	100·8	101·9	145·3

As in the Firth of Clyde, witches and long rough dabs give an increased average per haul of the net, and plaice do not show the same diminution as at the outer stations. Inasmuch as the observations hitherto made in the Clyde comprise a comparatively small number of hauls, inferences as to changes in the relative abundance of the fishes in the closed area must be provisional.

The special statistics of the fish caught by line in the closed waters of the Moray Firth and landed on the adjoining coast have been collected for the past six years. The total quantities and the average weight per "shot" of the lines for each year in the various districts around the Moray Firth are as follows:—

District.	1894.		1895.		1896.		1897.		1898.		1899.	
	Cwts.	Average.	Cwts.	Average.	Cwts	Average.	Cwts.	Average.	Cwts.	Average.	Cwts.	Average.
Wick, - -	19,008	2·47	23,009	4·03	31,556	5·40	44,258	6·16	31,383	6·49	26,116	5·106
Lybster, - -	4,408	4·91	3,977	3·77	4,241	2·87	7,118	4·22	4,438	3·26	4,309	1·398
Helmsdale, -	15,826	3·52	16,669	4·15	18,360	4·71	17,148	4·93	13,143	3·84	12,752	3·85
Cromarty, -	21,346	3·07	19,193	2·93	15,317	2·51	14,736	2·48	12,428	2·065	11,183	1·815
Findhorn, -	60,074	4·04	68,761	4·86	63,521	4·46	46,694	2·66	30,770	2·088	31,825	1·957
Buckie, - -	48,540	4·21	50,489	4·66	57,450	5·05	50,067	4·77	41,102	4·24	34,915	3·357
Banff, - -	49,292	2·94	76 491	4·77	66,471	3·82	61,329	3·70	36,057	2·13	26,675	2·406
Total, -	218,494	3·05	258,589	4·43	256,916	4·26	241,350	3·83	169,321	3·244	147,775	2·666

These figures refer only to the fish caught by line within the closed area and landed in the districts. The total quantities of line-caught fish, taken from without as well as from within the closed waters, and landed in each district in 1899 are as follows—the gross amount being 180,649 cwts., or 26,000 cwts. less than in the previous year:—

Wick.	Lybster.	Helmsdale.	Cromarty.	Findhorn.	Buckie.	Banff.
58,990	4,309	12,752	11,183	31,825	34,915	26,675

Comparison of these totals with those given in the above Table shows that a very large proportion of the line-caught fish landed in these districts comes from the closed waters of the Moray Firth—namely, 147,775 cwts. out of the total of 180,649 cwts. In all the districts, except Wick, the line-caught fish landed are returned as having been taken from these waters. In previous years this was the case with a few of the districts only, and this circumstance seems to show that the line-fishing is becoming more restricted in this area. In 1898 a small proportion of the line-caught fish landed in the districts of Banff, Buckie, and Findhorn were procured outside the closed area.

With regard to the fluctuations in the quantities captured by line in the Moray Firth in the various years, it will be observed that the gross quantity landed in 1899 is less than in any of the previous years, and that the average per "shot" of the line is also the lowest. The decrease in the quantity last year, as compared with 1898, amounted to 21,546 cwts.; as compared with 1895 the decrease is 110,814 cwts.; and each year since 1895 has shown a progressive falling-off in the quantity of line-caught fish landed. The average catch per "shot" of the line has also fallen in the same period. In 1895 it was 4·43 cwts.; in 1896 very nearly the same, 4·26 cwts.; in 1897, 3·83 cwts.; in 1898, 3·24 cwts.; and last year only 2·66 cwts. It does not appear that this diminution in the quantity of line-caught fish landed from the Moray Firth has been owing to special causes, since there occurred a similar decline on the southern part of the east coast as well as on the west coast of Scotland. Thus, while in 1898 the quantity of line-caught fish landed on the East Coast, other than the Moray Firth, amounted to 479,377 cwts., last year the quantity was 413,173 cwts., showing a decrease of 66,204 cwts. The figures for the whole East Coast are—for 1898, 686,695 cwts., and for 1899, 593,822 cwts.—a decrease of 92,873 cwts. In 1897 the quantity was 959,566 cwts., or 365,745 cwts. more than it was last year. Along the whole coast of Scotland the quantity of line-caught fish landed last year was 939,362 cwts., as compared with 1,058,994 cwts. in 1898 and 1,416,237 cwts. in 1897. It is evident, therefore, that the diminution in the Moray Firth represents a general change, and is in proportion to the diminution elsewhere. The decrease in the Moray Firth was common to all the districts, except Findhorn, which shows a slight improvement on the previous year. It was most marked in the districts of Banff, Buckie, and Wick. In Banff the total quantity was 26,675 cwts., as against 36,057 cwts. for the preceding year. In Buckie the total was 34,915 cwts., as compared with 41,102 cwts. in 1898; while in the Wick district the quantities for the two years were respectively 26,116 cwts. and 31,383 cwts. In the districts of Lybster, Helmsdale, and Cromarty the decrease was comparatively slight. The average weight per "shot" of the line also declined in all the districts, except in Helmsdale, where it was the same as in the previous year. In the Lybster district it fell from 3·26 in 1898 to 1·398 in 1899, which is the lowest average for any district in any of the years since 1894. Three of the districts had averages below 2 cwts. per "shot"—an average not represented in any previous year.

With respect to the various kinds of fish caught by line within the closed waters of the Moray Firth, the quantities and the average weight per "shot" for each of the six years are given in the following Table:—

FISH.	1894.		1895.		1896.		1897.		1898.		1899.	
	Cwts.	Aver-age.	Cwts.	Aver-age.	Cwts.	Aver-age.	Cwts.	Aver-age.	Cwts.	Aver-age.	Cwts.	Aver-age.
Cod	32,571	0·52	47,646	0·81	64,663	1·07	79,731	1·26	56,208	1·07	52,753	0·95
Ling	2,169	0·035	2,937	0·005	3,868	0·062	3,544	0·056	2,567	0·049	2,883	0·052
Torsk	25	0·002	24	—	94	—	25	—	43	—	82	—
Saithe	6,120	0·09	5,083	0·087	10,636	0·17	11,761	0·18	14,881	0·28	9,383	0·169
Haddock	153,529	2·47	178,370	3·056	156,703	2·6	126,031	2·004	81,098	1·554	68,075	1·229
Whiting	5,845	0·094	5,114	0·087	4,836	0·08	3,319	0·052	1,535	0·029	1,323	0·023
Turbot	5	—	—	—	15	—	16	—	13	—	60	—
Halibut	254	0·004	403	0·007	691	0·011	707	0·011	730	0·013	762	0·013
Lemon Sole	—	—	—	—	19	—	14	—	1	—	6	—
"Flounder, Plaice, and Brill"	5,477	0·088	5,765	0·09	3,402	0·056	3,978	0·063	3,425	0·065	5,005	0·09
Conger	1,244	0·02	777	0·013	823	0·013	1,533	0·024	826	0·015	741	0·013
Skate	3,281	0·053	3,014	0·051	3,683	0·061	3,999	0·063	3,273	0·062	3,584	0·064
Other kinds	7,976	0·128	9,456	0·16	7,483	0·12	6,663	0·105	4,574	0·087	3,116	0·056

More than four-fifths of the total quantity caught by line within the area consisted of cod and haddocks, and both of these show a diminution as compared with the previous year. The decrease in cod was comparatively slight, amounting for the year to 3415 cwts.—the average catch falling from 1·07 to 0·95 cwts. This decrease was common to all the districts, except Lybster and Findhorn. When the statistics for each of the six years are examined it is seen that there was a gradual rise both in the gross quantity and in the average per "shot" from 1894 to 1897, and since then a decline.

The averages for each district in each year are as follows :—

District.	1894.	1895.	1896.	1897.	1898.	1899.
Wick,	0·99	1·83	3·22	4·16	3·23	2·75
Lybster,	1·92	1·79	1·71	2·47	1·89	0·88
Helmsdale,	0·75	1·31	2·01	2·39	1·90	1·57
Cromarty,	0·59	0·617	0·74	0·61	0·63	0·51
Findhorn,	0·48	0·75	0·85	0·52	0·55	0·61
Buckie,	0·55	1·0	1·3	1·68	1·34	1·21
Banff,	0·13	0·2	0·22	0·41	0·53	0·44

In all the districts the average shows a decline from the previous year, except in the district of Findhorn, where a slight increase occurred in the averages as well as in the total quantity.

The diminution of the quantity of haddocks caught by line in the Moray Firth is still more noteworthy. In 1898 the quantity landed was 81,098 cwts., while last year it was only 68,075 cwts., or a falling-off of nearly 14,000 cwts. The average per "shot" also declined from 1·554 to 1·229 cwts. The fluctuations in the abundance of this important food-fish from year to year have been very considerable. In 1894 the quantity caught by line in the Moray Firth was 153,529 cwts.; in 1895 it rose to 178,370 cwts., and since then it declined to 156,703 cwts. in 1896, to 126,031 cwts. in 1897, to 81,098 cwts. in 1898, and to 68,075 cwts. last year. The average per "shot" has varied in much the same way. In 1894 it was 2·47 cwts.; in 1895, 3·056 cwts.; in 1896, 2·6 cwts.; in 1897, 2·0 cwts.; in 1898, 1·554 cwts.; and last year 1·229 cwts., or little more than a third of what it was in 1895. The decrease last year as compared with the previous year took place in all the districts, with the exception of Helmsdale. In Banff district the quantity landed fell from 23,637 cwts. to 17,939 cwts., and the average from 1·93 to 1·61; in Buckie district the corresponding decline in the quantity was from 24,161 cwts. to 19,518 cwts., and the average fell from 2·49 to 1·87. In the Findhorn district the diminution was not so marked—namely, in quantity from 19,772 cwts. to 18,300 cwts., and in the average from 1·34 to 1·12.

The average weight of haddocks caught per "shot" of the line in each of the districts in the various years is as follows:—

District.	1894.	1895.	1896.	1897.	1898.	1899.
Wick, - -	0·54	0·508	0·22	0·19	0·27	0·13
Lybster, - -	1·63	1·29	0·69	1·028	0·77	0·24
Helmsdale, - -	2·16	2·11	2·2	1·59	1·33	1·52
Cromarty, - -	2·18	1·96	1·51	1·54	1·10	0·95
Findhorn, - -	3·31	3·73	3·32	1·92	1·34	1·12
Buckie, - -	3·178	3·19	3·16	2·62	2·49	1·87
Banff, - - -	2·47	4·07	3·06	2·82	1·93	1·61

The next most abundant line-caught fish is the saithe or coal-fish, which, unlike the cod and the haddock, was obtained in gradually increasing quantities until last year. The quantity increased from 5083 cwts. in 1895 to 14,881 cwts. in 1898, the average per "shot" also rising in the same period from 0·087 to 0·28. Last year, however, the quantity fell to 9383 cwts., and the average to 0·169; and the decline was common throughout the Firth generally, all the districts showing a diminution both in the gross quantity landed and in the catch per shot of the line. The decrease was most marked in the districts of Wick and Banff. In the former, the quantity diminished from 9292 cwts. to 6330 cwts.; in the latter, from 2,597 cwts. to 850 cwts.

It is somewhat remarkable that throughout the period of six years there has been a progressive diminution in the abundance of whitings, which are chiefly caught in the Banff and Findhorn districts. In 1894 the quantity landed was 5845 cwts., the average per "shot" being 0·094 cwts.; last year the gross quantity was only 1323 cwts., and the average per "shot" 0·023 cwts. The decline has been fairly steady from year to year.

The quantity of conger landed in 1899 was but little below the total for the previous year, the figures being 741 and 826 cwts. respectively. There was, on the other hand, a slight increase in the quantity of skates—from 3273 to 3584 cwts.—but the averages were practically the same in the two years. The statistics for these fishes, indeed, show greater uniformity from year to year than in the case of any others. Of "other kinds of white fish" caught by line, besides those specified in the Tables, there was a decrease from 4574 to 3116 cwts., the average also declining from 0·087 to 0·056. In 1895 the quantity was 9456 cwts., and the average 0·16 and since then there has been a gradual decline.

Among flat-fishes, which, with the exception of the smaller forms in the group included under the heading "flounder, plaice, and brill," are not caught in great numbers by line in the Moray Firth, the statistics show that there was an increase last year as compared with the previous year. The total weight of those landed in 1898 was 4169 cwts., as compared with 5833 cwts. in 1899. Very few lemon soles are caught by line, the total quantity last year amounting to six cwts., while in 1898 only one cwt. were landed. Turbot increased from 13 cwts. in 1898 to 60 cwts. last year, and halibut from 730 to 762 cwts., although the average per "shot" remained the same. Among "flounder, plaice, and brill," the increase was from a total quantity of 3425 cwts. in 1898, to 5005 cwts. last year, the respective averages being 0·065 and 0·09; and this increase took place almost entirely in the three districts of Helmsdale, Cromarty, and Findhorn. The whole of the turbot included in the returns were landed in the Wick district.

The quantities of flat-fishes landed in each of the years and the percentages of the total are as follows :—

	1894.	1895.	1896.	1897.	1898.	1899.
Cwts. - - - -	5736	6170	4127	4715	4169	5833
Percentage of Total Catch, - -	2·6	2·3	1·6	1·9	2·5	3·9

The total quantity captured last year corresponds closely to the total in 1894, but the percentage is considerably higher, and is the highest in the series. The average weight per "shot," which was greatest in 1895 and lowest in 1896, has gradually increased since the latter year.

When we compare the fluctuations in the quantities of the fish caught by line in the Moray Firth with the corresponding statistics for the whole East Coast, and the whole of Scotland, it is found that the changes have been general, and not characteristic of the area named. The diminution in the abundance of cod and haddocks was common to the rest of the coast. The quantity of cod landed on the east coast of Scotland in 1898 amounted to 263,838 cwts., while last year it was 232,922 cwts.—a decrease of 30,916 cwts. In the other districts on the East Coast outside the Moray Firth the quantities were in 1898, 185,730 cwts., and in 1899, 160,321 cwts., or a reduction of 25,409 cwts. For the whole of Scotland the corresponding figures are 390,589 cwts. in 1898 and 321,669 cwts. in 1899—a falling-off of 68,920 cwts. So also with haddocks. In 1898 the quantity landed on the whole East Coast was 240,306 cwts., as compared with 181,397 last year—a difference of 58,909 cwts. In the districts on the East Coast south of the Moray Firth, the quantity landed in 1898 was 156,330 cwts., and in 1899, 111,544 cwts., showing a decrease of 44,786 cwts. in the latter year. On the whole coast of Scotland the decrease in the quantity of haddocks landed last year amounted to 62,116 cwts. The same is true in regard to saithe, the diminution noticed in the statistics from the Moray Firth being common to other parts of the East Coast. With respect to flat-fishes also, we find that there occurred a slight increase in the quantity landed last year as compared with the year before, not only in the Moray Firth, but on the other parts of the East Coast; although, in this case, the increase in the Moray Firth seems to be relatively greater. The quantity landed in the districts to the south of the Moray Firth in 1898 was 25,944 cwts., while last year the quantity amounted to 26,184 cwts.—an increase of 240 cwts. Within the Moray Firth the quantity landed from the closed waters was 4169 cwts. in 1898 and 5833 cwts. in 1899, showing an increase of 1664 cwts.

An examination of the statistics dealing with the number of "shots" of the line-fishing boats in the Moray Firth—that is, the number of visits to the fishing grounds—shows that during last year there was an increase in the case of both the large boats and the small boats as compared with the previous year. The figures for the whole of the Moray Firth in each of the six years are these:—

	1894	1895	1896	1897	1898	1899
Large Boats, . .	7,082	7,710	11,915	14,039	10,330	12,665
Small Boats, . .	54,866	50,643	48,346	48,836	41,853	42,808
	61,948	58,353	60,261	62,875	52,183	55,473

It will be observed that while the number of "shots" of the small-line boats has steadily declined over the period, the number of "shots" of the great-line boats increased from 1894 to 1897, and that the considerable fall in 1898 was partly made up last year. On the whole, however, line-fishing in the Moray Firth has declined during the last two years. The detailed statistics for each of the districts are as follows:—

Year.	Wick.		Lybster.		Helmsdale.		Cromarty.		Findhorn.		Buckie.		Banff.	
	Large.	Small.	Large.	Small.	Large.	Small.	Large.	Small.	Large.	Small.	Large.	Small.	Large.	Small.
1894	396	7,295	22	876	199	4,288	83	6,871	3,132	10,544	2,422	9,104	828	15,888
1895	1,553	4,155	90	965	366	3,614	12	6,561	2,653	11,481	1,929	8,907	1,107	14,930
1896	2,774	3,063	208	1,266	363	3,535	13	6,078	3,772	10,450	2,935	8,420	1,850	15,534
1897	3,911	3,266	264	1,440	466	3,010	3	5,918	4,738	12,810	2,537	7,943	2,120	14,449
1898	1,918	2,846	148	1,211	448	2,971	2	6,015	4,148	10,577	1,958	7,727	1,708	10,506
1899	1,865	3,249	1,932	1,149	382	2,930	61	6,146	5,377	10,883	1,940	8,476	1,108	9,975

In the Cromarty and Findhorn districts, the number of "shots" of both great and small-line boats increased; in Banff and Helmsdale districts there was a decrease in both; in Buckie and Wick districts the "shots" of large-line boats slightly decreased and those of small-line boats increased; and in Lybster district there was a great increase in the "shots" of the large line-boats and a slight decrease in those of the small-line boats. It may be added that the operations of a considerable number of foreign trawlers within the Moray Firth during the past few years must materially affect the results of the trawling investigations there. In 1895 and 1896 a single foreign trawler was engaged in fishing in the Moray Firth; in the next year there were seven observed frequenting it; and the number increased to 32 in 1898, and to 52 in 1899.

T. WEMYSS FULTON,
Scientific Superintendent.

TABLE A.—Showing Summary of Fish taken by the 'Garland' in Trawling Operations in 1899.

Station and Date.	Flat-Fish.									Round-Fish.							
	Plaice.	Lemon Soles.	Witch Soles.	Common Dabs.	Long Rough Dabs.	Black Soles.	Scaldfish.	Sail-Fluke.	Total.		Haddocks.	Whitings.	Gurnards.	Total.	Skate.	Other Fish.	Total.
Firth of Clyde.																	
Station I.																	
May 30, .	.	22	4	12	57	2	.	.	97	13	.	2	13	28	11	13	149
June 7, .	3	5	.	.	7	.	.	.	15	.	2	.	2	4	.	156	175
July 6, .	2	25	3	31	48	2	.	.	111	3	1	1	16	21	8	13	153
Sept. 1, .	5	26	.	66	3	1	.	.	101	14	12	.	27	53	9	15	178
Oct. 5, .	.	30	.	8	.	.	.	.	38	4	10	1	7	22	5	37	102
Nov. 10, .	.	4	.	10	11	2	.	.	27	.	2	5	9	16	9	29	81
Dec. 14, .	1	5	7	9	26	1	.	.	49	.	5	6	8	19	10	15	93
	11	117	14	136	152	8	.	.	438	34	32	15	82	163	52	278	931
Station II.																	
June 2, .	3	.	.	27	40	.	.	.	70	.	5	.	6	11	2	4	87
July 6. .	2	3	2	17	18	.	.	.	42	3	.	3	6	12	6	5	65
Sept. 1, .	5	9	4	36	14	.	.	.	68	.	4	.	9	13	8	17	106
Oct. 5, .	8	11	2	43	.	12	3	.	79	1	9	.	9	19	7	16	121
Nov. 9, .	15	3	.	7	.	.	.	.	25	1	1	.	17	19	1	4	49
Dec. 14, .	17	4	11	43	7	1	.	.	83	3	2	.	7	12	6	8	109
	50	30	19	173	79	13	3	.	367	8	21	3	54	86	30	54	537
Station III.																	
June 1, .	.	18	118	2	115	.	.	.	253	.	1	52	1	54	4	95	406
July 4, .	.	3	92	.	95	.	.	.	190	1	.	20	.	21	4	69	284
Sept, 5, .	1	35	55	123	50	.	.	.	264	1	6	2	15	24	5	129	422
Oct. 4, .	11	10	36	45	33	2	.	.	*138	6	5	4	28	43	5	112	298
Nov. 9, .	2	6	6	81	7	1	.	.	103	4	2	1	7	14	3	6	126
Dec. 5, .	.	19	38	67	16	2	.	.	142	2	.	.	43	45	11	23	221
	14	91	345	318	316	5	.	.	1090	14	14	79	94	201	32	434	1757
Station IV.																	
June 2 .	.	2	12	4	11	.	.	.	29	.	1	1	2	4	2	.	35
July 6, .	.	18	13	3	18	.	.	.	52	.	1	.	8	9	4	6	71
Sept. 2, .	.	9	4	2	34	.	.	.	49	2	9	.	22	33	4	11	97
Oct. 4, .	.	13	.	40	.	.	.	.	53	1	7	.	1	9	7	87	156
Nov. 9, .	.	7	.	32	.	1	.	.	40	.	.	.	1	1	1	.	42
Dec. 5, .	.	9	.	17	.	2	.	.	28	.	.	.	3	3	.	1	32
	.	58	29	98	63	3	.	.	251	3	18	1	37	59	18	105	433
Station V.																	
June 1, .	1	8	2	8	26	.	.	.	45	.	.	.	5	5	2	4	56
July 4, .	3	27	.	15	48	.	2	.	95	.	.	.	5	5	1	8	109
Sept. 8, .	.	17	.	29	.	.	.	.	46	.	4	.	2	6	.	192	244
Oct. 11, .	.	17	.	41	1	.	.	.	59	.	1	.	7	8	7	11	85
Nov. 17, .	.	15	.	46	1	.	.	.	62	.	.	.	8	8	.	3	73
Dec. 18, .	.	6	2	17	6	.	.	.	31	.	1	.	12	13	1	6	51
	4	90	4	156	82	.	2	.	338	.	6	.	39	45	11	224	618

* Including 1 brill.

TABLE A.—SHOWING SUMMARY OF FISH TAKEN BY THE 'GARLAND' IN TRAWLING OPERATIONS IN 1899—*continued.*

Station and Date.	Flat-Fish.									Round-Fish.							
	Plaice.	Lemon Soles.	Witch Soles.	Common Dabs.	Long Rough Dabs.	Black Soles.	Scald Fish.	Sail Fluke.	Total.	Cod.	Haddocks.	Whitings.	Gurnards.	Total.	Skate.	Other Fish.	Total.
FIRTH OF CLYDE—*continued.*																	
Station VI.																	
May 30, .	1	31	.	40	4	.	.	.	76	.	2	5	23	30	21	19	146
June 7, .	.	14	2	1	1	.	.	.	†19	4	.	.	3	7	6	7	39
July 7, .	1	45	.	28	.	.	.	.	74	6	1	.	11	18	18	40	150
Sept. 6, .	.	35	.	25	.	1	.	.	61	5	4	.	21	30	16	31	138
Oct. 5. .	.	33	.	4	.	.	1	.	38	1	.	.	11	12	14	10	74
Nov. 14, .	.	7	.	16	.	6	.	.	29	3	9	21	30	63	20	20	132
Dec. 6, .	.	8	.	61	.	9	.	.	78	1	7	1	91	100	23	5	206
	2	173	2	175	5	16	1	.	375	20	23	27	190	260	118	132	885
Station VII.																	
Jan. 17, .	3	.	87	13	7	1	.	.	111	.	4	27	6	37	7	6	161
May 29, .	.	2	61	3	3	.	.	.	69	1	1	16	17	35	5	11	120
June 7, .	.	1	44	3	7	.	.	.	55	.	1	8	23	32	4	26	117
July 7, .	.	.	61	5	16	.	1	.	83	.	1	12	10	23	1	6	113
Sept. 12, .	.	15	6	35	.	.	1	.	57	.	.	.	42	42	15	38	152
Oct. 6, .	.	1	7	11	.	.	2	.	21	.	1	.	8	9	18	10	58
Nov. 15, .	.	1	18	1	.	1	.	.	21	1	.	.	8	9	10	7	47
Dec. 12, .	.	.	.	.	4	.	.	.	4	.	.	.	1	1	6	1	12
	3	20	284	71	37	2	4	.	421	2	8	63	115	188	66	105	780
Station VIII.																	
May 29, .	.	2	239	.	3	1	.	7	*253	.	.	2	63	65	7	25	350
June 8, .	.	.	145	2	8	.	1	1	157	.	.	2	23	25	3	42	227
July 7, .	.	.	117	.	5	.	1	2	125	.	.	7	22	29	3	9	166
Sept. 13, .	.	.	105	.	4	.	.	10	119	.	.	1	20	21	10	1	151
Oct. 10, .	.	1	.	.	.	.	.	16	17	.	.	1	117	118	7	204	346
Nov. 23, .	.	.	47	.	.	.	1	3	*52	.	.	11	15	26	5	17	100
Dec. 12, .	.	.	18	.	.	.	3	8	29	.	.	5	21	26	.	24	79
	.	3	671	2	20	1	6	47	752	.	.	29	281	310	35	322	1419
Station IX.																	
Jan. 17, .	1	.	37	13	3	1	.	.	55	.	.	50	31	81	6	49	191
May 29, .	.	.	88	.	9	.	.	1	98	1	.	.	23	24	2	36	160
June 8, .	.	1	143	.	14	.	.	.	158	.	.	2	20	22	3	17	200
July 8, .	.	.	140	2	33	.	.	2	177	.	.	4	33	37	6	24	244
Sept. 8, .	.	.	14	.	1	.	.	2	17	.	.	68	13	81	2	5	105
Oct. 10, .	.	.	28	.	.	.	.	1	29	.	.	13	4	17	3	3	52
Nov. 15, .	.	.	43	.	.	.	.	1	44	.	.	3	26	29	3	55	131
Dec. 13, .	.	.	38	.	.	.	.	1	39	.	.	5	39	44	.	5	88
	1	1	531	15	60	1	.	8	617	1	.	145	189	335	25	194	1171
Station X.																	
Jan. 16, .	.	2	64	2	7	4	.	.	79	.	18	130	.	148	7	124	358
May 30, .	.	5	31	2	67	2	1	.	†109	.	.	1	15	16	8	16	149
June 13, .	.	5	33	3	61	2	.	.	104	.	1	4	45	50	14	20	188
July 19, .	.	2	71	.	42	1	3	1	120	.	.	17	35	52	9	28	209
Sept. 6, .	.	1	.	.	5	.	.	.	6	.	26	51	140	217	21	99	343
Oct. 9, .	.	.	.	2	.	.	.	.	2	.	.	.	29	29	6	4	41
Nov. 14, .	.	.	21	.	.	.	1	2	24	1	.	2	29	32	3	23	82
Dec. 6, .	.	.	76	3	12	.	1	.	92	.	.	4	61	65	6	52	215
	.	15	296	12	194	9	6	3	536	1	45	209	354	609	74	366	1585

* Including 1 brill. † Including 1 turbot

TABLE A.—Showing Summary of Fish taken by the 'Garland' in Trawling Operations in 1899—*continued.*

Station and Date.	Flat-Fish.									Round-Fish.							
	Plaice.	Lemon Soles.	Witch Soles.	Common Dabs.	Long Rough Dabs.	Black Soles.	Scaldfish.	Sail-Fluke.	Total.	Cod.	Haddocks.	Whitings.	Gurnards.	Total.	Skate.	Other Fish.	Total.
Firth of Clyde—*continued.*																	
Station XI.																	
Jan. 24, .	22	7	69	62	82	1	.	.	*244	.	1	2	30	33	1	10	288
June 1, .	.	2	29	2	112	.	.	.	145	1	1	5	2	9	6	14	174
July 4, .	.	.	37	.	119	.	.	.	156	.	.	16	19	35	2	13	206
Sept. 15, .	4	.	82	3	76	.	.	.	165	.	.	27	64	91	1	21	278
Oct. 12, .	2	.	45	14	32	.	.	.	93	.	.	2	8	10	3	24	130
Nov. 20, .	6	2	78	11	75	.	.	.	172	.	.	2	102	104	5	31	312
Dec. 15, .	2	.	69	3	9	.	.	.	83	.	.	3	21	24	3	48	158
	36	11	409	95	505	1	.	.	1058	1	2	57	246	306	21	161	1546
Station XII.																	
Jan. 20, .	1	.	108	.	405	1	.	.	515	1	.	8	1	10	6	47	578
May 31, .	.	.	38	.	192	.	.	.	230	1	.	17	1	19	2	23	274
June 17, .	.	.	53	.	303	.	.	.	356	.	.	7	.	7	4	15	382
July 24, .	1	.	50	.	218	.	.	.	269	.	1	51	12	64	3	32	368
Sept. 14, .	3	1	157	.	173	.	.	.	334	.	.	17	78	95	3	57	489
Oct. 12, .	1	.	223	.	126	.	.	.	350	.	.	8	18	26	.	61	437
Nov. 25, .	1	.	179	1	76	.	.	.	257	.	.	27	10	37	2	97	393
Dec. 18, .	.	.	93	.	61	.	.	.	154	.	.	25	69	94	2	32	282
	7	1	901	1	1554	1	.	.	2465	2	1	160	189	352	22	364	3203
Station XIII.																	
May 26, .	9	3	14	3	74	.	.	.	103	13	15	.	10	38	1	18	160
June 20, .	7	1	12	4	30	1	.	.	55	9	7	1	4	21	1	12	89
July 27, .	7	.	4	6	48	.	.	.	65	4	10	3	10	27	.	4	96
Sept. 27, .	.	1	1	4	46	.	.	.	52	4	.	.	39	43	2	4	101
Oct. 18. .	.	.	.	1	19	.	.	.	20	3	2	2	8	15	1	8	44
Nov. 27, .	.	.	1	.	15	.	.	.	16	3	1	.	7	11	2	47	76
Dec. 20, .	.	3	5	.	11	.	.	.	19	4	4	.	.	8	4	21	52
	23	8	37	18	243	1	.	.	330	40	39	6	78	163	11	114	618
Station XIV.																	
May 26, .	5	1	23	5	37	.	.	.	71	5	3	1	4	13	.	9	93
June 20, .	2	2	12	1	15	.	.	.	32	7	13	2	11	33	.	9	74
July 27, .	3	.	25	2	74	.	.	.	104	9	4	.	3	16	.	15	135
Sept. 27, .	.	3	2	2	5	.	.	.	12	10	4	.	3	17	3	21	53
Oct. 18, .	.	.	.	.	37	.	.	.	37	.	2	5	6	13	.	20	70
Nov. 27, .	.	1	1	.	9	.	.	.	11	17	13	2	11	43	1	54	109
Dec. 21, .	.	.	26	.	19	.	.	.	45	.	1	6	9	16	.	8	69
	10	7	89	10	196	.	.	.	312	48	40	16	47	151	4	136	603
Station XV.																	
June 21, .	1	.	239	.	135	.	.	.	375	1	3	.	.	4	1	4	384
July 27, .	1	.	82	.	115	.	.	.	198	5	2	3	2	12	1	27	238
Sept. 28, .	18	.	374	26	246	.	.	.	664	3	1	.	2	6	.	7	677
Oct. 18, .	16	.	160	.	231	.	.	.	407	3	9	2	1	15	3	55	480
Nov. 27, .	4	.	83	.	59	.	.	.	146	10	4	1	.	15	3	8	172
Dec. 21, .	3	.	165	.	35	.	.	.	203	.	3	4	7	14	1	6	224
	43	.	1103	26	821	.	.	.	1993	22	22	10	12	66	9	107	2175

* Including 1 brill.

TABLE A.—SHOWING SUMMARY OF FISH TAKEN BY THE 'GARLAND' IN TRAWLING OPERATIONS IN 1899—*continued.*

Station and Date.	Flat-Fish.									Round-Fish.							
	Plaice.	Lemon Soles.	Witch Soles.	Common Dabs.	Long Rough Dabs.	Black Sole.	Scaldfish.	Sail-Fluke.	Total.	Cod.	Haddocks.	Whitings.	Gurnards.	Total.	Skate.	Other Fish.	Total.
FIRTH OF CLYDE—*continued.*																	
Station XVI.																	
May 27, .	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	1
June 22, .	.	.	170	.	.	.	.	.	170	.	2	.	.	2	.	1	173
July 26, .	.	.	5	.	.	.	.	.	5	.	1	.	.	1	.	.	6
Sept. 28, .	.	.	3	.	3	.	.	.	6	.	1	.	.	1	.	1	8
Oct. 19, .	.	.	105	.	5	.	.	.	110	.	16	.	.	16	.	3	129
Nov. 28, .	.	.	18	.	13	.	.	.	31	1	.	.	.	1	.	1	33
	.	..	302	.	21	.	.	.	323	1	20	.	.	21	.	6	350
Station XVII.																	
May 27, .	12	4	26	11	17	.	.	.	70	2	1	.	8	11	1	2	84
June 23, .	7	1	46	.	29	.	.	.	83	5	.	2	1	8	1	2	94
July 26, .	6	.	113	2	72	.	.	.	193	10	2	1	4	17	1	6	217
Sept. 29, .	2	.	79	2	39	.	.	.	122	2	2	2	4	10	3	6	141
Oct. 24, .	18	3	145	9	144	.	.	.	319	5	.	4	4	13	2	6	340
Nov. 28, .	7	1	49	.	29	.	.	.	86	1	3	.	.	4	.	6	96
Dec. 21, .	1	.	28	.	38	.	.	.	67	.	.	.	.	.	2	8	77
	53	9	486	24	368	.	.	.	940	25	8	9	21	63	10	36	1049

TABLE B.—ANALYSIS OF THE 'GARLAND'S' STATISTICS RELATING TO THE RELATIVE ABUNDANCE OF FISH.

Station.	Flat-Fish.									Round-Fish.					Skate.	Other Fish.	Total.
	Plaice.	Lemon Soles.	Witch Soles.	Common Dabs.	L. Rough Dabs.	Black Sole.	Scaldfish.	Sail-Fluke.	Total.	Cod.	Haddocks.	Whitings.	Gurnards.	Total.			
								Firth of Clyde.									
I.	1·6	16·7	2·0	19·4	21·7	1·1	–	–	62·6	4·9	4·6	2·1	11·7	23·3	7·4	39·7	133
II.	8·3	5·0	3·2	28·8	13·2	2·2	0·5	–	61·2	1·3	3·5	0·5	9·0	14·3	5·0	9·0	89·5
III.	2·3	15·2	57·5	53·0	52·7	0·8	–	–	181·7	2·3	2·3	13·2	15·7	33·5	5·3	72·3	292·8
IV.	–	9·7	4·8	16·3	10·5	0·5	–	–	41·8	0·5	3·0	0·2	6·2	9·8	3·0	17·5	72·2
V.	0·7	15·0	0·7	26·0	13·7	–	0·3	–	56·3	–	1·0	–	6·5	7·5	1·8	37·3	103·0
VI.	0·3	24·7	0·3	25·0	0·7	2·3	0·1	–	53·6	2·9	3·3	3·9	27·1	37·1	16·9	18·9	126·4
VII.	0·4	2·5	35·5	8·9	4·6	0·2	0·5	–	52·6	0·2	1·0	7·9	14·4	23·5	8·2	13·1	97·5
VIII.	–	0·4	95·9	0·3	2·9	0·1	0·9	6·7	107·4	–	–	4·1	40·1	44·3	5·0	46·0	202·7
IX.	0·1	0·1	66·4	1·9	7·5	0·1	–	1·0	77·1	0·1	–	18·1	23·6	41·9	3·1	24·2	146·4
X.	–	1·9	37·0	1·5	24·2	1·1	0·7	0·4	67·0	0·1	5·6	26·1	44·2	76·1	9·2	45·7	198·1
XI.	5·1	1·6	58·4	13·6	72·1	0·1	–	–	151·1	0·1	0·3	8·1	35·1	43·7	3·0	23·0	220·9
XII.	0·9	0·1	112·6	0·1	194·2	0·1	–	–	308·1	0·2	0·1	20·0	23·6	44·0	2·7	45·5	400·4
XIII.	3·3	1·1	5·3	2·6	34·7	0·1	–	–	47·1	5·7	5·6	0·9	11·1	23·3	1·6	16·3	88·3
XIV.	1·4	1·0	12·7	1·4	28·0	–	–	–	44·6	6·9	5·7	2·3	6·7	21·6	0·6	19·4	86·1
XV.	7·2	–	183·8	4·3	136·8	–	–	–	332·2	3·7	3·7	1·7	2·0	11·0	1·5	17·8	362·5
XVI.	–	–	50·3	–	3·5	–	–	–	53·8	0·2	3·3	–	–	3·5	–	1·0	58·3
XVII.	7·6	1·3	69·4	3·4	52·6	–	–	–	134·3	3·6	1·1	1·3	3·0	9·0	1·4	5·1	149·9
Month.																	
January, .	5·4	1·8	73·0	18·0	100·8	1·6	–	–	200·8	0·2	4·6	43·4	13·6	61·8	5·4	47·2	315·2
May, . .	2·5	6·4	47·7	6·9	42·1	0·5	0·1	0·7	107·0	3·3	2·0	4·0	16·1	25·4	5·3	15·6	153·3
June, . .	1·4	3·5	62·3	3·3	53·8	0·2	0·06	0·06	124·8	1·6	2·2	5·1	8·7	17·5	3·1	25·2	170·6
July, . .	1·5	7·2	47·9	6·5	57·0	0·2	0·4	0·3	121·1	2·4	1·4	8·1	11·5	23·5	3·9	17·9	166·5
September, .	2·2	8·9	52·1	20·8	41·1	0·1	0·06	0·7	126·1	2·4	4·3	9·9	29·5	46·1	6·0	38·5	216·6
October, .	3·3	7·0	44·2	12·8	36·9	0·8	0·4	1·0	106·5	1·4	3·6	2·5	15·6	23·2	5·2	39·5	174·3
November, .	2·1	2·8	32·0	12·1	17·3	0·6	0·1	0·3	67·4	2·5	2·1	4·4	16·5	25·4	4·0	24·0	120·8
December, .	1·5	3·4	36·0	13·8	15·2	0·9	0·2	0·6	71·6	0·6	1·4	3·7	24·5	30·2	4·7	16·4	123·0

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde.

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station I.																						
1899.																						
May 30.	Red gurnard,	.	.	.	1	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	3
1-57 p.m. to	Common gurnard,	.	1	2	5	3	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	13
3-52 p.m.	Angler,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*2
	John Dory,	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1
	Dragonet,	.	1	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
	Cod,	.	.	.	1	2	3	3	3	.	.	.	.	.	.	.	.	.	.	.	.	†13
	Brassie,	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
	Whiting,	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	.	.	.	2
	Long rough dab,	1	9	35	11	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	57
	Lemon sole,	.	2	4	1	5	1	1	4	.	1	2	1	.	.	.	.	.	.	.	.	22
	Witch sole,	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	4
	Common dab,	1	4	4	2	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	12
	Black sole,	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Argentine,	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Thornback skate,	.	.	.	.	.	2	2	2	.	2	.	.	.	.	.	.	.	.	1	.	9
	Cuckoo ray,	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	.	2
																						149
June 7.	Common gurnard,	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	2
10-25 a.m. to	Angler,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‡1
11-55 a.m.	Haddock,	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	2
	Brassie,	7	17	32	52	36	4	1	.	.	.	.	.	.	.	.	.	.	.	.	.	149
	Hake,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	2
	Ling,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‖1
	Long rough dab,	.	1	3	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7
	Plaice,	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	.	.	1	.	3
	Lemon sole,	.	.	1	1	.	.	1	.	.	2	.	.	.	.	.	.	.	.	.	.	5
	Conger,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	§1
	Nurse-hound,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	¶2
																						175
July 6.	Common gurnard,	4	2	.	4	4	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	**16
2-10 p.m. to	Angler,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	††2
3-45 p.m.	Dragonet,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Cod,	.	.	.	1	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Haddock,	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1
	Brassie,	.	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
	Whiting,	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
	Hake,	.	.	.	.	.	.	.	.	1	.	2	.	.	2	.	.	.	.	.	.	‡‡6
	Long rough dab,	.	7	17	21	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	48
	Plaice,	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	2
	Lemon sole,	1	10	5	4	1	.	2	.	1	1	.	.	.	.	.	.	.	.	.	.	25
	Witch sole,	.	.	.	.	.	.	1	.	.	.	.	1	1	.	.	.	.	.	.	.	3
	Common dab,	3	4	15	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	31
	Black sole,	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	2
	Thornback skate,	.	.	.	.	1	.	2	3	1	.	.	.	.	.	.	.	.	.	.	.	7
	Cuckoo ray,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
																						153

* 28 and 49 inches. † One 3 inches. ‡ 30 inches. ‖ 49 inches. § 53½ inches. ¶ 28 inches. ** One 3 inches.
†† 26 and 30 inches. ‡‡ One 28 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station I.																						
Sept. 1. 11-15 a.m. to 0-40 p.m.	Common gurnard,	5	9	2	9	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	27
	John Dory,	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
	Dragonet,	.	1	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Cod,	.	.	.	1	1	6	2	3	.	.	1	.	.	.	.	.	.	.	.	.	14
	Haddock,	.	.	.	.	5	3	.	.	.	.	.	.	1	2	1	.	.	.	.	.	12
	Brassie,	4	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7
	Hake,	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1
	Long rough dab,	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Plaice,	.	.	.	.	.	.	.	.	1	.	3	1	.	.	.	.	.	.	.	.	5
	Lemon sole,	.	2	5	8	1	.	3	2	3	2	.	.	.	.	.	.	.	.	.	.	26
	Common dab,	5	26	28	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	66
	Black sole,	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
	Conger,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*2
	Nurse-hound,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
	Thornback skate,	.	.	.	.	.	1	1	2	3	1	.	.	.	.	1	.	.	.	.	.	9
																						178
Oct. 5. 2-20 p.m. to 4-8 p.m.	Red gurnard,	.	.	1	.	3	2	.	1	1	.	.	.	.	.	.	.	.	.	.	.	8
	Common gurnard,	.	.	1	.	4	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	7
	Cod,	.	.	.	.	.	2	.	.	.	1	.	.	.	.	.	.	1	.	.	.	4
	Haddock,	.	.	.	.	8	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	10
	Brassie,	.	17	10	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	29
	Whiting,	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
	Lemon sole,	.	1	8	6	5	1	.	.	6	2	1	.	.	.	.	.	.	.	.	.	30
	Common dab,	.	3	2	2	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	8
	Thornback skate,	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	1	1	.	5
																						102
Nov. 10. 0-30 p.m. to 1-55 p.m.	Streaked gurnard,	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
	Common gurnard,	.	.	3	3	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	9
	Haddock,	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Brassie,	.	8	12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	20
	Whiting,	.	.	.	.	.	.	.	.	4	1	.	.	.	.	.	.	.	.	.	.	5
	Saithe,	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	2
	Hake,	.	.	.	.	.	.	.	.	.	.	1	.	1	.	2	1	.	.	.	.	5
	Long rough dab,	.	.	2	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11
	Lemon sole,	.	.	2	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	4
	Common dab,	1	5	2	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	10
	Black sole,	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Argentine,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Grey skate,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†1
	Thornback skate,	.	.	.	.	.	.	2	2	.	1	1	.	.	.	1	.	.	.	.	.	7
	Cuckoo ray,	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
																						81
Dec. 14. 0-5 p.m. to 1-35 p.m.	Common gurnard,	.	.	.	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8
	Haddock,	.	.	.	.	1	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
	Brassie,	.	7	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11
	Whiting.	.	.	.	.	.	.	.	2	3	.	1	.	.	.	.	.	.	.	.	.	6
	Hake,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	3
	Long rough dab,	.	.	12	11	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	26
	Plaice,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
	Lemon sole,	.	.	.	1	.	.	.	2	.	1	.	.	.	.	.	.	.	.	1	.	5
	Witch sole,	.	.	.	.	.	.	.	.	1	.	4	2	.	.	.	.	.	.	.	.	7
	Common dab,	.	.	4	4	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9
	Black sole,	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1
	Nurse-hound,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‡1
	Thornback skate,	.	.	1	1	1	1	1	.	1	.	1	.	.	.	.	.	.	.	.	.	7
	Cuckoo ray,	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	3
																						93

* 53 and 58 inches. † 30 inches. ‡ 35 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches. 4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	Total.
Station II.																						
June 2. 0-20 p.m. to 1-45 p.m.	Common gurnard,	.	1	.	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
	Haddock,	.	.	.	4	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
	Brassie,	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Hake,	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	2
	Long rough dab,	3	6	9	19	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	40
	Plaice,	.	.	.	.	.	.	.	1	1	.	1	.	.	.	.	.	.	.	.	.	3
	Common dab,	7	7	9	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	27
	Thornback skate,	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	2
																						87
July 6. 11-10 a.m. to 0-47 p.m.	Common gurnard,	.	.	1	4	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	6
	Angler,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*1
	Cod,	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Brassie,	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Whiting,	.	.	.	.	1	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	3
	Hake,	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.	.	.	2
	Long rough dab,	.	.	9	8	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	18
	Plaice,	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	2
	Lemon sole,	.	.	2	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	3
	Witch sole,	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	2
	Common dab,	4	8	4	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	17
	Thornback skate,	1	.	.	1	.	1	1	2	.	.	.	.	.	.	.	.	.	.	.	.	6
																						65
Sept. 1. 2-35 p.m. to 4-0 p.m.	Common gurnard,	.	2	.	2	3	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	9
	Haddock,	.	.	1	.	1	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	4
	Hake,	.	.	.	.	.	.	.	.	.	.	1	2	5	3	2	2	2	.	.	.	17
	Long rough dab,	1	2	3	6	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14
	Plaice,	.	.	.	.	.	.	.	1	.	.	1	1	.	1	.	1	.	.	.	.	5
	Lemon sole,	.	.	2	2	2	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	9
	Witch sole,	.	.	.	1	1	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	4
	Common dab,	1	17	11	5	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	36
	Thornback skate,	.	.	.	.	3	1	2	1	.	.	.	.	.	.	.	.	.	.	1	.	8
																						106
Oct. 5. 8-6 a.m. to 9-36 a.m.	Common gurnard,	.	2	3	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9
	Angler,	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	2
	John Dory,	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
	Dragonet,	.	2	1	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
	Cod,	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1
	Haddock,	.	.	.	.	1	3	2	.	.	1	.	1	1	.	.	.	.	.	.	.	9
	Hake,	.	.	.	.	.	.	.	.	.	.	.	.	1	1	2	3	.	.	.	.	7
	Scald-fish,	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Plaice,	.	.	.	1	.	.	.	1	.	1	4	1	.	.	.	.	.	.	.	.	8
	Lemon sole,	.	2	2	.	3	1	3	.	.	.	.	.	.	.	.	.	.	.	.	.	11
	Witch sole,	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	2
	Common dab,	.	6	18	12	5	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	43
	Black sole,	.	.	.	.	.	2	7	2	1	.	.	.	.	.	.	.	.	.	.	.	12
	Thornback skate,	.	.	.	1	1	2	.	3	.	.	.	.	.	.	.	.	.	.	.	.	7
																						121
Nov. 9. 1-50 p.m. to 3-27 p.m.	Common gurnard,	.	8	5	2	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	17
	Dragonet,	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Cod,	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Haddock,	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Hake,	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1
	Plaice,	.	.	.	.	.	.	.	.	5	4	2	1	.	1	1	.	.	.	1	.	15
	Lemon sole,	.	.	1	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	3
	Common dab,	.	1	3	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7
	Grey skate,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
	Zeugopterus punctatus,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
																						49

* 35 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches. 4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	Total.
Station II.																						
Dec. 14. 9-10 a.m. to 10-34 a.m.	Common gurnard,	.	.	1	4	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7
	Dragonet,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Cod,	.	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Haddock,	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Hake,	.	.	.	.	.	.	.	.	.	.	.	1	1	1	2	2	.	.	.	.	7
	Long rough dab,	.	.	.	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7
	Plaice,	.	.	.	.	.	.	.	1	5	3	.	3	1	.	1	1	.	1	1	.	17
	Lemon sole,	.	.	.	.	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	4
	Witch sole,	.	.	.	.	.	.	.	.	2	2	4	2	1	.	.	.	.	.	.	.	11
	Common dab,	1	4	16	12	4	4	.	1	.	.	.	.	.	.	.	.	.	.	.	.	*43
	Black sole,	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Grey skate,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	†3
	Thornback skate,	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
																						109
Station III.																						
June 1. 2-15 p.m. to 3-40 p.m.	Common gurnard,	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Angler,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‡2
	Haddock,	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1
	Brassie,	.	.	3	1	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8
	Poor-cod,	.	44	10	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	54
	Whiting,	.	2	.	2	9	25	11	.	1	1	.	.	.	.	.	.	.	1	.	.	52
	Saithe,	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	2
	Hake,	.	.	.	.	.	.	.	.	.	2	1	3	1	2	.	.	.	1	9	8	‖28
	Long rough dab,	5	7	44	44	5	8	1	.	.	.	.	.	.	.	.	.	.	.	.	.	§115
	Lemon sole,	.	.	.	.	10	1	4	3	.	.	.	.	.	.	.	.	.	.	.	.	18
	Witch sole,	.	.	1	2	1	7	4	12	16	31	18	16	7	3	.	.	.	.	.	.	118
	Common dab,	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Argentine,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Grey skate,	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Thornback skate,	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	1	.	.	.	3
																						406
July 4. 1-47 p.m. to 2 57 p.m	Cod,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	¶1
	Brassie,	.	7	8	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	17
	Poor-cod,	.	23	10	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	34
	Whiting,	.	.	.	.	1	6	4	2	3	2	1	1	.	.	.	.	.	.	.	.	20
	Hake,	.	.	.	.	.	.	.	.	.	2	2	4	3	3	.	.	1	.	2	.	**18
	Long rough dab,	.	8	28	35	16	5	2	1	.	.	.	.	.	.	.	.	.	.	.	.	95
	Lemon sole,	.	.	.	.	.	1	.	.	1	.	.	.	.	1	.	.	.	.	.	.	3
	Witch sole,	.	.	.	.	.	2	5	7	10	9	23	25	5	6	.	.	.	.	.	.	92
	Grey skate,	.	.	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	2
	Fuller's ray,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
	Thornback skate,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	††1
																						284
Sept. 5. 3-55 p.m. to 5-25 p.m.	Common gurnard,	1	1	3	4	3	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	15
	Dragonet,	.	1	2	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‡‡8
	Diminutive sucker,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‖‖2
	Cod,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
	Haddock,	.	.	.	.	1	.	.	.	.	.	1	.	2	1	1	.	.	.	.	.	6
	Brassie,	.	9	26	9	7	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	53
	Poor-cod,	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Whiting,	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	2
	Hake,	.	.	.	.	.	.	.	.	.	2	3	5	11	8	9	5	.	.	8	.	§§60
	Long rough dab,	3	5	16	17	8	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	50
	Plaice,	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
	Lemon sole,	1	7	18	4	.	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.	35
	Witch sole,	.	.	2	10	10	2	8	5	16	1	1	.	.	.	.	.	.	.	.	.	55
	Common dab,	22	29	50	16	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	123
	Conger,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	¶¶1
	Piked dog-fish,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	***3
	Thornback skate,	4	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
																						422

* One $2\frac{3}{4}$ inches. † One 38 inches. ‡ One 40 inches. ‖ One 35 inches. § One 3 inches. ¶ 28 inches.
** One 35 inches. †† 30 inches. ‡‡ One 3 inches. ‖‖ Two 1 inch. §§ Seven 26, one 28, one 35 inches.
¶¶ 40 inches. *** Two 30 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station III.																						
Oct. 4. 2-5 p.m. to 3-30 p.m.	Common gurnard,	.	.	.	4	4	7	2	5	2	.	3	1	.	.	.	.	.	.	.	.	28
	Cod,	.	.	.	.	1	.	2	1	2	.	.	.	.	.	.	.	.	.	.	.	6
	Haddock,	.	.	.	.	.	.	.	.	.	.	3	.	1	.	.	1	.	.	.	.	5
	Brassie,	.	2	9	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13
	Whiting,	.	.	.	.	.	.	2	1	.	1	.	.	.	.	.	.	.	.	.	.	4
	Hake,	.	.	.	.	.	.	.	.	.	.	2	4	18	40	31	.	1	1	.	.	97
	Long rough dab,	.	3	10	17	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*33
	Brill,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
	Plaice,	.	.	1	.	.	.	2	2	5	.	1	.	.	.	.	.	.	.	.	.	11
	Lemon sole,	.	4	4	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10
	Witch sole,	.	.	1	7	6	3	6	6	2	3	2	.	.	.	.	.	.	.	.	.	36
	Common dab,	3	14	16	8	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	45
	Black sole,	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	2
	Argentine,	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Piked dog-fish,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†1
	Thornback skate,	.	.	.	1	.	1	.	.	1	.	.	1	.	.	.	.	.	.	.	.	‡5
																						298
Nov. 9. 11-3 a.m. to 0-50 p.m.	Red gurnard,	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
	Common gurnard,	..	2	.	.	1	.	3	1	.	.	.	.	.	.	.	.	.	.	.	.	7
	Angler,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	2
	Cod,	.	.	.	.	1	.	1	.	1	.	.	1	.	.	.	.	.	.	.	.	4
	Haddock,	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	2
	Whiting,	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Hake,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	.	.	3
	Long rough dab,	.	1	2	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7
	Plaice,	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	.	2
	Lemon sole,	.	.	2	1	2	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	6
	Witch sole,	.	.	.	.	3	2	.	.	.	.	1	.	.	.	.	.	.	.	.	.	6
	Common dab,	.	27	19	19	9	3	2	1	.	1	.	.	.	.	.	.	.	.	.	.	81
	Black sole,	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
	Thornback skate,	.	.	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	2
	Cuckoo ray,	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
																						126
Dec. 5. 0-41 p.m. to 2-17 p.m.	Common gurnard,	.	.	1	2	3	11	1	4	7	11	2	1	.	.	.	.	.	.	.	.	43
	John Dory,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‖1
	Dragonet,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Cod,	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Brassie,	.	.	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
	Hake,	.	.	.	.	.	.	.	.	.	.	.	.	3	4	5	2	2	.	.	.	16
	Long rough dab,	1	1	2	9	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	16
	Lemon sole,	.	.	2	6	3	3	2	1	2	.	.	.	.	.	.	.	.	.	.	.	19
	Witch sole,	.	.	.	1	4	4	6	5	4	6	2	4	2	.	.	.	.	.	.	.	38
	Common dab,	3	17	26	10	2	4	2	3	.	.	.	.	.	.	.	.	.	.	.	.	67
	Black sole,	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	2
	White skate,	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1
	Thornback skate,	.	3	4	1	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	10
																						221
Station IV.																						
June 2. 2-54 p.m. to 3-30 p.m.	Common gurnard,	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Haddock,	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Whiting,	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Long rough dab,	1	1	4	4	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11
	Lemon sole,	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Witch sole,	.	.	.	.	2	2	2	4	1	.	1	.	.	.	.	.	.	.	.	.	12
	Common dab,	.	.	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
	Thornback skate,	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	§2
																						35

* One 3 inches. † 26 inches. ‡ One 28 inches. ‖ 3 inches. § One 3 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches. 4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	Total.
Station IV.																						
July 6. 8-50 a.m. to 9-40 a.m.	Com. gurnard,		2	3	1	1	1															8
	Haddock,					1																1
	Brassie,	1	3	2																		6
	Long rough dab,	2	5	8	2	1																18
	Lemon sole,		1	6	6	2	1		1	1												18
	Witch sole,				3	2	2	2		2			2									13
	Common dab,			2	1																	3
	Thornback skate,				1						1											2
	Cuckoo ray,				1							1										2
																						71
Sept. 2. 7-0 a.m. to 7-50 a.m.	Com. gurnard,		4	6	8	1			2	1												22
	Dragonet,				1																	1
	Dimin. sucker,																					*1
	Cod,					1	1															2
	Haddock,				1	1	5	1					1									9
	Brassie,			1																		1
	Hake,											2			6							8
	Long rough dab,	15	4	12	3																	34
	Lemon sole,			5	2	2																9
	Witch sole,					2	1	1														4
	Common dab,			1	1																	2
	Thornback skate,			1		1				1												†4
																						97
Oct. 4. 0-40 p.m. to 1-20 p.m.	Com. gurnard,		1																			1
	Cod,					1																1
	Haddock,					1	3	2	1													7
	Hake,															22	32	5	7			‡87
	Lemon sole,		3	4	3	2		1														13
	Common dab,		14	16	8	2																40
	Thornback skate,			1			3				2											6
	Cuckoo ray,											1										1
																						156
Nov. 9. 9-24 a.m. to 10-10 a.m.	Com. gurnard,	1																				1
	Lemon sole,			2	3	1	1															7
	Common dab,		9	10	4	4	4	1														32
	Black sole,														1							1
	Thornback skate,				1																	1
																						42
Dec. 5. 10-57 a.m. to 11-48 a.m.	Com. gurnard,			1	1						1											3
	Angler,													1								1
	Lemon sole,			1	1	2	3	2														9
	Common dab,		3	4	9		1															17
	Black sole,								1				1									2
																						32
Station V.																						
June 1. 10-48 a.m. to 11-50 a.m.	Com. gurnard,	1	3		1																	5
	Dragonet,					1																1
	Brassie,			2		1																3
	Long rough dab,	1	5	16	4																	26
	Plaice,												1									1
	Lemon sole,		1	3	2	1			1													8
	Witch sole,								2													2
	Common dab,	1	3	3	1																	8
	Thornback skate,								1													1
	Cuckoo ray,																					§1
																						56

* 1 inch. †One 30 inches. ‡ Six 22, three 23, nine 24, three 26 inches. § 3 inches.

TABLE C.—RECORD OF OBSERVATIONS MADE ON BOARD THE 'GARLAND' DURING 1899.

A. FISH CAUGHT—FIRTH OF CLYDE—*continued.*

Station, Date, and Time Trawl Down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station V.																						
July 4. 10-0 a.m. to 11-5 a.m.	Com. gurnard,	.	4	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
	Dragonet,	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Brassie,	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Poor-cod,	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Hake,	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1
	Long rough dab,	2	12	24	8	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	*48
	Scald-fish,	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Plaice,	.	.	.	.	.	.	1	.	1	.	.	1	.	.	.	.	.	.	.	.	3
	Lemon sole,	1	7	9	4	2	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	27
	Common dab,	1	6	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†15
	Thornback skate,	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
																						109
Sept. 8. 3-52 p.m. to 4-45 p.m.	Com. gurnard,	.	.	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	2
	Angler,	.	.	.	.	.	.	.	1	1	2	.	.	.	.	.	.	.	.	.	.	4
	Haddock,	.	.	.	1	2	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	4
	Brassie,	8	127	45	8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	188
	Lemon sole,	.	3	7	3	1	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	17
	Common dab,	1	13	12	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	29
																						244
Oct. 11. 12 noon to 1-5 p.m.	Com. gurnard,	.	1	3	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7
	Haddock,	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Hake,	.	.	.	.	.	.	.	.	.	.	.	.	6	1	.	3	.	.	1	.	11
	Long rough dab,	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Lemon sole,	.	1	7	8	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	17
	Common dab,	3	21	12	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	41
	Thornback skate,	.	.	.	.	1	.	2	.	.	.	.	.	.	.	1	.	.	.	.	.	4
	Cuckoo ray,	.	.	.	.	1	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	3
																						85
Nov. 17. 9-40 a.m. to 10-30 a.m.	Com. gurnard,	.	.	3	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8
	Hake,	.	.	.	.	.	.	.	.	.	2	.	.	1	.	.	.	.	.	.	.	3
	Long rough dab,	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Lemon sole,	.	.	2	7	2	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	15
	Common dab,	.	15	17	2	4	7	1	.	.	.	.	.	.	.	.	.	.	.	.	.	46
																						73
Dec. 18. 2-45 p.m. to 3-38 p.m.	Com. gurnard,	.	.	9	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12
	Angler,	.	.	.	.	.	.	.	.	2	.	.	1	1	.	.	.	.	.	.	.	4
	Dragonet,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Haddock,	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Hake,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1
	Long rough dab,	.	.	4	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
	Lemon sole,	.	.	.	3	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	6
	Witch sole,	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	2
	Common dab,	.	.	12	.	2	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	17
	Cuckoo ray,	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1
Station VI.																						51
May 30. 11-32 a.m to 1-15 p.m.	Red gurnard,	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Com. gurnard,	.	.	2	6	9	3	1	.	1	.	1	.	.	.	.	.	.	.	.	.	23
	Dragonet,	.	.	3	2	4	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11
	Haddock,	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Whiting,	.	.	.	.	1	.	1	.	3	.	.	.	.	.	.	.	.	.	.	.	5
	Hake,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	‡3
	Long rough dab,	.	.	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
	Plaice,	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
	Lemon sole,	.	6	12	6	1	2	1	1	1	.	1	.	.	.	.	.	.	.	.	.	31
	Common dab,	1	12	22	2	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	40
	Nurse-hound,	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	§2
	Grey skate,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1
	Thornback skate,	.	.	.	1	.	.	.	.	6	3	4	2	.	.	.	.	.	.	1	.	17
	Cuckoo ray,	.	.	.	.	.	.	1	.	1	.	.	.	1	.	.	.	.	.	.	.	3
																						146

* One 3 inches. † One 3 inches. ‡ One 28 inches. § One 28 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl Down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station VI.																						
June 7. 0-51 p.m. to 2-30 p.m.	Red gurnard,														1							1
	Com. gurnard,					1		1	1													3
	John Dory,							2									1					3
	Cod,					1		2	1													4
	Hake,												1									1
	Long rough dab,				1																	1
	Turbot,																					*1
	Lemon sole,			5	3	1				1	3		1									14
	Witch sole,					2																2
	Common dab,			1																		1
	Nurse-hound,																			1		†2
	Cuckoo ray,				1	1				1				3								6
																						39
July 7. 8-30 a.m. to 10-15 a.m.	Red gurnard,							1	1									1		1		4
	Com. gurnard,		1		2	5		1	1			1										11
	Angler,						1										1			1	1	4
	Cod,					2		3	1													6
	Haddock,								1													1
	Brassie,		3	2	4	13	5															27
	Hake,													1						2		3
	Plaice,										1											1
	Lemon sole,		7	24	6	2	2	1		2	1											45
	Common dab,		4	16	8																	28
	Conger,																					‡1
	Nurse-hound,										1											1
	Thornback skate,					2	1	2	3	2	1	1	1		1				1			15
	Cuckoo ray,				1									2								3
																						150
Sept. 6. 7-55 a.m. to 9-55 a.m.	Red gurnard,					1		1	1													3
	Com. gurnard,		2	1	3	5	2	3	1	3	1											21
	Angler,																			1		1
	Dragonet,			2	1																	3
	Cod,						1	2	1		1											5
	Haddock,						1	1	1				1									4
	Brassie,	1	4	15	2																	22
	Poor-cod,			1																		1
	Lemon sole,	1	12	11	3	6			1		1											35
	Common dab,		4	12	6	1	2															25
	Black sole,										1											1
	Nurse-hound,																			1		1
	Thornback skate,								1			1	4	1							1	‖9
	Cuckoo ray,					1	1	3						2								7
																						138
Oct. 5. 12 noon to 1-35 p.m.	Red gurnard,					3	2	1		1	1											8
	Com. gurnard.				1		1	5	1	2	1											11
	Angler,																					§1
	Dragonet.					1																1
	Cod,										1											1
	Scald-fish.	1																				1
	Lemon sole,		6	8	13	2	3	1														33
	Common dab,				1	3																4
	Grey skate,																					¶1
	Thornback skate,							1											1			**3
	Cuckoo ray,			1		2		2					3					1				††10
																						74

* 26 inches. † One 30 inches. ‡ Over 40 inches. ‖ One 28 inches. § 30 inches. ¶ 35 inches. ** One 28 inches. †† One 3 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl Down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station VI.																						
Nov. 14. 8-56 a.m. to 10-30 a.m.	Streaked gurnard,	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
	Red gurnard,	.	.	.	.	1	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	2
	Com. gurnard,	.	1	7	5	5	1	1	1	3	5	.	1	.	.	.	.	.	.	.	.	30
	Cod,	.	.	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	3
	Haddock,	.	.	.	.	.	1	.	1	.	3	3	1	.	.	.	.	.	.	.	.	9
	Brassie,	.	2	9	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13
	Whiting,	.	.	.	.	.	1	5	7	8	.	.	.	.	.	.	.	.	.	.	.	21
	Hake,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1
	Lemon sole,	.	2	1	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7
	Common dab,	.	3	7	5	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	16
	Black sole,	.	.	.	.	1	1	.	1	1	.	1	.	1	.	.	.	.	.	.	.	6
	Nurse-hound.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1	.	.	1	.	3
	Thornback skate,	.	.	.	.	.	1	.	1	1	2	.	3	.	2	.	.	.	.	.	.	*11
	Cuckoo ray,	1	1	2	.	1	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	9
																						132
Dec. 6. 1-19 p.m. to 3-0 p.m.	Red gurnard,	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
	Com. gurnard,	.	3	14	34	26	7	1	2	.	4	.	.	.	.	.	.	.	.	.	.	91
	Pogge,	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Cod,	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
	Haddock,	.	.	.	.	.	2	5	.	.	.	.	.	.	.	.	.	.	.	.	.	7
	Brassie,	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†3
	Whiting,	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1
	Lemon sole,	.	.	.	4	.	1	.	2	1	.	.	.	.	.	.	.	.	.	.	.	8
	Common dab,	.	1	22	25	9	3	.	.	1	.	.	.	.	.	.	.	.	.	.	.	61
	Black sole,	.	.	.	.	.	.	2	1	.	1	.	3	2	.	.	.	.	.	.	.	9
	Thornback skate,	.	1	.	.	.	.	1	2	2	1	1	1	1	.	.	.	.	.	.	.	‡12
	Cuckoo ray,	.	.	.	.	.	1	.	1	.	1	1	4	2	.	.	.	.	.	.	.	‖11
																						206
Station VII.																						
Jan. 17. 1-40 p.m, to 3-27 p.m.	Com. gurnard,	.	1	1	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
	Haddock,	.	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	4
	Brassie,	.	.	2	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Whiting,	.	1	1	.	11	.	.	.	12	.	2	.	.	.	.	.	.	.	.	.	27
	Hake,	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
	Ling,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	§1
	Long rough dab,	1	1	1	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7
	Plaice,	.	.	.	.	.	.	.	.	.	1	1	.	1	.	.	.	.	.	.	.	3
	Witch sole,	.	.	.	.	.	3	.	18	13	32	11	10	.	.	.	.	.	.	.	.	87
	Common dab,	.	6	.	3	2	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	13
	Black sole,	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Argentine,	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Thornback skate,	.	.	.	.	2	1	1	1	.	1	.	.	.	.	.	.	.	.	.	.	6
	Fuller's ray,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
																						161
May 29. 9-20 a.m. to 11-5 a.m.	Red gurnard,	1	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
	Com. gurnard,	.	.	.	3	5	3	1	1	2	2	.	.	.	.	.	.	.	.	.	.	17
	John Dory,	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
	Dragonet,	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Cod,	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Haddock,	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1
	Brassie,	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Whiting,	.	.	.	4	9	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	16
	Hake,	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	1	.	3
	Long rough dab,	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	¶3
	Lemon sole,	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Witch sole,	.	.	.	.	2	3	6	10	13	17	6	2	2	.	.	.	.	.	.	.	61
	Common dab,	.	1	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Thornback skate,	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**5
																						120

* One 35 inches. † One 3 inches. ‡ One 28, one 30 inches. ‖ One 3 inches. § 49 inches.
¶ Two 3 inches. ** Three 3 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station VII. June 7. 6-15 p.m. to 7-52 p.m.	Com. gurnard,			1	6	10	1		2		3											23
	Haddock,					1																1
	Brassie,			5	10	3	3															*22
	Whiting,				1	1	1	3	1	1												8
	Hake,										1		1								1	3
	Long rough dab,		1	5			1															7
	Lemon sole,			1																		1
	Witch sole,				1	1	3	7	14	9	6	1	1	1								44
	Common dab,			2	1																	3
	Conger,																					†1
	Thornback skate,									1												‡4
																						117
Night Trawl. June 15. 9-40 p.m. to 11-40 p.m.	Com. gurnard,			3	11	6	5	2	1	3	1	1										33
	Dragonet,					1																1
	Cod,								1													‖2
	Haddock,			1	1	1					1											4
	Brassie,		3	1	4	6																14
	Poor-cod,	4	2																			§7
	Whiting,						6	5	7	4	2	1										25
	Hake,										1	1		2								4
	Ling,																					¶1
	Long rough dab,	1		7	2																	10
	Lemon sole,			1	2	1					1											5
	Witch sole,					3	9	15	45	28	34	8	8									150
	Common dab,		4	6	1																	11
	Black sole,					1		1														2
	Grey skate,			1																		1
																						270
July 7. 4-17 p.m. to 6-5 p.m.	Com. gurnard,			2	6	2																10
	Haddock,					1																1
	Whiting,				2	6	3		1													12
	Hake,											3	1	1								5
	Long rough dab,	3	1	7	3	1																**16
	Scald-fish,																					††1
	Witch sole,					2	4	13	18	14	7	3										61
	Common dab,		2	2		1																5
	Nurse-hound,																				1	1
	Thornback skate,		1																			1
																						113
Night Trawl. July 19. 9-35 p.m. to 11-20 p.m.	Angler,																		1			1
	Dragonet,			2																		2
	Cod,																					‡‡3
	Haddock,					1																1
	Brassie,	3	8	2	1	3																17
	Poor-cod,		3																			3
	Whiting,				3	7	3	1		1		1										16
	Hake,										2		1									3
	Lemon sole,			1																		1
	Witch sole,						4	10	14	10	6	2										46
	Common dab,		4	2	3	4																13
	Conger,																					‖‖1
	Thornback skate,	3																				§§5
																						112
Sept. 12. 10-25 a.m. to 0-10 p.m.	Red gurnard,								1	1	2											4
	Com. gurnard,			8	7	16	3	3	2	2					1							42
	Angler,												1									1
	Brassie,		14	8		1	1	3	2	1		1										31
	Hake,											1				1						2
	Scald-fish	1																				1
	Lemon sole,	1	5	7	2																	15
	Witch sole,						1	1	2	1			1									6
	Common dab,	6	9	13	4		3															35
	Thornback skate,	6		1		1				3	1	1	1							1		15
																						152

* One 3 inches. † Over 40 inches. ‡ Three 3 inches. ‖ One 30 inches. § One 3 inches. ¶ 40 inches. ** One 3 inches. †† 3 inches. ‡‡ 35 inches. ‖‖ 40 inches. §§ Two 3 inches.

TABLE C.—RECORD OF OBSERVATIONS MADE ON BOARD THE 'GARLAND' DURING 1899.

FISH CAUGHT—FIRTH OF CLYDE—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station VII.																						
Oct. 6.	Com. gurnard,	.	.	2	1	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	8
3-58 p.m.	Angler,	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
to	Dragonet,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
5-42 p.m.	Haddock,	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1
	Brassie,	.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
	Hake,	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	2
	Scald-fish	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*2
	Lemon sole,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Witch sole,	.	.	.	.	2	1	1	1	2	.	.	.	.	.	.	.	.	.	.	.	7
	Common dab,	3	4	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11
	Thornback skate,	2	5	2	.	.	1	.	.	.	2	.	1	.	1	.	.	.	.	1	.	15
	Cuckoo ray,	.	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	3
																						58
Nov. 15.	Com. gurnard,	.	.	.	.	7	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	8
2-15 p.m.	Angler	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†1
to	Cod,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‡1
4-5 p.m.	Brassie,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Lemon sole,	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Witch sole,	.	.	.	.	.	.	10	2	4	2	.	.	.	.	.	.	.	.	.	.	18
	Common dab,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Black sole,	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Conger,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	§1
	Piked dog-fish,	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	‖4
	Thornback skate,	1	6	.	.	.	.	.	.	1	.	2	.	.	.	.	.	.	.	.	.	10
																						47
Dec. 12.	Streaked gurnard,	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
8-8 a.m.	Com. gurnard,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
to	Long rough dab,	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
9-51 a.m.	Thornback skate,	.	.	.	.	1	.	.	.	.	.	1	1	.	.	.	.	.	.	1	.	¶5
	Cuckoo ray	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
																						12
Station VIII.																						
May 29.	Red gurnard,	.	.	.	1	.	.	1	.	2	.	.	1	.	.	.	.	.	.	.	.	5
0-56 p.m.	Com. gurnard,	.	.	1	20	20	10	10	.	1	1	.	.	.	.	.	.	.	.	.	.	63
to	Angler,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**2
-54 p.m.	Dragonet,	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Whiting,	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Hake,	.	.	.	.	.	.	.	.	.	3	6	.	2	.	.	.	.	1	1	2	††17
	Long rough dab,	1	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Brill,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1
	Sail-fluke	.	.	.	.	.	.	.	1	2	.	1	.	.	.	.	1	1	1	.	.	7
	Lemon sole,	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Witch sole,	.	.	.	2	17	41	46	56	42	23	8	2	2	.	.	.	.	.	.	.	239
	Black sole,	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
	Grey skate,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1
	Thornback skate,	.	.	.	.	.	.	2	.	.	1	.	2	.	.	.	.	.	.	.	1	6
																						350
June 8.	Red gurnard,	.	.	.	.	.	.	.	.	3	.	1	3	4	.	.	.	.	.	.	.	11
11-20 a.m.	Com. gurnard,	.	1	.	4	6	9	1	1	.	1	.	.	.	.	.	.	.	.	.	.	23
to	Whiting,	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	.	.	.	2
1-10 p.m.	Hake,	.	.	.	.	.	.	.	1	4	5	2	2	.	.	2	.	1	.	2	2	‡‡28
	Long rough dab,	.	.	3	4	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8
	Sail-fluke,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1
	Scald-fish,	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Witch sole,	.	.	1	9	10	33	33	23	16	9	9	2	.	.	.	.	.	.	.	.	145
	Common dab,	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Piked dog-fish,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	.	.	3
	Thornback skate,	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	1	.	3
																						227

* One 3 inches. † Over 40 inches. ‡ Over 40 inches. § Over 40 inches. ‖ One 28 one 30 inches.
¶ One 28 inches. ** 35 inches. †† Two 30 inches. ‡‡ Two 3, two 28, one 30, two 35 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station VIII. Night Trawl. June 13. 9-55 p.m. to 11-55 p.m.	Red gurnard,										1											1
	Com. gurnard,				1			1														2
	Angler,														1				1			2
	Poor-cod,		11	2																		13
	Whiting,					1																1
	Hake,										1			1	1					1		4
	Long rough dab,				3																	3
	Witch sole,					9	20	13	8	8	6	3										67
	Argentine,		1																			1
																						94
July 7. 12 noon to 2-5 p.m.	Com. gurnard,			1	2	12	4	2					1									22
	Angler,																	1				*2
	Whiting,					3	3	1														7
	Hake,										2	2							1			†6
	Three-bearded rockling,						1															1
	Long rough dab,		1	2		1	1															5
	Sail-fluke,																	2				2
	Scald-fish,		1																			1
	Witch sole,				3	17	22	26	22	19	2	3	2	1								117
	Grey skate,										1											1
	Thornback skate,											2										2
																						166
Night Trawl. 21 July. 8-50 p.m. to 10-50 p.m.	Com. gurnard,				1		2	1				1										5
	Angler,																					‡1
	Cod,																					§1
	Brassie,			2		2																4
	Poor-cod,	6	29	4																		39
	Whiting,		2	6	2	4	1	2		1												18
	Hake,									1		1								3	2	‖9
	Long rough dab,	3	4	6	5	1																19
	Sail-flukes,		2										1		1							4
	Witch sole,			2		6	22	10	19	9	9	1	5									83
	Conger,																					¶1
	Thornback skate,												1									1
																						185
Sept. 13. 0-30 p.m. to 2-15 p.m.	Com. gurnard,			1	8	6	3		1	1												20
	Whiting,							1														1
	Long rough dab,				2	1	1															4
	Sail-fluke,		2	3	1							1	2	1								10
	Witch sole,			1	2	7	36	30	16	7	3	1	2									105
	Piked dog-fish,																					**1
	Grey skate,													1								1
	Fuller's ray,									1												1
	Thornback skate,					1		1			1				1		1	1		1		7
	Cuckoo ray,													1								1
																						151
Oct. 10. 8-0 a.m. to 9-55 a.m.	Com. gurnard,			2	3	31	29	21	12	7	10	1	1									117
	Brassie,	1	86	104	7	3	1															202
	Whiting,								1													1
	Sail-fluke,			10	3		1	1			1											16
	Lemon sole,			1																		1
	Sprat,	1																				1
	Nurse-hound,																					††1
	Thornback skate,		1		1		1	1				1	1									6
	Cuckoo ray,												1									1
																						346

* One 35 inches. † One 30 inches. ‡ 30 inches. § 35 inches. ‖ One 30, one 35 inches.
¶ 35 inches. ** 28 inches. †† 30 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches. 4+	5+	6+	7+	8+	9+	10+	11+	12+	13+	14+	15+	16+	17+	18+	19+	20+	21+	23+	25+	Total.
Station VIII.																						
Nov. 23. 7.53 a.m. to 9-48 a.m.	Red gurnard,						1															1
	Com. gurnard,			1		1	2	1	3	1	5	1										15
	Angler,				1										1							*3
	Whiting,						4	4	2		1											11
	Hake,																	1				1
	Brill,																			1		1
	Sail-fluke,			1									1						1			3
	Scald-fish,	1																				1
	Witch sole,			1	5	15	14	7	4	1												47
	Argentines,			3																		3
	Piked dog-fish,											2	1			1	1					†9
	White skate,																1		1			2
	Thornback skate,														2							‡3
																						100
Dec. 12. 0-20 p.m. to 2-20 p.m.	Com. gurnard,			1	2	2	4	5	2	4	1											21
	Angler,											1										1
	Brassie,			1																		1
	Poor-cod,			2																		2
	Whiting,						3	2														5
	Hake,											1				1			3			5
	Sail-fluke,			1	4			1			1				1							8
	Scald-fish,	3																				3
	Witch sole,					2	4	2	3	4		2	1									18
	Argentine,		1	1																		2
	Nurse-hound,																		1			1
	Piked dog-fish,							1				1			2			1		2	2	§12
Station IX.																						79
Jan. 17. 9-37 a.m. to 11-30 a.m.	Red gurnard,								2		3		1	1								7
	Com. gurnard,					1	4	2	4	16	4											31
	Angler,									1										1		2
	Brassie,			1	1																	2
	Whiting,				31		14	2	3													50
	Poor-cod,	3	13																			16
	Hake,									6	5	3				1						‖16
	Long rough dab,			1	2																	3
	Plaice,									1												1
	Witch sole,					1	6		10	2	13	5										37
	Common dab,	5	4	4																		13
	Black sole,									1												1
	Zeugopterus, sp.	1																				1
	Argentine,	1																				¶4
	Conger,																					**1
	Thornback skate,								1	1	1	1		1	1							6
																						191
May 29. 4-11 p.m. to 5-55 p.m.	Com. gurnard,			1	5	9	1	3	1	3												23
	Angler,																1					††2
	Cod,				1																	1
	Hake,									1	4	5	3	3	2	1	2	4	3	3		‡‡33
	Ling,																					§§1
	Long rough dab,	1	3	4	1																	9
	Sail-fluke,															1						1
	Witch sole,				3	6	15	18	23	13	5	5										88
	Thornback skate,											1					1					2
																						160
June 8. 2-20 p.m. to 4-15 p.m.	Com. gurnard,		1	1	7	4	1	6														20
	Whiting,						2															2
	Hake,									1	2	3		2	1	1					1	11
	Long rough dab,	1		4	7	2																14
	Lemon sole,		1																			1
	Witch sole,			3	6	16	27	27	24	21	12	6	1									143
	Piked dog-fish,																	1	1	4		6
	Thornback skate,																		1			‖‖3
																						200

* One 35 inches. † Three 26, one 28 inches. ‡ One 3 inches. § Two 28, one 30 inches. ‖ One over 40 inches.
¶ Three 3 inches. ** 48 inches. †† One 28 inches. ‡‡ One 26, one 28 inches. §§ Over 40 inches. ‖‖ Two 3 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station IX.																						
July 8. 10-30 a.m. to 11-45 a.m.	Com. gurnard,				5	11	5	4	2	1	3	1	1									33
	Angler,																					*2
	Whiting,					3	1															4
	Hake,										1				2				1	3	4	†18
	Long rough dab,	1	1	16	7	6	2															33
	Sail-fluke,														2							2
	Witch sole,			1	4	15	24	31	22	24	8	6	3	1	1							140
	Common dab,				1	1																2
	Nurse-hound,																				1	1
	Piked dog-fish,													1	1						1	3
	Thornback skate,				1										1				1		2	‡6
																						244
Sept. 8. 9-39 a.m. to 11-35 a.m.	Com. gurnard,					2	2	3	5													13
	Angler,																			1		§2
	Whiting,					31	29	6	1													‖68
	Hake,												1									1
	Long rough dab,			1																		1
	Sail-fluke,			1								1										2
	Witch sole,					2	4	1	4	2	1											14
	Nurse-hound,																					¶1
	Piked dog-fish,																1					1
	Thornback skate,											1				1						2
																						105
Oct. 10. 11-39 a.m. to 1-43 p.m.	Com. gurnard,						1			2		1										4
	Whiting,					2	4	5	1	1												13
	Hake,					1								1		1						3
	Sail-fluke,			1																		1
	Witch sole,					8	8	5	4	2	1											28
	Thornback skate,															1			1			**3
																						52
Nov. 15. 10-0 a.m. to 11-47 a.m.	Com. gurnard,				4	6	3	2	5	4	2											26
	Angler,																1					††2
	Brassie,		1																			1
	Poor-cod		2																			2
	Whiting,							2		1												3
	Hake,							2		1	1											4
	Sail-fluke,																	1				1
	Witch sole,			1	2	5	14	8	4	5	2	1	1									43
	Conger,																					‡‡1
	Piked dog-fish,											1	3	15	12	9	1		1			§§45
	Thornback skate,		1													1		1				3
																						131
Dec. 13. 9-0 a.m. to 10-53 a.m.	Red gurnard,											1		1								2
	Com. gurnard.				1	15	14	4	2		3											39
	Angler,																					⦀1
	Poor-cod,			1																		1
	Whiting,							4	1													5
	Sail-fluke,				1																	1
	Witch sole,					1	3	10	8	9	5	2										38
	Conger,																					¶¶1
																						88

* One 30, one 35 inches. † Three 30, three 35, one 40 inches. ‡ One 28 inches. § One 30 inches. ‖ One 3 inches. ¶ 28 inches. ** One 40 inches. †† One 30 inches. ‡‡ Over 40 inches. §§ Three 28 inches. ⦀ 30 inches. ¶¶ Over 40 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches. 4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	Total.
Station X.																						
Jan. 16.	Haddock,	2	1		2				3	3		5	1									*18
11-50 a.m.	Brassie,	1							3													4
to	Poor-cod,	6	4																			10
1-30 p.m.	Whiting,		4		6	63			43		12		2									130
	Hake,								4	48	33	12			4	2	2				3	108
	Long rough dab,	4		3																		7
	Lemon sole,						1		1													2
	Witch sole,						6	13		13	13	17		2								64
	Common dab,			2																		2
	Black sole,									1	1		1		1							4
	Argentine,				1																	†2
	Thornback skate,			1							1		1				1					4
	Fuller's ray,													1				1		1		3
																						358
May 30.	Com. gurnard,			2	7	4	2															15
8-7 a.m.	Angler,															1						1
to	Dragonet,	1	1			2																‡6
10-5 a.m.	Whiting,							1														1
	Hake,								1		2	1	1	2				2				9
	Long rough dab,		9	29	27	2																67
	Turbot,																			1		1
	Scald-fish,		1																			1
	Lemon sole,			4		1																5
	Witch sole,						5	6	10	4	4		1			1						31
	Common dab,			1	1																	2
	Black sole,													1	1							2
	Grey skate,																					§1
	Thornback skate,						1	3						1		1						6
	Cuckoo ray,															1						1
																						149
June 13.	Red gurnard,								1			1										2
4-40 p.m.	Com. gurnard,			2	27	8	1	3	4													45
to	Angler,																1					1
6.30 p.m.	Dragonet,						1															1
	Haddock,						1															1
	Whiting,					1	1		2													4
	Hake,									1		2		1						2	1	‖11
	Long rough dab,	2	9	21	27	2																61
	Zeugopterus, sp.?	1	3																			4
	Lemon sole,		1	2	1		1															5
	Witch sole,					1		2	10	10	5	1	4									33
	Common dab,			2	1																	3
	Black sole,						1						1									2
	Piked dog-fish,													1								1
	Thornback skate,									1	1	2	2	1	1	1		1				10
	Cuckoo ray,		1	1	1																	¶4
																						188
July 19.	Com. gurnard,			2	5	5	5	8	4	5	1											35
11-50 a.m.	Angler,																					
to	Dragonet,				1																	1
1-43 p.m.	Whiting,				3	7	6	1														17
	Hake,										1		4	2			1	1	3	2		14
	Long rough dab,	2	10	18	10																	††42
	Sail-fluke,	1																				1
	Scald-fish,	2	1																			3
	Lemon sole,				2																	2
	Witch sole,				6	6	7	5	20	14	9	3		1								71
	Black sole,											1										1
	Piked dog-fish,									1		1	2	3	3		1		1			12
	Thornback skate,	1		1				1	1			1	2		1			1				9
																						209

* One 3 inches. † One 3 inches. ‡ One 2, one 3 inches. § 35 inches. ‖ Two 28, two 30 inches. ¶ One 3 inches.
** 35 inches. †† Two 3 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station X.																						
Sept. 6. 4-7 p.m. to 5-5 p.m.	Com. gurnards,		4	20	90	17	4	3	1	1												140
	Angler,																			1		*2
	Dragonet,			1	1																	2
	Haddock,					9	14	2	1													26
	Brassie,	1	39	38	11																	89
	Poor cod,			1																		1
	Whiting,					10	25	14	1	1												51
	Hake,					1								1								2
	Long rough dab,		1	3																		†5
	Lemon sole,			1																		1
	Argentine,	1																				1
	White-hound,																					‡1
	Nurse-hound,																			1		1
	Thornback skate,					2	1	1	5		4	4	1							1		19
	Cuckoo ray,												1									§2
																						343
Oct. 9. 11-5 a.m. to 1-5 p.m.	Com. gurnard,		1	3	8	9	4	2		2												29
	Angler,																					‖1
	Hake,														2						1	3
	Common dab,	1		1																		2
	Thornback skate,		2					1				1			1					1		6
																						41
Nov. 14. 11-38 a.m. to 1-37 p.m.	Red gurnard,										1											1
	Com. gurnard,			2	3	10	6	3	2	2				1								29
	Cod,																					¶1
	Brassie,				1																	1
	Whiting,								1			1										2
	Hake,										2						2			2		6
	Sail-fluke,		1		1																	2
	Scald-fish,		1																			1
	Witch sole,						1	5	6	5	3	1										21
	Piked dog-fish,											5	3	3	1	1			2			15
	Thornback skate,												2								1	3
																						82
Dec. 6. 8-55 a.m. to 11-0 a.m.	Com. gurnard,				8	13	13	7	5	6	6	1		1		1						61
	Angler,			1							1											**3
	Horse mackerel,																					††3
	Poor cod,	1																				1
	Whiting,						1	1	1	1												4
	Hake,	1								3	2		1	2	3	3	2	1		1		19
	Long rough dab,		1	3	4	4																12
	Scald-fish,		1																			1
	Witch sole,					4	14	10	14	15	11	5	3									76
	Common dab,				3																	3
	Nurse-hound,		1																			1
	Piked dog-fish,							2							11		9		3			25
	Thornback skate,				2				1				1						1	1		6
Station XI.																						215
Jan. 24. 8-33 a.m. to 10-55 a.m.	Com. gurnard,			1		14	13	1		1												30
	Streaked ,,					1				1												2
	Dragonet,	1																				1
	Haddock,	1																				1
	Whiting,				1		1															2
	Hake,									7												7
	Brill,															1						1
	Long rough dab,	8	32		22	17	2															‡‡82
	Plaice,			1	1		2		1	5	3	1	2	2		3	1					22
	Lemon sole,			1	2	1		1	1	1												7
	Witch sole,					2	5	17	14	1	18	10	2									69
	Common dab,	19	18	13	8		4															62
	Black sole,					1																1
	Thornback skate,																					§§1
																						288

* One 30 inches. † One 3 inches. ‡ 35 inches. § One 3 inches. ‖ 35 inches. ¶ 30 inches.
** One 30 inches. †† 2 inches. ‡‡ One 3 inches. §§ 26 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date and Time Trawl down.	Kind of Fish.	Size in Inches. 4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	Total.
Station XI.																						
June 1.	Com. gurnard,						1		1													2
7-15 a.m.	Angler,													1								*2
to	Cod,						1															1
8-45 a.m.	Haddock,							1														1
	Brassie,		1																			1
	Whiting,				2	2			1													5
	Hake,								2	1	3	1	1		1	1				1		11
	Long rough dab,	6	13	59	25	9																112
	Lemon sole,					1					1											2
	Witch sole,						2	2	3	4	7	5	5	1								29
	Common dab,			1	1																	2
	Grey skate,								1					1								2
	Thornback skate,																	2	2			4
																						174
July 4.	Com. gurnard,				3	8	1	1	1	1	1	1	1	1								19
6-45 a.m.	Angler,																					†1
to	Whiting,					6	6	3		1												16
8-15 a.m.	Hake,										5	3	2							1		11
	Three-bearded rockling,				1																	1
	Long rough dab,	4	10	71	27	5		1		1												119
	Witch sole,						4	5	1	9	6	5	6	1								37
	Thornback skate,																			2		2
																						206
Sept. 15.	Com. gurnard,			1	6	17	19	8	5	7		1										64
8-25 a.m.	Angler,																					‡1
to	Whiting,					4	19	4														27
10-5 a.m.	Hake,					1	6	2	1		1	1		1	4		1		1			19
	Long rough dab,	3	5	39	21	8																76
	Plaice,											1				1	2					4
	Witch sole,				2	2	4	8	15	20	19	10	2									82
	Common dab,		2	1																		3
	Piked dog-fish,																				1	1
	Fuller's ray,									1												1
																						278
Oct. 12.	Com. gurnard,					1	2		2	3												8
9-5 a.m.	Brassie,		4	1																		5
to	Poor-cod,																					§1
10-30 a.m.	Whiting,						1	1														2
	Hake,						3	1	1				1	2		1			1			‖11
	Three-bearded rockling,						1															1
	Long rough dab,	1	3	18	7	1																¶32
	Plaice,									1				1								2
	Witch sole,				2	3	7	10	8	9	2	2	2									45
	Common dab,	2	2	2	3	4			1													14
	Piked dog-fish,											3		1	2							6
	Thornback skate,																1		1	1		3
																						130
Nov. 20.	Com. gurnard,				2	11	7	28	17	13	18	6										102
1-55 p.m.	Angler,																		1			1
to	Brassie,		1	3																		4
3-27 p.m.	Poor-cod,		1	1																		2
	Whiting,							1		1												2
	Hake,								7						3	1	2	3		1		**21
	Long rough dab,	5	10	31	23	4	2															75
	Plaice,										1				1	1		2	1			6
	Lemon sole,			1		1																2
	Witch sole,				3	5	13	28	10	9	3	4	3									78
	Common dab,	1	6	2		2																11
	Argentine,	1		1																		2
	Piked dog-fish,										1											1
	Fuller's ray,		1																	1		2
	Thornback skate,																	3				3
																						312

* One 30 inches. † 30 inches. ‡ Over 40 inches. § 3 inches. ‖ One 30 inches. ¶ Two 3 inches. ** Four 3 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station XI. Dec. 15. 1-28 p.m. to 3-0 p.m.	Com. gurnard,	.	.	2	3	3	1	5	3	2	1	1	.	.	.	.	.	.	.	.	.	21
	Angler,	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
	Brassie,	.	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
	Poor-cod,	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Whiting,	.	.	.	.	.	.	2	.	1	.	.	.	.	.	.	.	.	.	.	.	3
	Hake,	5	.	.	.	.	.	.	1	1	.	.	.	1	1	2	1	.	2	3	1	20
	Long rough dab,	.	.	1	7	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9
	Plaice,	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	2
	Witch sole,	.	.	.	.	7	10	13	16	10	4	5	2	2	.	.	.	.	.	.	.	69
	Common dab,	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Piked dog-fish,	.	.	.	.	.	.	.	.	4	2	2	5	5	1	2	.	.	.	.	.	21
	Thornback skate,	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	†3
																						158
Station XII. Jan. 20. 10-24 a.m. to 0-10 p.m.	Red gurnard,	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Com. gurnard,	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Angler,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‡1
	Cod,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	§1
	Brassie,	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Poor-cod,	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‖8
	Whiting,	.	.	.	1	7	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8
	Hake,	.	.	1	.	3	.	.	.	.	15	.	.	.	3	.	2	3	.	.	2	¶33
	Rockling sp.,	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Long rough dab,	.	37	67	97	144	56	4	.	.	.	.	.	.	.	.	.	.	.	.	.	405
	Plaice,	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Witch sole,	13	.		4	.	8	.	16	20	.	19	.	28	.	.	.	.	.	.	.	108
	Black sole,	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
	Argentine,	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Thornback skate,	1	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	**5
	Fuller's ray,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1
																						578
May 31. 8-43 a.m. to 10-43 a.m.	Com. gurnard	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Angler,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	††4
	Cod,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‡‡1
	Brassie,	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Whiting,	.	7	1	.	2	5	2	.	.	.	.	.	.	.	.	.	.	.	.	.	17
	Hake,	.	.	1	1	.	.	.	.	.	1	2	.	1	.	.	.	.	1	2	.	§§11
	Long rough dab,	19	38	94	33	7	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	192
	Witch sole,	.	.	.	.	3	1	1	3	2	8	9	8	3	.	.	.	.	.	.	.	38
	Argentine,	.	.	.	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
	Thornback skate,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	2
																						274
June 17. to 9-35 a.m.	Angler,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‖‖1
	Whiting,	1	4	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7
	Hake,	.	.	.	1	.	.	.	.	.	1	2	4	1	.	.	2	.	1	.	.	¶¶13
	Long rough dab,	5	19	131	112	30	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	303
	Witch sole,	.	1	2	.	3	1	4	10	10	5	9	5	3	.	.	.	.	.	.	.	53
	Conger,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	***1
	Thornback skate,	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1	1	.	.	1	.	4
																						382
Night Trawl. June 12. 10-5 p.m. to 0-45 a.m.	Angler,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
	Cod,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†††1
	Brassie,	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Poor-cod,	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Whiting,	.	.	.	3	2	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	6
	Hake,	.	.	1	.	2	.	.	.	.	1	2	.	.	.	.	.	.	.	1	1	‡‡‡11
	Long rough dab,	.	6	79	61	11	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	162
	Witch sole,	2	.	1	.	3	4	3	5	10	6	13	4	1	.	.	.	.	.	.	.	52
	Conger,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
	Thornback skate,	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
																						242

* Two 3 inches. † Two 28 inches. ‡ 35 inches. § 38 inches. ‖ Five 3 inches. ¶ Three 26, one 28 inches. ** One between 2 and 3 inches, one 26 inches. †† One 28, two 30 inches. ‡‡ 35 inches. §§ One 26, one 28 inches. ‖‖ 30 inches. ¶¶ One 28 inches. *** 35 inches. ††† 35 inches. ‡‡‡ One 28, two 35 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl Down.	Kind of Fish.	Size in Inches. 4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	Total.
Station XII. July 24. 3-20 p.m. to 5-20 p.m.	Com. gurnard,					3	4	3	2													12
	Angler,																					*2
	Haddock,																		1			1
	Poor-cod,	2	1	11																		14
	Whiting,			4	7	21	14	4		1												51
	Hake,				1	3							1	1		1		1			2	†13
	Long rough dab,	15	10	110	69	12	1															‡218
	Plaice,																		1			1
	Witch sole,					1	2	4	5	8	7	14	6	3								50
	Argentine,			1																		1
	Piked dog-fish,																	1	1			2
	Grey skate,				1																	1
	Thornback skate					1							1									2
																						368
Night Trawl. July 18. 8-55 p.m. to 10-55 p.m.	Cod,									1												1
	Poor-cod,	3	11	8																		22
	Whiting,			2		3	5															10
	Hake,														2				1			§4
	Long rough dab,	3	9	64	42	6	3															‖129
	Witch sole,			1			2	4	5	7	8	14	10	2	1							54
	Conger,																					¶1
	Thornback skate,												1							1	1	3
																						224
Sept. 14. 8-37 a.m. to 9-30 a.m.	Com. gurnard,				4	16	10	10	14	9	9	3	3									78
	Angler,																			1		1
	Norway pout,		1																			1
	Whiting,					9	4	3	1													17
	Hake,												8	4	1	3	1		3	2	1	**24
	Long rough dab,	17	28	70	37	16	3															††173
	Plaice,																1		1	1		3
	Lemon sole,				1																	1
	Witch sole,					3	12	29	30	41	19	17	4	2								157
	Argentine,			1																		1
	Piked dog-fish,										1	3	6	13	4	3						30
	Thornback skate,												1		1					1		3
																						489
Oct. 12. 11-12 a.m. to 1-13 p.m.	Com. gurnard,					1	3	2	4	2	1	2	3									18
	Angler,																				1	1
	Norway pout,			2																		2
	Whiting,				1	2	4	1														8
	Hake,								1					1	1					4	1	8
	Long rough dab,	18	19	46	28	4																‡‡126
	Plaice,												1									1
	Witch sole,		2	5	9	31	45	50	43	27	10		1									223
	Conger,																					§§1
	Piked dog-fish,									4	4	6	9	14	7	1	1		1	2		49
																						437
Nov. 25. 7-57 a.m. to 9-52 a.m.	Com. gurnard,						5	3			1	1										10
	Brassie,		1	1																		2
	Poor cod,		5	9	1																	15
	Norway pout,	5	4	8	1																	18
	Whiting,		1			9	9	6	2													27
	Hake,	10							6					2		6	1	2	2			‖‖‖57
	Long rough dab,	10	5	34	17	2	4															¶¶76
	Plaice,													1								1
	Witch sole,		1	7	10	25	39	33	31	17	11	5										179
	Common dab,			1																		1
	Argentine,	2	1																			***4
	Conger,																					†††1
	Thornback skate,														1					1		2
																						393

* 30 inches. † One 28, one 30, one 35 inches. ‡ One 3 inches. § One 28 inches. ‖ Two 3 inches.
¶ Over 40 inches. ** One 28 inches. †† Two 3 inches. ‡‡ One 2, ten 3 inches. §§ Over 40 inches.
‖‖‖ Five 2, twenty-three 3 inches. ¶¶ Four 3 inches. *** One 3 inches. ††† Over 40 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station XII.																						
Dec. 18.	Com. gurnard,	.	.	.	.	6	16	14	13	15	3	2	.	.	.	.	.	.	.	.	.	69
10-50 a.m.	Angler,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*1
to	Brassie,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
0-45 p.m.	Poor-cod,	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
	Whiting,	.	.	.	.	.	11	9	3	2	.	.	.	.	.	.	.	.	.	.	.	25
	Hake,	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1	2	3	.	2	1	10
	Long rough dab,	.	.	22	34	4	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	61
	Witch sole,	.	.	.	6	16	21	14	10	11	10	4	.	1	.	.	.	.	.	.	.	93
	Piked dog-fish,	.	.	.	.	.	.	.	.	.	.	.	1	10	.	4	.	.	.	.	.	†16
	Thornback skate,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	2
																						282
Station XIII.																						
May 26.	Com. gurnard,	.	1	.	.	2	3	2	1	.	1	.	.	.	.	.	.	.	.	.	.	10
9-45 a.m.	Cod,	.	.	4	5	2	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	13
to	Haddock,	.	.	.	9	3	1	.	.	.	.	.	1	1	.	.	.	.	.	.	.	15
10-50 a.m.	Brassie,	1	9	.	3	1	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	17
	Hake,	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1
	Long rough dab,	26	3	18	13	12	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	74
	Plaice,	.	.	.	.	.	1	1	.	2	.	4	1	.	.	.	.	.	.	.	.	9
	Lemon sole,	.	.	.	.	.	.	.	.	1	1	.	.	1	.	.	.	.	.	.	.	3
	Witch sole,	.	.	.	.	.	.	.	1	6	3	3	1	.	.	.	.	.	.	.	.	14
	Common dab,	.	.	.	.	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Thornback skate,	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1
																						160
June 20.	Com. gurnard,	.	.	1	1	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	4
0-40 p.m.	Cod,	.	.	2	3	3	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	9
to	Haddock,	.	.	.	.	6	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7
1-45 p.m.	Brassie,	1	8	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11
	Whiting,	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Hake,	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
	Long rough dab,	4	2	2	10	11	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	30
	Plaice,	.	.	.	.	.	.	1	.	1	1	1	2	.	.	1	.	.	.	.	.	7
	Lemon sole,	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1
	Witch sole,	.	.	.	.	.	.	.	2	5	3	2	.	.	.	.	.	.	.	.	.	12
	Common dab,	.	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
	Black sole,	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
	Thornback skate,	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
																						89
July 27.	Com. gurnard,	.	.	.	.	1	2	2	2	3	.	.	.	.	.	.	.	.	.	.	.	10
2-5 p.m.	Cod,	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
to	Haddock,	.	.	.	.	6	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10
3-10 p.m.	Brassie,	.	2	2	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
	Whiting,	.	.	.	.	.	2	.	1	.	.	.	.	.	.	.	.	.	.	.	.	3
	Long rough dab,	5	24	4	3	10	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	48
	Plaice,	.	.	.	.	.	.	.	.	.	2	4	1	.	.	.	.	.	.	.	.	7
	Witch sole,	.	.	.	.	.	.	.	.	.	4	.	.	.	.	.	.	.	.	.	.	4
	Common dab,	.	.	2	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6
																						96
Sept. 27.	Com. gurnard,	.	3	10	21	2	1	1	.	.	1	.	.	.	.	.	.	.	.	.	.	39
0-50 p.m.	Cod,	.	.	1	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	4
to	Brassie,	.	.	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
1-57 p.m.	Long rough dab,	3	34	3	2	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	46
	Lemon sole,	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
	Witch sole,	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1
	Common dab,	.	1	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
	Thornback skate,	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1	.	.	2
																						101

* 35 inches. † One 30 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT.—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station XIII.																						
Oct. 18.	Com. gurnard, .	.	2	3	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8
8-32 a.m.	Diminutive sucker	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*2
to	Cod, . . .	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
9-37 a.m.	Haddock, . .	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Brassie, . .	.	4	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
	Whiting, . .	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Long rough dab,	2	14	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	19
	Common dab, .	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Piked dog-fish, .	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
	Fuller's ray, .	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
																						44
Nov. 27.	Com. gurnard, .	.	.	.	2	1	.	3	.	1	.	.	.	.	.	.	.	.	.	.	.	7
10-5 a.m.	Angler, . .	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†1
to	Diminutive sucker	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‡6
11 15 a.m.	Cod, . . .	.	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Haddock, . .	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Brassie, . .	.	2	13	6	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	22
	Long rough dab,	4	5	.	2	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	15
	Witch sole, .	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1
	Piked dog-fish, .	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	3	5	5	.	§18
	Thornback skate,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‖1
	Cuckoo ray, .	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	¶1
																						76
Dec. 20.	Goby, . .	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	**2
8-51 a.m.	Diminutive sucker	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	††9
to	Cod, . . .	.	.	.	.	.	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.	4
9-45 a.m.	Haddock, . .	.	.	.	.	.	2	.	1	.	.	.	.	.	1	.	.	.	.	.	.	4
	Brassie, . .	.	.	4	3	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	9
	Long rough dab,	.	.	7	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11
	Lemon sole, .	.	.	.	.	.	.	.	2	.	.	.	1	.	.	.	.	.	.	.	.	3
	Witch sole, .	.	.	.	.	.	.	.	.	4	1	.	.	.	.	.	.	.	.	.	.	5
	Piked dog-fish, .	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	1
	Thornback skate,	.	.	.	.	.	.	.	.	2	.	.	.	1	.	.	.	.	1	.	.	4
																						52
Station XIV.																						
May 26.	Com. gurnard, .	.	.	.	.	.	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	4
11-10 a.m.	Cod, . . .	.	.	1	.	.	.	.	.	1	.	.	.	1	1	.	.	.	1	.	.	5
to	Haddock, .	.	.	.	1	.	.	.	.	.	1	.	.	.	1	.	.	.	.	.	.	3
0-15 p.m.	Brassie, . .	.	1	.	2	5	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‡‡9
	Whiting, . .	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
	Long rough dab.	.	4	7	9	8	9	.	.	.	.	.	.	.	.	.	.	.	.	.	.	37
	Plaice, . .	.	.	.	.	.	.	.	.	.	.	3	2	.	.	.	.	.	.	.	.	5
	Lemon sole, .	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1
	Witch sole, .	.	.	.	.	.	.	.	3	6	6	5	3	.	.	.	.	.	.	.	.	23
	Common dab, .	.	.	.	2	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
																						93
June 20.	Com. gurnard, .	.	.	1	2	3	1	3	.	1	.	.	.	.	.	.	.	.	.	.	.	11
11-20 a.m.	Cod, . . .	.	.	3	1	.	.	.	.	.	.	1	.	.	.	1	.	.	.	.	1	7
to	Haddock, . .	.	.	.	2	4	2	.	.	.	.	2	.	.	3	.	.	.	.	.	.	13
0-20 p.m.	Brassie, . .	.	1	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
	Whiting, . .	.	.	.	.	.	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	2
	Hake, . . .	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1	.	.	.	2
	Long rough dab,	2	.	3	4	5	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	15
	Plaice, . .	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	2
	Lemon sole, .	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	2
	Witch sole. .	.	.	.	.	.	.	.	1	2	4	3	1	1	.	.	.	.	.	.	.	12
	Common dab, .	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Piked dog-fish, .	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	3
																						74

* Two 1 inch. † 28 inches. ‡ Two 1, four 2 inches. § One 26 inches. ‖ 30 inches ¶ 3 inches.
** 2 inches. †† Six 2, three 3 inches. ‡‡ One 3 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station XIV. July 27. 0-5 p.m. to 1-55 p.m.	Com. gurnard,			2			1															3
	Cod,				4	3	2															9
	Haddock,					2	2															4
	Brassie,		5	5	3	1																14
	Long rough dab,	9	16	5	17	24	2															*74
	Plaice,											2	1									3
	Witch sole,							1	2	3	13	4	2									25
	Common dab,			1	1																	2
	Conger,																					†1
																						135
Sept. 27. 2-18 p.m. to 3-45 p.m.	Com. gurnard,				1				1	1												3
	Cod,					3	1	3	2						1							10
	Haddock,							4														4
	Brassie,			11	5	2	2															20
	Norway pout,						1															1
	Long rough dab,	1	2				2															5
	Lemon sole,									3												3
	Witch sole,										2											2
	Common dab,					1	1															2
	Thornback skate,		1		1																	2
	Cuckoo ray,										1											1
																						53
Oct. 18. 10-0 a.m. to 11-15 a.m.	Com. gurnard,			2	1		1	1	1													6
	Haddock,						2															2
	Brassie,		2	14	1		1															18
	Norway pout,				1																	1
	Whiting,							4		1												5
	Hake,																1					1
	Long rough dab,	3	18	4	7	5																37
																						70
Nov. 27. 11-38 a.m. to 0-45 p.m.	Com. gurnard,				1	2	2	1	3	2												11
	Angler,																				1	1
	Cod,						2	6	3	2	1			1					2			17
	Haddock,						2	8	1					1	1							13
	Brassie,			31	10	2	2															45
	Poor-cod,			1	1																	2
	Whiting,								1			1										2
	Hake,																	1	1			2
	Long rough dab,	1	2	4		1	1															9
	Lemon sole,													1								1
	Witch sole,								1													1
	Piked dog-fish,																			3		‡4
	Thornback skate,																			1		1
																						109
Dec. 21. 0-40 p.m. to 2-15 p.m.	Com. gurnard,			8							1											9
	Haddock,							1														1
	Whiting,							4		1	1											6
	Long rough dab,			12	5	1	1															19
	Witch sole,							1		13	5	6		1								26
	Piked dog-fish,																1		5	2		8
																						69
Station XV. June 21. 9-50 a.m. to 11-25 a.m.	Cod,										1											1
	Haddock,					3																3
	Brassie,					1																1
	Hake,													1	1							2
	Long rough dab,	2	9	27	54	39	3	1														135
	Plaice,												1									1
	Witch sole,					2	14	16	58	70	44	27	8									239
	Piked dog-fish,																			1		1
	Fuller's ray,																		1			1
																						384

* One 3 inches. † 35 inches. ‡ One 35 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station XV.																						
July 27, 10-0 a.m. to 11-15 a.m.	Com. gurnard,					1	1							1								2
	Cod,					1										1	1					*5
	Haddock						2															2
	Brassie,		2	3																		5
	Whiting,						1	2						3								3
	Saithe,								1		2	7	1		1		1		1			17
	Hake,												1									1
	Long rough dab,	1	13	21	40	34	6															115
	Plaice,												1									1
	Witch sole,						3	5	23	31	6	8	6									82
	Herring,									1												1
	Piked dog-fish,																			1	1	†3
	Grey skate														1							1
																						238
Sept. 28. 8-10 a.m. to 9-40 a.m.	Com. gurnard,				1				1													2
	Cod,				2											1						3
	Haddock,							1														1
	Brassie,			4	1	1																6
	Long rough dab,	11	42	45	85	55	8															246
	Plaice,								2	3	3	6	2	1				1				18
	Witch sole,						5	34	105	107	70	38	15									374
	Common dab,				24	1		1														26
	Conger,																					‡1
																						677
Oct. 18. 0-5 p.m. to 1-25 p.m.	Com. gurnard,			1																		1
	Cod,							1			1			1								3
	Haddock,						3	1			1			1	2	1						9
	Brassie,			1																		1
	Whiting,							2														2
	Long rough dab,	12	24	47	82	55	11															231
	Plaice,								1	1	4	6	2	1		1						16
	Witch sole,				1	1	5	28	43	42	24	12	1	3								160
	Herring,							16	17	1												34
	Piked dog-fish,																		1	9		§20
	White skate,												1			1			1			3
																						480
Nov. 27. 2-22 p.m. to 3-45 p.m.	Cod,						2		3			1						1		3		10
	Haddock,							3								1						4
	Brassie,			6																		6
	Whiting,						1															1
	Hake,															1						1
	Long rough dab,		5	3	32	15	4															59
	Plaice,										2	2										4
	Witch sole,						2	9	28	22	13	7		2								83
	Conger,																					‖1
	Thornback skate,											1			1				1			3
																						172
Dec. 21. 10-53 a.m. to 0-5 p.m.	Com. gurnard,			1	1		2			3												7
	Haddock,											1					1		1			3
	Brassie,			3		1	1															5
	Whiting,							3	1													4
	Long rough dab,		2	7	14	10	1	1														35
	Plaice,											3										3
	Witch sole,						1	19	48	39	29	21	8									165
	Conger,																					¶1
	Thornback skate,													1								1
																						224

* One 28 inches. † One 28 inches. ‡ 35 inches. § Six 26, four 28 inches. ‖ 35 inches. ¶ Over 40 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl Down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station XVI.																						
May 27. 9-32 a.m. to 11.25 a.m.	Witch sole,	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1
June 22. 11-10 a.m. to 1-30 p.m.	Haddock,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	2
	Brassie,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Witch sole,	.	.	1	.	2	5	29	39	44	19	20	10	1	.	.	.	.	.	.	.	170
																						173
July 26. 1-25 p.m. to 3-20 p.m.	Haddock,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
	Witch sole,	.	.	.	.	.	.	.	.	2	1	2	.	.	.	.	.	.	.	.	.	5
																						6
Sept. 28. 1-6 p.m. to 3.2 p.m.	Haddock,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1
	Saithe,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
	Long rough dab,	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Witch soles,	.	.	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	3
																						8
Oct. 19. 7.20 a.m. to 9.45 a.m.	Angler,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*1
	Haddock,	.	.	.	.	.	1	2	.	.	.	5	1	2	3	.	.	1	.	1	.	16
	Brassie,	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Long rough dab,	.	1	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
	Witch sole,	.	.	.	.	1	1	11	28	28	23	12	1	.	.	.	.	.	.	.	.	105
																						129
Nov. 28. 11.55 a.m. to 2.5 p.m.	Cod,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
	Brassie,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Long rough dab,	.	1	10	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	13
	Witch sole,	.	.	.	.	.	1	.	.	2	2	10	3	.	.	.	.	.	.	.	.	18
																						33
Station XVII.																						
May 27. 6.45 a.m. to 8.0 a.m.	Com. gurnard,	.	.	.	.	3	1	4	.	.	.	.	.	.	.	.	.	.	.	.	.	8
	Cod,	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	2
	Haddock,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	1
	Long rough dab,	.	4	2	6	2	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	17
	Plaice,	.	.	.	.	.	.	.	.	1	1	1	1	4	2	1	1	.	.	.	.	12
	Lemon sole,	.	.	.	.	.	.	.	.	1	2	1	.	.	.	.	.	.	.	.	.	4
	Witch sole,	.	.	.	.	.	1	.	.	4	9	9	3	.	.	.	.	.	.	.	.	26
	Common dab,	.	3	3	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	11
	Conger,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†2
	Thornback skate,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1
																						84

* 30 inches. † One 30, one 35 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station XVII.																						
June 23. 10-15 a.m. to 11-35 a.m.	Com. gurnard,	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Cod,	.	.	2	.	2	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	5
	Brassie,	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Whiting,	.	.	.	1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	2
	Long rough dab,	3	8	4	8	4	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*29
	Plaice,	.	.	.	.	.	.	.	.	.	1	.	1	1	3	1	.	.	.	.	.	7
	Lemon sole,	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	1
	Witch sole,	.	.	.	.	.	1	.	3	11	15	8	6	2	.	.	.	.	.	.	.	46
	Fuller's ray,	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1
																						94
July 26. 7-30 a.m. to 9.0 a.m.	Com. gurnard,	.	.	2	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	4
	Cod,	.	.	.	1	1	1	.	1	.	.	1	.	.	.	2	2	.	1	.	.	10
	Haddock,	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	2
	Brassie,	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Whiting,	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Saithe,	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Long rough dab,	5	14	16	15	14	6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	†72
	Plaice,	.	.	.	.	.	.	.	.	.	.	1	1	1	1	.	2	.	.	.	.	6
	Witch sole,	.	.	.	.	.	4	7	22	26	24	15	9	4	2	.	.	.	.	.	.	113
	Common dab,	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Conger,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‡3
	Thornback skate,	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
																						217
Sept. 29. 6-17 a.m. to 7-30 a.m.	Com. gurnard,	.	.	.	.	2	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	4
	Cod,	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Haddock,	.	.	.	.	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	2
	Brassie,	.	1	2	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5
	Whiting,	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	Saithe,	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
	Long rough dab,	1	10	4	10	9	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	§39
	Plaice,	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	2
	Witch sole,	.	.	.	.	2	4	6	14	21	25	2	3	2	.	.	.	.	.	.	.	79
	Common dab,	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
	White skate,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1
	Fuller's ray,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1
	Thornback skate,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	1
																						141
Oct. 24. 11-37 a.m. to 1-0 p.m.	Com. gurnard,	.	.	.	1	1	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	4
	Cod,	.	.	.	.	1	1	1	1	1	.	.	.	.	.	.	.	.	.	.	.	5
	Brassie,	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1
	Whiting,	.	.	.	.	.	.	2	1	1	.	.	.	.	.	.	.	.	.	.	.	4
	Saithe,	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1
	Hake,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	1	3
	Long rough dab,	4	35	29	31	31	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.	144
	Plaice,	.	.	.	.	.	.	.	.	1	2	2	3	6	4	.	.	.	.	.	.	18
	Lemon sole,	.	.	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	3
	Witch sole,	.	.	.	2	.	3	9	18	51	29	21	8	3	1	.	.	.	.	.	.	145
	Common dab,	.	.	1	1	.	5	2	.	.	.	.	.	.	.	.	.	.	.	.	.	9
	Conger,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	‖1
	Thornback skate,	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	1	2
																						340
Nov. 28. 9-20 a.m. to 10-45 a.m.	Cod,	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	1
	Haddock,	.	.	.	.	.	.	2	.	.	.	.	.	.	1	.	.	.	.	.	.	3
	Brassie,	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
	Saithe,	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	2
	Hake,	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1
	Long rough dab,	.	2	7	10	6	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	29
	Plaice,	.	.	.	.	.	.	.	.	3	.	.	1	3	.	.	.	.	.	.	.	7
	Lemon sole,	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	1
	Witch sole,	.	.	.	.	.	.	1	9	11	12	6	7	2	1	.	.	.	.	.	.	49
																						96

* One 3 inches. † Two 3 inches. ‡ One 30, two 35 inches. § One 3 inches. ‖ 35 inches.

TABLE C.—Record of Observations made on Board the 'Garland' during 1899.

A. FISH CAUGHT—Firth of Clyde—*continued.*

Station, Date, and Time Trawl down.	Kind of Fish.	Size in Inches.																				Total.
		4 +	5 +	6 +	7 +	8 +	9 +	10 +	11 +	12 +	13 +	14 +	15 +	16 +	17 +	18 +	19 +	20 +	21 +	23 +	25 +	
Station XVII.																						
Dec. 21.	Brassie,	.	.	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
8-0 a.m.	Saithe,	.	.	.	.	.	.	.	.	.	.	.	1	3	.	.	.	.	.	.	.	4
to	Long rough dab,	.	.	6	15	15	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	38
9-15 a.m.	Plaice,	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1
	Witch sole,	.	.	.	.	.	.	6	4	2	4	8	2	.	1	.	.	1	.	.	.	28
	Thornback skate,	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	2
																						77

TABLE B.—Record of Observations made on Board the 'Garland' during 1899.

B. PHYSICAL OBSERVATIONS—Firth of Clyde.

Station, Date, and Hour.	End of Station.	Temperature.				Wind.		Weather.	Sea.	Tide.	Barometer.	Transparency. Fathoms.
		Air.	Water.									
		Dry Bulb.	Surface.	Bottom.	Depth in faths.	Direction.	Force.					
Station I.												
1899. May 30. 1.50 p.m.	S.	60·98	50·00	48·9 48·9	19½ 9¾	Variable	1	Fine.	Smooth.	3h. 50m. fl.	30·25	9
4.5 p.m.	N.	60·26	50·1	46·6 47·8	22 11	N.W.	3	,,	Slight.	High water	30·24	5
June 7. 10.20 a.m.	N.	55·76	50·5	46·8 49·3	20 10	W.	5	Fine, haze.	,,	4h. 30m. fl.	30·36	3½
0.7 p.m.	S.	61·88	52·0	47·7	18	Variable	1	Fine.	,,	37 m. ebb.	,,	7½
July 6. 2.5 p.m.	N.	60·80	55·0	49·1 51·6	21 10½	S.	3	Fine, clear.	Smooth.	3¼ h. ,,	30·22	5
4.3 p.m.	S.	59·72	56·0	49·9	17	,,	4	Fine.	,,	5h.13m.eb.	30·21	5
Sept. 1. 11.0 a.m.	N.	61·70	56·5	54·5 56·3	21 10½	Variable	..	Fine, cl'dy.	,,	1½ h. ebb.	29·69	5
0.55 p.m.	S.	60·44	56·8	54·7	15	S.	3	Cloudy.	,,	3½ ,,	29·68	6
Oct. 5. 2.12 p.m.	S.	49·82	54·9	53·3 53·5	16 8	N.	4	Fine.	,,	2 ,,	30·19	5½
4.25 p.m.	N.	50·00	53·4	53·4 53·1	22 11	N.N.W.	2	Fine, clear.	,,	4¼ ,,	30·20	6
Nov. 11. 0·25 p.m.	S.	53·60	52·0	52·0 51·8	19 9½	S.W	6	Squally, and rain.	Moderate.	1¾ h. fl.	29·14	3
2.5 p.m.	N.	52·70	51·8	51·6 51·6	32 16	W.	7	Squally, with rain.	Rough.	3½ ,,	29·17	3
Dec. 14. 12 noon.	N.	39·56	48·1	49·1 48·0	25 12½	S.	5	Cloudy.	,,	2½ h. ebb.	29·67	3½
1.42 p.m.	S.	40·10	48·1	47·0 48·1	21 10½	,,	5	,,	,,	4½ ,,	,,	3½
Station II.												
June 2. 0.15 p.m.	N.	50·36	49·9	46·8	18	W.N.W.	7	Rain & mist.	Choppy. S. swell.	5¾ h. ebb.	30·5	6
1.35 p.m.	S.	52·88	49·3	47·0 47·5	24½ 12¼	N.W. by W.	7	Dull, cl'dy.	Choppy.	1¾ h. fl.	30·6	4½
July 6. 11.5 a.m.	N.	61·16	55·9	50·4	17	S.	2	Fine, haze overland.	Smooth.	¼ h. ebb.	30·22	5
1.0 p.m.	S	63·32	55·6	49·3 53·1	19½ 9¾	,,	2	Fine.	,,	2h.10m. ,,	,,	5
Sept. 1. 2.30 p.m.	N.	61·16	56·9	54·8	18	S.S.W.	4	Fine, clear.	Slight.	5 h. ebb.	29·68	5½
4.15 p.m.	S.	59·90	57·1	54·5 56·8	22 11	,,	4	Fine, cl'dy.	,,	½ h. fl.	29·66	6
Oct. 5. 8.0 a.m.	N.	44·96	53·3	52·1	13	N.N.E.	4	Fine, clear.	,,	2 h. ,,	30·16	5
9.40 a.m.	S.	50·00	53·2	53·0 53·0	18 9	,,	4	,,	,,	4 h. ,,	30·18	7
Nov. 9. 1.45 p.m.	N.	48·92	51·9	51·5 51·8	17 8½	W.N.W.	3	Fine.	Smooth.	4¼ h. ,,	29·79	4
3.37 p.m.	S.	48·92	52·0	51·6	14	S.S.W.	2	Fine, cl'dy.	,,	Near high water.	,,	3
Dec. 14. 9.7 a.m.	N.	37·76	48·0	49·0 48·3	17 8½	S.S.E.	5	Cloudy.	Rough.	,,	29·65	3½
10.45 a.m.	S.	38·30	47·9	49·2 48·7	23 11½	,,	5	,,	,,	1h.20m.eb.	29·66	3½

TABLE B.—Record of Observations made on Board the 'Garland' during 1899.

B. PHYSICAL OBSERVATIONS.—Firth of Clyde—*continued.*

Station, Date, and Hour.	End of Station.	Temperature. Air. Dry Bulb.	Water. Surface.	Water. Bottom.	Water. Depth in faths.	Wind. Direction.	Wind. Force.	Weather.	Sea.	Tide.	Barometer.	Transparency. Fathoms.
Station III.												
1899. June 1. 2.10 p m.	S.	66·99	52·5	47·3 47·8	25 12½	Light S. airs.	..	Fine, haze.	Calm.	2½ h. fl.	30·12	7
4.0 p.m.	N.	62·98	53·8	46·6 47·5	33 16½	S.	1	,,	Smooth.	4½ ,,	30·08	5
July 4. 1.40 p.m.	N.	59·00	52·0	48·9 50·9	34 17	N.	3	Fine, clear.	Slight.	4h.40m.eb.	30·14	5
3.12 p.m.	S.	62·24	53·0	47·8 51·5	39 19½	,,	3	,,	Smooth.	Lowwater.	30·17	4½
Sept. 5. 3.50 p.m.	N.	60·80	57·6	52·4 57·0	31 15½	W.N.W.	3	,,	Calm.	3¾ h. ebb.	29·90	5
5.40 p.m.	S.	61·70	57·8	52·5 57·1	27 13½	,,	3	,,	,,	5½ ,,	29·92	6
Oct. 4. 2.0 p.m.	N,	54·50	53·4	53·1 53·3	30 15	N.N.W.	5	Cloudy, fine.	Choppy.	2½ ,,	29·86	5
3.40 p.m.	S.	53·60	53·2	53·1 53·3	26 13	N.	5	Fine, clear.	,,	3¾ ,,	29·90	5
Nov. 9. 10.55 a.m.	N.	49·28	52·0	52·0 51·6	18 9	W.N.W.	5	Fine, cl'dy.	Slight.	1½ h. fl.	29·77	4
0.56 p.m.	S.	49·82	52·0	52·0 51·6	16 8	,,	4	Fine.	,,	3h. 25m. fl.	29·78	4
Dec. 5. 0.37 p.m.	N.	47·30	50·2	50·8 50·5	20 10	E.S.E.	3	Continuous rain.	,,	5½ h. fl.	30·05	5
2.35 p.m.	S.	47·48	50·1	50·5 50·2	28 14	,,	2	Overcast, continuous rain.	,,	1¼ h. ebb.	30·02	5
Station IV.												
June 2. 2.50 p.m.	N.E.	51·62	52·3	46·5 50·6	27 13½	N.W.	5	Dull, cl'dy.	Choppy.	2¾ h. fl.	30·10	7
3.45 p.m.	S.W.	50·90	52·1	47·1 48·2	20 10	,,	5	Cloudy, bright at intervals.	,,	3¼ ,,	30·11	7
July 6. 8.45 a.m.	N.E.	59·36	55·8	49·9 52·0	25 12½	Variable	1	Fine. cl'dy.	Calm.	4 ,,	30·21	5
9.58 a.m.	S.W.	62·24	56·00	51·0 52·0	25 12½	S.	1	Fine.	Smooth.	5¼ ,,	30·22	5
Sept. 2. 6.55 a.m.	S.W.	55·40	57·5	54·5 57·1	21 10½	Variable	1	Showery.	,,	3 ,,	29·64	8
7.52 a.m.	N.E.	56·12	57·6	54·5 56·8	25 12½	,,	1	,,	,,	4 ,,	,,	7
Oct. 4. 0.35 p.m.	N.E.	52·52	53·2	53·5 53·4	20 10	N.W.	5	Fine, clear.	Slight.	1 h. ebb.	29·84	4
1.30 p.m.	S.W.	54·32	53·2	53·5 53·3	18 9	,,	4	,,	,,	2 ,,	29·85	5
Nov. 9. 9.20 a.m.	N.E.	47·12	52·0	52·0 51·8	23 11½	W.	4	Fine, cl'dy.	Smooth.	6 ,,	29·74	4
10.2 a.m.	S.W.	49·28	51·6	51·8 51·6	18 9	W.N.W.	4	,,	Slight.	¾ h. fl.	29·76	4
Dec. 5. 10.53 a.m.	N.E.	47·84	50·2	50·4 50·5	24 12	Variable	1	Overcast, continuous rain.	Westerly Swell.	3¾ ,,	30·08	5
12 noon.	S.W.	48·74	50·2	49·2	15	,,	1	Overcast, continuous rain.	Calm.	4h. 50m. fl.	30·6	4

TABLE B.—Record of Observations made on Board the 'Garland' during 1899.

B. PHYSICAL OBSERVATIONS—Firth of Clyde—*continued.*

Station, Date, and Hour.	End of Station.	Temperature.				Wind.		Weather.	Sea.	Tide.	Baro-meter.	Transparency, Fathoms.
		Air.	Water.									
		Dry Bulb.	Sur-face.	Bot-tom.	Depth in faths.	Direc-tion.	Force.					
Station V.												
1899. June 1. 10.40 a.m.	N.	60·80	50·0	47·7	19	..	..	Fine, slight haze.	Calm.	..	30·16	6
0.4 p.m.	S.	65·48	50·0	48·1	15½	..	..	,,	,,	½ h. fl.	30·15	5
July 4. 9.55 a.m.	N.	57·38	54·6	51·9	18	N.N.W.	4	Fine, clear.	Smooth.	1 h. ebb.	30·12	4
				53·7	9							
11.10 a.m.	S.	60·80	54·9	53·7	18½	N.	3	Fine.	,,	2h.10m.eb.	30·13	3½
Sept. 8. 3.45 p.m.	N.	60·44	59·0	57·0	17	N.N.W.	4	Fine, clear.	Slight.	2¼ h. ,,	30·10	6
4.58 p.m.	.	58·64	59·1	57·0	19	,,	5	Cloudy.	,,	3½ h. fl.	30·11	7
Oct. 11. 12 noon.	S.	56·12	54·0	53·9	15	S.W.	5	Rain, overcast.	Choppy.	2h. 20m. fl.	29·76	5½
1.5 p.m.	N.	56·30	54·0	53·7	20	,,	6	Overcast.	Slight.	3h. 25m. ,,	29·72	5
				53·7	10							
Nov. 17. 9.35 a.m.	S.	50·00	51·3	51·1	18	..	..	,,	Smooth.	4½ h. fl.	30·64	4½
				51·0	9							
10.40 a.m.	N.	50·36	51·1	51·5	19	Variable	1	Fine, haze.	,,	5½ ,,	30·66	4
Dec. 18, 2.43 p.m.	S.	43·70	48·3	48·3	16½	S.S.E.	4	Overcast.	Choppy.	2h.20m.eb.	30·05	4
3.50 p.m.	N.	43·70	49·2	48·3	21	,,	4	,,	Slight.	4½ h. ,,	,,	5
				48·5	10½							
Station VI.												
May 30. 11.25 a.m.	S.	56·84	50·0	48·4	25	S.W.		Fine, slight haze.	Slight.	1h. 25m. fl.	30·26	8
				48·2	12½							
1.27 p.m.	N.	59·00	49·0	48·2	23	..	..	Fine.	Calm.	3h. 25m. ,,	30·25	7½
				48·8	11½							
June 7. 0.43 p.m.	N.	60·08	52·0	49·8	21	S.	1	Fine, slight haze.	Smooth.	1¼ h. ebb.	30·37	7
				50·0	10½							
2.40 p.m.	S.	66·56	53·5	49·7	22	Variable	1	Fine.	,,	3h. 10m. ,,	,,	7
				49·8	11							
July 7. 8.25 a.m.	N.	59·90	52·4	50·9	22	S.S.W.	1	Fine.	Calm.	2h. 50m. fl.	30·20	4½
				51·5	11							
10.30 a.m.	S.	59·36	53·1	52·2	25	,,	3	Overcast.	Smooth.	4h. 55m. ,,	,,	4
				52·8	12½							
Sept. 6. 7.50 a.m.	N.	55·58	56·0	54·9	21	N.W.	2	Fine.	,,	1h. 20m. ,,	29·97	5
				55·1	10½							
10.5 a.m.	.	62·24	56·9	55·7	26½	W.	1	,,	,,	3½ h. fl.	30·00	5
				56·1	13¼							
Oct. 5. 11.48 a.m.	S.	51·44	55·0	55·0	25	N.N.E.	3	Fine, clear.	Slight.	5¾ ,,	30·20	6
				54·9	12½							
1.48 p.m.	N.	50·54	54·0	54·3	23	N.	4	,,	Calm.	1¾ h. ebb.	30·19	6
				54·1	11½							
Nov. 14. 8.50 a.m.	N.	53·60	51·3	52·0	20	S.S.W.	4	Overcast, continuous rain.	Southerly swell.	High water.	29·90	3
				51·9	10							
10.53 a.m.	S.	53·42	51·3	52·2	27	,,	4	Overcast, rain.	Heavy southerly swell.	2h. ebb.	29·92	4
				51·5	13½							
Dec. 6. 1.15 p.m.	S.	51·08	51·0	51·4	25	S.S.E.	5	Mist, and fine rain.	Rough.	5h. 20m. fl.	29·66	4
				51·3	12½							
3.15 p.m.	N.	51·08	51·0	51·0	20	S.E.	4	,,	,,	1¼ h. ebb.	29·62	3½
				51·0	10							

TABLE B.—Record of Observations made on Board the 'Garland' during 1899.

B. PHYSICAL OBSERVATIONS.—Firth of Clyde—*continued.*

Station, Date, and Hour.	End of Station.	Temperature.				Wind.		Weather.	Sea.	Tide.	Baro-meter.	Transparency. Fathoms.
		Air.	Water.									
		Dry Bulb.	Sur-face.	Bot-tom.	Depth in faths.	Direc-tion.	Force.					
Station VII.												
1899. May 29. 9.15 a.m.	N.E.	56·30	52·0	47·4	18	..	..	Fine, slight haze.	Smooth.	Lowwater.	30·41	5
11.15 a.m.	S.W.	62·60	57·4	47·6	18	S.W.	1	,,	,,	1¾ h. fl.	30·40	4½
June 7. 6.10 p.m.	N.E.	58·64	50·9	47·3 47·1	21 10½	Variable	1	Fine.	Calm, S.W. swell.	25 m. fl.	30·36	5
8.5 p.m.	S.W.	55·04	54·6	48·0 47·5	24 12	W.	1	Fine, sweatening fog.	Choppy.	2h.20m. ,,	30·36	5
June 15. 9.35 p.m.	S.W.	59·18	56·0	48·8 48·8	24 12	,,	1	Fine, hazy.	Smooth.	5 h. ebb.	30·11	..
11.45 p.m.	N.E.	58·82	60·2	48·8 48·0	20 10	,,	1	Fine, star-light.	,,	1¼ h. fl.	30·12	..
July 7. 4.12 p.m.	N.E.	60·80	57·9	50·2 50·8	22 11	S.S.W.	4	Showery.	Slight.	4½ h. ebb.	30·18	5
6.20 p.m.	S.W.	60·26	58·9	51·0 51·2	19 9½	,,	4	,,	,,	½ h. fl.	,,	5
July 19. 9.30 p.m.	N.E.	59·90	58·1	51·5 55·1	24 12	..	..	Fine.	Smooth.	1 h. ebb.	30·0	..
11.35 p.m.	S.W.	59·00	59·3	52·1	19	N.W.	1	Fine, moon-light.	Calm.	3 ,,	30·2	..
Sept. 12. 10.20 a.m.	N.E.	60·80	57·8	56·8	17	S.S.W.	2	Fine, cl'dy.	Smooth.	½ h. fl.	30·11	5
0.25 p.m.	S.W.	60·80	58·0	57·1	12	S.W.	4	Overcast.	Slight.	2½ h. ,,	,,	6
Oct. 6. 3.53 p.m.	N.E.	52·16	54·4	54·7 54·4	23 11½	,,	1	,,	Smooth.	3¼ h. ebb.	30·16	5½
5.55 p.m.	S.W.	51·62	54·7	55·0	16	..	..	Fine.	Quite smooth.	5¼ ,,	,,	5
Nov. 15. 2.10 p.m.	N.E.	49·64	52·3	53·0 52·9	23 11½	E.	2	Overcast.	Calm, E. swell.	4½ ,,	30·57	3
4.15 p.m.	S.W.	50·00	52·0	52·9	14	,,	1	,,	Calm.	First of flood.	30·60	3
Dec. 12. 8.2 a.m.	S.W.	39·20	50·0	48·6	12	E.S.E.	4	Cloudy.	N.W.swell.	1½ h. ebb.	49·77	2
10.0 a.m.	N.E.	38·84	50·2	52·2 49·9	25 12½	N.E.	3	Fine.	Slight.	3½ ,,	29·82	3
Station VIII.												
May 29. 0.50 p.m.	W.	58·28	50·0	48·4 48·3	35 17½	S.W.	1	Fine, slight haze.	Smooth.	3¼ h. fl.	33·38	5
3.5 p.m.	E.	59·36	51·7	48·0 48·7	30 15	,,	2	,,	Slight.	5½ ,,	30·38	8
June 8. 11.15 a.m.	W.	56·48	52·0	48·5 49·6	34½ 17¼	N.N.E.	2	Overcast.	Calm, S.W.swell.	5½ ,,	30·45	4
1.20 p.m.	E.	57·02	52·3	48·6 50·0	28 14	N.E.	1	Dull, hazy.	Slight.	1h.20m.eb.	,,	5½
June 13. 9.40 p.m.	W.	55·22	55·2	49·0 49·1	32½ 16¼	S.W.	2	Fine.	Smooth.	½ h. fl.	30·13	..
0.20 a.m.	E.	55·94	55·4	49·0 49·0	28½ 14¼	,,	1	Fine, star-light.	Calm.	2¾ ,,	30·12	..
July 7. 11.55 a.m.	W.	59·00	57·00	51·2 51·6	34½ 17¼	S.S.W.	4	Dull, cl'dy.	Slight.	20m. ebb.	30·20	5
2·13 p.m.	E.	60 08	56·3	51·1 51·8	29 14½	,,	4	,,	,,	2½ h. ,,	30·18	5

TABLE B.—Record of Observations made on Board the 'Garland' during 1899.

B PHYSICAL OBSERVATIONS.—Firth of Clyde—*continued.*

Station, Date, and Hour.	End of Station.	Temperature.				Wind.		Weather.	Sea.	Tide.	Barometer.	Transparency. Fathoms.
		Air.	Water.									
		Dry Bulb.	Surface.	Bottom.	Depth in faths.	Direction.	Force.					
Station VIII.												
1899. July 21. 8.45 p.m.	W.	59·54	57·2	52·0 54·0	35 17½	N.E.	2	Dull, mist.	Smooth.	4¼ h. fl.	30·09	..
11.7 p.m.	E.	59·00	57·6	51·5 53·0	28 14	N.E.	2	Dull.	Calm.	½ h. ebb.	30·10	..
Sept. 13. 0.27 p.m.	E.	59·00	57·3	57·0 57·1	29 14½	N.	4	Fine, clear.	Choppy.	1h.51m.fl.	,,	5
2.30 p.m.	W.	59·54	57·7	57·0 57·1	35 17½	N.N.W.	5	,,	,,	3h.40m. ,,	30·09	7
Oct. 10. 7.55 a.m.	W.	55·40	54·0	55·6 54·5	38 19	S.W.	4	Overcast.	Slight.	5¼ h. ebb.	30·10	10
10.0 a.m.	E.	57·56	54·0	54·5 53·4	26 13	S.W.	3	Fine, haze.	Smooth, S.W. swell.	1¼ h. fl.	30·11	7
Nov. 23. 7.43 a.m.	W.	50·00	52·0	52·3 52·0	35 17½	W.S.W.	6	Overcast.	Rough.	4½ h. ebb.	30·18	3
10.5 a.m.	E.	50·90	51·2	52·9 52,2	30 15	S.W.	6	Cloudy.	,,	¾ h. fl.	30·17	5
Dec. 12. 0.20 p.m.	E.	39·74	50·0	50·1 50·0	26 13	N.E.	2	Fine.	Slight.	5¾ h. ebb.	29·84	3½
2.30 p.m.	W.	41·00	49·7	51·2 53·5	35 17½	N.E.	3	,,	,,	1 h. fl.	,,	3½
Station IX.												
May 29. 4.3 p.m.	S.W.	57·20	50·0	48·0 48·4	29 14½	S.W.	2	Fine, haze.	Smooth.	½ h. ebb.	30·36	7
6.10 p.m.	N.E.	58·82	51·5	48·0	27	S.W.	1	Fine.	,,	2h.40m.eb.	30·35	6½
June 8. 2.15 p.m.	S.W.	59·36	53·0	48·7 49·0	28¼ 14	..	..	Fine, cl'dy.	,,	2¼ h. ebb.	34·4	6
4.30 p.m.	N.E.	62·24	53·0	48·7 51·5	27 13½	Variable	1	Fine, hazy.	,,	4½ ,,	30·44	7
July 8. 10.25 a.m.	S.W.	57·56	56·3	51·1 53·5	30 15	N.W.	4	Fine, clear.	Slight.	3¼ h. fl.	30·16	5½
11.50 a.m.	N.E.	59·18	58·0	51·2 51·4	27 13½	N.W.	4	Fine.	,,	5h.40m. ,,	30·15	5¼
Sept. 8. 9.35 a.m.	N.E.	55·40	58·0	52·8 54·7	28 14	N.N.W.	4	Cloudy, passing showers.	Choppy.	2 h. fl.	30·08	7
11.55 a.m.	S.W.	60·44	57·5	54·5 56·8	28 14	N.N.W.	2	Fine.	Calm.	4½ ,,	30·09	7
Oct. 10. 11.35 a.m.	S.W.	57·56	53·9	55·0 53·5	28 14	S.W.	3	Fine, haze.	Slight.	2h.35m. ,,	30·10	7
1.40 p.m.	N.E.	56·84	54·0	54·0 53·5	28 14	S.S.W.	2	Overcast, fine rain.	,,	4h.50m. ,,	30·9	7
Nov. 15. 9.50 a.m.	N.E.	46·22	51·2	51·5 51·1	30 15	E.	6	Cloudy.	Moderate, choppy.	Top of high water	30·56	4
12 noon.	S.W.	47·48	51·5	52·0 51·3	28 14	E.N.E.	5	Overcast.	Moderate, choppy.	2h.20m.eb.	30·57	3½
Dec. 13. 8.55 a.m.	N.E.	38·30	50·0	50·5 50·0	26 13	S.S.E.	5	,,	Rough.	¾ h. ebb.	29·49	3½
11·8 a.m.	S.W.	38·84	49·1	50·2 49·2	29 14½	S.S.E.	6	,,	,,	3 ,,	29·44	4

TABLE B.—Record of Observations made on Board the 'Garland' during 1899.

B. PHYSICAL OBSERVATIONS—Firth of Clyde—*continued.*

Station, Date, and Hour.	End of Station.	Temperature.				Wind.		Weather.	Sea.	Tide.	Barometer.	Transparency. Fathoms.
		Air.	Water.									
		Dry Bulb.	Surface.	Bottom.	Depth in faths.	Direction.	Force.					
Station X.												
1899. May 30. 8.0 a.m.	N.E.	53·60	50·6	48·1 47·8	29 14½	S.W.	2	Fine, hazy.	Smooth.	4 h. ebb.	30·29	8
10.15 a.m.	S.W.	54·86	49·5	48·1 48·4	27 13½	S.W.	2	Fine, haze.	,,	15 m. fl.	30·26	8
June 13. 4.30 p.m.	N.E.	59·18	57·3	49·8 51·3	28 14	W.S.W.	3	,,	Slight.	1½ h. ebb.	30·13	5
6.45 p.m.	S.W.	59·00	56·0	49·5 50·1	26 13	W.S.W.	3	Fine.	,,	3¾ ,,	,,	6
July 19. 11.45 a.m.	N.E.	60·80	57·3	50·8 52·4	25 12½	S.	...	Fine, haze.	Smooth.	3h.50m. ,,	29·94	7
2.0 p.m.	S.W.	62·78	54·7	51·8 52·0	25 12½	S.	1	,,	,,	Low water	29·95	5
Sept. 6. 4.2 p.m.	N.E.	66·56	58·0	53·2 56·5	27 13½	N.W.	4	Fine, clear.	Slight.	3h.25m.eb.	30·00	7
6.0 p.m.	S.W.	62·24	57·8	56·2 56·5	26 13	N.W.	2	Fine.	Smooth.	5½ h. ,,	,,	6
Oct. 9, 10.57 a.m.	S.W.	54·68	54·9	55·4 55·3	27 13½	S.W.	4	Overcast.	Slight.	2¾ h. fl.	30·20	7
1.15 p m.	N.E.	55·76	53·9	53·8 53·4	28 14	S.S.W.	4	Overcast, haze.	Choppy.	5 ,,	30·16	7
Nov. 14. 11.28 a.m.	S.W.	53·24	52·0	51·9 51·8	25 12½	S.S.W.	4	Overcast.	Heavy S.W. swell.	2h.40m.eb.	29·93	3½
1.45 p.m.	N.E.	53·42	51·6	51·8 51·5	27 13½	W.	1	Cloudy.	Southerly swell.	5 h. ebb.	29·97	3½
Dec. 6. 8.50 a.m.	N.E.	51·62	50·6	50·7 50·5	23 11½	S.	4	Fine rain.	Choppy.	1 h. fl.	29·74	5
11.10 a.m.	S.W.	51·08	50·6	50·9 50·4	30 15	S.S E	3	Misty.	Rough.	3h. 20m. fl.	29·72	5
Station XI.												
May 31. 12 noon.	S.W.	62·96	50·5	47·2 47·0	35 17½	..	..	Fine, haze.	Calm.	1 h. fl.	30·26	4
1.45 p.m.	N.E.	66·20	53·00	46·8	17	..	..	,,	,,	2¾ ,,	,,	5
June 1. 7.10 a.m.	N.E.	57·20	50·2	46·9 47·2	25 12½	E.	1	,,	Smooth.	1½ h. ebb.	30·20	5
9.20 a.m.	S.W.	61·16	52·2	47·1 46·4	35 17½	E.	1	,,	,,	3¾ ,,	30·17	4½
July 4. 6.40 a.m.	N.E.	53·24	51·8	49·1 49·8	24 12	N.W.	4	Fine, cl dy.	Choppy.	4 h. fl.	30·11	5
8.25 a.m.	S.W.	56·48	53·7	49·3 48·8	32 16	N.N.W.	4	Fine.	Slight.	5¾ ,,	30·12	5
Sept. 15. 8.19 a.m.	N E.	52·70	57·4	54·5 57·0	25 12½	S.S.W.	5	Overcast, continuous rain.	Choppy.	1 h. ebb.	29·92	7½
10.15 a.m.	S.W.	55·22	57·8	55·7 57·4	35 17½	S.S.W.	6	Continuous rain.	Rough.	3 ,,	29·83	7
Oct. 12. 9.0 a.m.	.E.	51·08	54·0	53·7 53·5	28 14	W.N.W.	5	Cl'dy, rain.	Choppy.	4h.40m. ,,	29·46	5½
10.47 a.m.	S.W.	52·16	54·0	54·0 53·7	33 16	N.W.	6	Cloudy.	,,	10 m. fl.	,,	5
Nov. 20. 1.53 p.m.	N.E.	50·00	50·4	51·8 51·0	25 12½	E.N.E.	1	Fine, haze.	Smooth.	½ h. ebb.	30·30	4
3.30 p.m.	S.W.	49·10	50·2	51·5 51·0	30 15	E.N.E.	3	,,	Slight.	2h·20m. ,,	,,	4

TABLE B.—Record of Observations made on Board the 'Garland' during 1899.

B. PHYSICAL OBSERVATIONS—Firth of Clyde—*continued.*

Station, Date, and Hour.	End of Station.	Temperature. Air. Dry Bulb.	Water. Surface.	Water. Bottom.	Water. Depth in faths.	Wind. Direction.	Wind. Force.	Weather.	Sea.	Tide.	Barometer.	Transparency. Fathoms.
1899.												
Dec. 15. 1.23 p.m.	S.W.	41·72	49·1	50·9 49·3	31 15½	S.S.W.	5	Overcast.	Rough.	3 h. ebb.	29·78	4
3.17 p.m.	N.E.	43·16	49·0	49·0 49·0	25 12½	,,	6	,,	Very rough.	5 ,,	29·75	4
Station XII.												
May 31. 8.30 a.m.	W.	57·74	50·4	46·2 46·9	42½ 21¼	..	..	Fine, slight haze.	Calm.	3½ ,,	30·26	4½
10.55 a.m.	E.	64·76	51·3	46·8 47·0	34 17	,,	..	Fine.	,,	About low water.	30·27	5½
June 12. 10.5 p.m.	E.	59·00	57·8	47·2 47·8	33½ 16¾	S.W.	2	Fine, cl'dy.	Slight.	1¼ h. fl.	30·12	..
0.45 a.m.	W.	59·00	56·8	48·6 46·8	44 22	Variable	..	Fi e.	Calm.	4 ,,	,,	..
June 17. 7.30 a.m.	E.	56·66	59·2	48·7 48·0	35 17½	N.E.	2	Dull and misty.	Smooth.	1½ h. ebb.	30·03	5¼
9.58 a.m.	W.	59·90	59·2	48·8 49·0	43 21½	,,	2	Fine, misty.	,,	4 ,,	30·01	6
July 18. 8.50 p.m.	E.	59·36	59·1	48·0 51·0	35 17½	S.	1	Heavy rain.	,,	1½ ,,	29·99	..
11.15 p.m.	W.	57·56	56·3	48·0 50·0	42 21	,,	2	Continuous rain.	Calm.	3h. 50m. ,,	29·96	..
July 24. 3.15 p.m.	E.	59·90	55·5	50·9 50·3	33 16½	N.W.	4	Fine, clear.	Choppy.	2 h. ebb.	30·6	4¾
5.25 p.m.	W.	59·54	58·2	50·4 49·0	40 20	,,	4	Cloudy.	Slight.	4h.10m. ,,	30·08	5
Sept. 14. 8.33 a.m.	E.	58·28	58·0	52·7 56·5	33 16½	W.S.W.	5	Dull and cloudy.	Choppy.	2h.40m. ,,	30·02	5
10.46 a.m.	W.	60·08	58·1	51·0 53·1	39 19½	N.W.	4	Fine.	Slight.	5 h. ebb	,,	8
Oct. 12. 11.7 a.m.	E.	51·80	53·9	54·3 53·7	34½ 17¼	,,	6	Cloudy.	Choppy.	½ h. fl.	29·46	5
1.27 p.m.	W.	51·44	53·8	53·8 54·0	37 18½	,,	6	Squally.	Rough.	2h.50m. ,,	,,	4
Nov. 25. 7.53 a.m.	E.	51·62	51·9	52·0 50·9	35 17½	W.	4	Overcast.	Slight.	½ h. ebb	30·17	6
10.15 a.m.	W.	51·62	50·5	52·4 50·5	47 23½	S.W.	3	Fine, cl'dy.	,,	5½ ,,	30·20	6
Dec. 18. 10.45 a.m.	E.	41·36	49·0	49·6 49·0	34 17	S	2	Overcast.	Calm.	4½ h. fl.	30·09	4½
1.0 p.m.	W.	43·16	49·0	49·6 49·3	45 22½	,,	4	,,	Slight.	40 m. ebb	30·07	3½
Station XIII.												
May 26. 9.35 a.m.	S.W.	51·98	47·8	46·2	25	S.W.	2	Fine, cl'dy.	Smooth.	3 h. fl.	30·14	5½
11.0 a.m.	N.E.	53·24	48·1	46·7 47·3	34½ 17¼	,,	2	,,	,,	4½ ,,	30·16	5½
June 20. 0.35 p.m.	S.W.	54·50	51·9	46·9 48·2	34 17	E.S.E.	4	Cloudy.	,,	5 h. ebb.	29·52	4
2.0 p.m.	N.E	55·58	53·1	47·4 48·0	36 18	Variable	1	Dull and showery.	,,	3½ ,,	29·53	4

TABLE B.—Record of Observations made on Board the 'Garland' during 1899.

B. PHYSICAL OBSERVATIONS—Firth of Clyde—*continued.*

Station, Date, and Hour.	End of Station.	Temperature.				Wind.		Weather.	Sea.	Tide.	Barometer.	Transparency. Fathoms.
		Air.	Water.									
		Dry Bulb.	Surface.	Bottom.	Depth in faths.	Direction.	Force.					
1899.												
July 27. 2.0 p.m.	N.E.	57·92	52·2	48·5 50·0	35 17½	W.N.W.	5	Cloudy.	Slight.	4h. 50m. fl.	30·27	5
3.30 p.m.	S.W.	57·38	51·9	49·0 50·0	27 13½	,,	5	,,	Smooth.	Just after high w ter.	,,	4
Sept. 27. 0.45 p.m.	S.W.	54·86	51·9	51·7 51·9	23 11½	N.N.W.	4	Fine, passing showers.	,,	1¼ h. fl.	29·43	5
2.10 p.m.	N.E.	53·96	53·00	52·0 51·9	35 17½	,,	2	,,	,,	2h. 40m. fl.	29·42	5½
Oct. 18. 8.27 a.m.	S.W.	55·4	51·8	51·7 51·7	28 14	S.	2	Overcast.	Calm.	3h. 40m. ,,	30·20	5
9.55 a.m.	N.E.	55·22	52·0	52·0 51·7	35 17½	Calm.	..	Misty, overcast.	Smooth.	5 h. fl.	30·22	5½
Nov. 27. 10.0 a.m.	S.W.	51·08	50·0	51·9 51·3	31 15½	W.	5	Showery.	Slight.	3 h. ebb.	30·18	4
11.27 a.m.	N.E.	51·26	51·0	52·0 51·5	34 17	W.S.W.	5	Cloudy.	,,	4h.40m. ,,	30·19	4½
Dec. 20. 8.47 a.m.	S.W.	39·20	47·2	47·8 47·3	23 11½	E.S.E.	6	Dull, continuous rain.	,,	1 h. fl.	30·10	3½
10.20 a.m.	N.E.	39·20	47·0	48·2 46·9	28 14	,,	6	,,	,,	2½ ,,	30·12	3½
Station XIV.												
May 26. 0.25 p.m.	N.E.	56·84	48·4	46·9 47·3	31 15½	S.W.	2	Fine, bright.	Smooth.	5½ ,,	30·16	6
June 20. 11.10 a.m.	N.E.	58·10	54·8	47·6 48·1	25 12½	E.N.E.	2	Cloudy, dull.	,,	2¼ h. ebb	29·53	4½
0.35 p.m.	S.W.	55·58	53·1	47·4 48·0	36 18	Variable	1	Dull and raining.	,,	3½ ,,	,,	4
July 27. 11.55 a.m.	N.E	57·92	53·2	49·2 50·0	23 11½	W.	5	Showery.	Slight.	2¾ h. fl.	30·25	4
2.0 p.m.	S.W.	57·92	52·2	48·5 50·0	35 17½	W.N.W.	5	Cloudy.	,,	4h.50m. ,,	30·27	5
Sept. 27. 2.10 p.m.	S.W.	53·96	53·0	52·0 51·9	35 17½	N.N.W.	2	Fine, passing showers.	Smooth.	2h.40m. ,,	29·42	5½
4.10 p.m.	N.E.	53·96	52·4	51·9 52·0	30 15	N.	3	Fine.	Calm.	4h.40m. ,,	29·45	4
Oct. 18. 9.55 a.m.	S.W.	55·22	52·0	52·0 51·7	35 17½	Calm.	..	Mist, overcast.	,,	5 h. fl.	30·22	5½
11.30 a.m.	N.E.	55·58	51·6	52·0 51·8	27 13½	Variable	1	,,	Smooth.	25m. ebb.	30·23	7
Nov. 27. 11.27 a.m.	S.W.	51·26	51·0	52·0 51·5	34 17	W.S.W.	5	Cloudy.	Slight.	4h.40m. ,,	30·19	4½
1.5 p.m.	N.E.	50·18	50·9	51·9 50·5	30 15	,,	5	,,	,,	Low water.	,,	5
Dec. 21. 0.35 p.m.	N.E.	42·26	45·0	48·0 47·2	25 12½	E.	2	,,	Ripple.	4 h. fl.	30·30	4½
2.20 p.m.	S.W.	41·72	45·7	48·0 48·1	30 15	,,	2	Overcast.	Smooth.	5¾ ,,	30·29	5

TABLE B.—Record of Observations made on Board the 'Garland' during 1899.

B. PHYSICAL OBSERVATIONS.—Firth of Clyde—*continued.*

Station, Date, and Hour.	End of Station.	Temperature.				Wind.		Weather.	Sea.	Tide.	Barometer.	Transparency. Fathoms.
		Air.	Water.									
		Dry Bulb.	Surface.	Bottom.	Depth in faths.	Direction.	Force.					
Station XV.												
1899. June 21. 9.43 a.m.	S.W.	61·70	57·2	48·0 48·5	34 17	N.E.	4	Cloudy.	Slight.	5¾ h. fl.	29·62	5¼
11.35 a.m.	N.E.	65·66	59·2	48·1 47·5	35 17½	,,	2	,,	Smooth.	1h.35m.eb.	29·64	5
July 27. 9.55 a.m.	N.E.	57·74	54·0	48·0 52·1	36½ 18¼	W.	5	Cloudy, passing showers.	Slight.	¾ h. fl.	30·23	3
11.27 a.m.	S.W.	57·74	54·0	48·0 52·0	32 16	,,	5	Showery.	Smooth.	2¼ ,,	30·24	4
Sept. 28. 8.6 a.m.	S.W.	44·06	49·1	51·4 51·9	35 17½	E.N.E.	2	Fine.	,,	1h.40m.eb.	29·63	3½
10.0 a.m.	N.E.	46·04	47·9	48·7 51·7	42 21	,,	1	Fine, cl'dy.	Quite calm.	3h.35m. ,,	29·64	3½
Oct. 18. 12 noon.	S.W.	56·30	51·4	51·0 51·6	34 17	S.S.W.	2	Overcast.	Calm.	55 m. fl.	30·23	5
1.40 p.m.	N.E.	57·38	51·8	49·8 51·4	40 20	,,	4	,,	Smooth.	2h.35m.eb.	30·22	6
Nov. 27. 2.17 p.m.	S.W.	52·70	50·4	52·0 50·6	30 15	W. by S.	5	Showery.	Slight.	1¼ h. fl.	30·19	5
4.5 p.m.	N.E.	51·62	50·0	50·5 50·2	40 20	W.	6	Overcast, continuous rain.	,,	3 ,,	30·20	3½
Dec. 21. 10 50 a.m.	N.E.	41·54	45·0	48·0 47·2	25 12½	E.	2	Cloudy.	Ripple.	2¼ ,,	30·30	4
0.18 p.m.	S.W.	41·72	44·0	50·0 47·8	33 16½	,,	2	,,	,,	3¾ ,,	,,	4
Station XVI.												
May 27. 9.5 a.m.	N.E.	52·52	48·4	46·7 46·1	53 26½	..	..	Fine, clear.	Calm.	1½ h. fl.	30·33	5
10.40 a.m.	S.W.	59·90	49·0	46·7 46·0	61 30½	,,	..	,,	,,	3¼ ,,	30·38	5
June 22. 8.17 a.m.	N.E.	59·00	49·0	47·0 46·9	63 31½	N.E.	1	Dull, cl'dy.	,,	3h.40m. ,,	29·80	3
10.55 a.m.	S.W.	59·90	53·0	47·4 47·6	68 34	S.E.	3	,,	Smooth.	High water	29·82	4
July 26. 1.20 p.m.	N.E.	58·96	56·2	47·9 47·7	61 30½	W.	6	Fine, cl'dy.	Slight.	5 h. fl.	30·07	2
3.40 p.m.	S.W.	58·82	55·0	47·9 50·3	51 25½	,,	6	Fine.	Choppy.	1h. 5m. eb.	30·10	3
Sept 28. 1.0 p.m.	S.W.	53·24	51·0	48·0 51·5	62 31	W.S.W.	2	Fine, clear.	Quite calm.	¼ h. fl.	29·67	5
3.15 p.m.	N.E.	56·30	56·3	48·0 51·0	60 30	S.W.	1	,,	,,	2½ ,,	29·68	5
Oct. 19. 7.15 a.m.	S.W.	50·36	51·1	48·0 48·2	62 31	Calm.	..	Fine, haze.	Smooth.	1h. 20m. fl.	30·27	5½
10.7 a.m.	N.E.	54·32	52·0	48·0 51·1	60 30	,,	..	,,	,,	4¼ h. fl.	30·28	5
Nov. 28. 11.47 a.m.	N.E.	50·00	49·7	49·0 49·8	60 30	S.W.	7	Squally, continuous rain.	Choppy.	3¾ h. ebb.	30·18	2½
2.15 p.m.	S.W.	51·62	48·0	50·5 50·0	66 33	,,	6	,,	,,	Low water.	30·20	4

TABLE B.—Record of Observations made on Board the 'Garland' during 1899.

B. PHYSICAL OBSERVATIONS—Firth of Clyde—*continued.*

Station, Date, and Hour.	End of Station.	Temperature. Air. Dry Bulb.	Water. Surface.	Water. Bottom.	Depth in faths.	Wind. Direction	Wind. Force.	Weather.	Sea.	Tide.	Barometer.	Transparency. Fathoms.
Station XVII.												
1899. May 27.												
6.40 a.m.	N.E.	42·62	48·9	47·4	13	Calm.	..	Fine, clear.	Smooth.	5 h. ebb.	30·33	5
8.16 a.m.	S.W.	50·18	48·0	47·4	35	..	..	,,	Calm.	½ h. fl.	,,	4½
				46·6	17½							
June 23.												
10.10 a.m.	N.E.	60·80	47·8	46·5	12½	Variable	1	Cloudy.	Smooth.	4h. 40m. fl.	29·92	5
11.40 a.m.	S.W.	59·72	48·0	47·2	33	,,	1	Dull, cl'dy.	,,	Highwater	,,	4½
				46·7	16½							
July 26.												
7.25 a.m.	N.E.	55·04	57·9	57·4	13	W.	6	Fine, cl'dy.	Slight.	5h.10m.eb.	30·00	2 ft.
9.10 a.m.	S.W.	58·10	56·2	55·9	34	W.S.W.	6	,,	,,	¾ h. fl.	,,	4 ,,
				56·1	17							
Sept. 29.												
6.13 a.m.	N.E.	41·00	50·1	48·2	13	Variable	1	Cloudy.	Smooth.	4½ ,,	29·68	4
7.40 a.m.	S.W.	41·18	49·9	48·2	35	,,	1	Overcast, fine rain.	,,	5¾ ,,	29·70	4
				51·6	17½							
Oct. 24.												
11.33 a.m.	N.E.	51·26	51·0	51·0	13	..	..	Fine.	Quite smooth.	2¼ ,,	30·28	7¼
1.20 p.m.	S.W.	53·60	51·0	50·0	35	W.S.W.	2	Fine, cl'dy,	Smooth.	4h. 5m. fl.	30·29	6
				51·2	17½							
Nov. 28.												
9.15 a.m.	N.E.	50·72	49·2	50·0	15	W.	7	Showery.	Slight.	1¼ h. ebb.	30·18	1½
11.0 a.m.	S.W.	50·18	49·9	50·4	37	W.S.W.	7	,,	,,	3 ,,	30·19	1½
				50·0	18½							
Dec. 21.												
7.55 a.m.	N.E	41·54	46·2	50 0	14	N.E.	4	Cloudy.	Ripple.	5½ ,,	30·28	3
9.27 a.m.	S.W.	41·90	45·0	50·5	36	E.N.E.	4	,,	,,	1 h. fl.	,,	5
				49·4	18							

TABLE D.—Showing the Quantities of Fish caught by Line in 1899 within the Moray Firth (inside a Line between Duncansby Head and Rattray Point), and the Number of Shots of the Boats by which the Fish were caught.

WICK DISTRICT.

Months.	Number of Shots.		Cod.		Ling.		Torsk (Tusk).		Saithe (Coalfish).		Haddock.		Whiting.		Turbot.		Halibut.		Sole (Lemon Sole).		Flounder, Plaice, Brill.		Eel.		Skate.		Other kinds of White Fish.		Total of Line-caught Fish.	
	Large Boats.	Small Boats.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.
Jan.	549	509	3,315	3·133	284	0·268	13	0·012	2,219	2·097	133	0·125	.	.	24	0·022	99	0·093	.	.	.	.	92	0·087	535	0·5	102	0·096	6,816	6·442
Feb.	335	307	3,152	4·9	433	0·674	.	.	583	0·9	24	0·037	.	.	13	0·02	112	0·174	.	.	39	0·06	67	0·104	678	1·056	58	0·09	5,159	8·035
March	252	272	2,297	4·383	378	0·721	51	0·097	320	0·61	86	0·164	.	.	18	0·034	132	0·251	.	.	52	0·099	75	0·143	675	1·288	83	0·158	4,167	7·952
April	78	318	718	1·813	140	0·353	2	0·005	206	0·52	88	0·222	.	.	4	0·01	43	0·108	3	0·007	16	0·04	5	0·012	149	0·376	49	0·123	1,423	3·593
May	26	186	513	2·42	24	0·113	.	.	339	1·599	18	0·084	.	.	.	.	3	0·014	.	.	44	0·207	.	.	7	0·033	20	0·094	968	4·566
June	120	173	587	2·003	22	0·075	.	.	618	2·109	13	0·044	.	.	.	.	.	.	.	.	14	0·047	.	.	4	0·013	32	0·109	1,290	4·402
July	200	39	807	3·376	.	.	.	.	533	2·23	63	0·263	.	.	.	.	.	.	.	.	.	.	.	.	.	.	26	0·108	1,429	5·979
Aug.	300	234	1,276	2·389	.	.	.	.	984	1·842	48	0·09	.	.	.	.	.	.	.	.	25	0·046	.	.	.	.	68	0·127	2,401	4·496
Sept.	.	425	385	0·905	2	0·004	.	.	201	0·472	46	0·108	.	.	.	.	.	.	.	.	27	0·063	.	.	.	.	49	0·115	710	1·67
Oct.	.	477	404	0·846	.	.	.	.	155	0·324	42	0·088	.	.	.	.	.	.	.	.	23	0·048	.	.	.	.	57	0·119	681	1·427
Nov.	4	175	377	2·106	8	0·044	.	.	42	0·234	106	0·592	.	.	.	.	4	0·022	.	.	2	0·011	17	0·094	6	0·033	45	0·251	607	3·391
Dec.	1	134	253	1·874	2	0·014	.	.	130	0·963	39	0·288	.	.	1	0·007	1	0·007	2	0·014	12	0·088	5	0·037	7	0·051	13	0·096	465	3·444
Totals,	1,865	3,249	14,084	2·754	1,293	0·252	66	0·012	6,330	1·237	706	0·138	.	.	60	0·011	394	0·077	5	0·0009	254	0·049	261	0·051	2,061	0·403	602	0·117	26,116	5·106

TABLE D.—*continued.*—LYBSTER DISTRICT.

Months.	Number of Shots.		Cod.		Ling.		Torsk (Tusk).		Saithe (Coalfish).		Haddock.		Whiting.		Turbot.		Halibut		Sole (Lemon Sole).		Flounder, Plaice, Brill.		Eel.		Skate.		Other kinds of White Fish.		Total of Line-caught Fish.	
	Large Boats.	Small Boats.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.
Jan.	108	220	706	2·152	.	.	.	.	57	0·173	209	0·637	.	.	.	.	.	.	.	.	.	.	.	.	.	.	58	0·176	1,030	3·14
Feb.	90	120	840	4·0	.	.	.	.	46	0·219	103	0·49	.	.	.	.	6	0·028	.	.	.	.	11	0·052	.	.	80	0·38	1,086	5·171
March	18	106	192	1·548	.	.	.	.	.	.	17	0·137	.	.	.	.	1	0·008	.	.	.	.	.	.	.	.	14	0·112	224	1·806
April	.	90	110	1·222	.	.	.	.	.	.	8	0·088	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	0·044	122	1·355
May	.	147	139	0·945	.	.	.	.	29	0·197	13	0·088	.	.	.	.	.	.	.	.	.	.	.	.	.	.	17	0·115	198	1·346
June	29	116	154	1·062	.	.	.	.	34	0·234	5	0·034	.	.	.	.	.	.	.	.	.	.	.	.	.	.	22	0·151	215	1·482
July	652	39	145	0·21	.	.	.	.	83	0·12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	30	0·043	258	0·373
Aug.	1,008	37	114	0·109	.	.	.	.	57	0·054	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	49	0·046	220	0·21
Sept.	23	76	111	1·121	.	.	.	.	30	0·303	6	0·06	.	.	.	.	.	.	.	.	.	.	37	0·373	.	.	25	0·252	209	2·111
Oct.	.	105	102	0·971	.	.	.	.	15	0·142	160	1·523	.	.	.	.	.	.	.	.	.	.	.	.	.	.	46	0·438	323	3·076
Nov.	.	73	69	0·945	.	.	.	.	13	0·178	182	2·493	.	.	.	.	.	.	.	.	.	.	.	.	.	.	25	0·342	289	3·958
Dec.	4	20	55	2·291	.	.	.	.	.	.	65	2·708	.	.	.	.	.	.	.	.	.	.	.	.	.	.	15	0·625	135	5·625
Totals,	1,932	1,149	2,737	0·888	.	.	.	.	364	0·118	768	0·249	.	.	.	.	7	0·002	.	.	.	.	48	0·015	.	.	385	0·124	4,309	1·398

TABLE D.—*continued.*—HELMSDALE DISTRICT.

Months.	Number of Shots.		Cod.		Ling.		Torsk (Tusk).		Saithe (Coalfish).		Haddock.		Whiting.		Turbot.		Halibut.		Sole (Lemon Sole).		Flounder, Plaice, Brill.		Eel.		Skate.		Other kinds of White Fish.		Total of Line-caught Fish.	
	Large Boats.	Small Boats.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.
Jan.	140	360	1,479	2·958	12	0·024	.	.	90	0·18	654	1·308	11	0·022	.	.	6	0·012	.	.	59	0·118	19	0·038	18	0·036	109	0·218	2,457	4·914
Feb.	133	361	1,492	3·02	13	0·026	.	.	23	0·046	218	0·441	2	0·004	.	.	6	0·012	.	.	453	0·917	12	0·024	9	0·018	33	0·066	2,261	4·576
March	109	193	695	2·301	.	.	.	.	19	0·062	32	0·106	2	0·006	.	.	4	0·013	.	.	223	0·738	2	0·006	6	0·019	.	.	983	3·255
April	.	166	147	0·885	.	.	.	.	20	0·12	21	0·126	.	.	.	.	.	.	.	.	66	0·397	.	.	.	.	50	0·301	304	1·831
May	.	220	185	0·84	.	.	.	.	44	0·2	56	0·254	.	.	.	.	.	.	.	.	56	0·254	.	.	.	.	65	0·295	406	1 845
June	.	198	130	0·656	.	.	.	.	56	0·282	56	0·282	.	.	.	.	.	.	.	.	13	0·065	.	.	.	.	40	0·202	295	1·49
July	.	51	49	0·96	.	.	.	.	28	0·55	38	0·745	.	.	.	.	.	.	.	.	30	0·588	33	0·647	.	.	15	0·294	193	3·784
Aug.	.	53	93	1·754	.	.	.	.	48	0·905	117	2·207	8	0·15	.	.	.	.	.	.	24	0·452	.	.	.	.	.	.	290	5·471
Sept.	.	323	193	0·597	.	.	.	.	26	0·08	844	2·613	13	0·04	.	.	.	.	.	.	197	0·609	21	0·065	.	.	.	.	1,294	4·006
Oct.	.	523	320	0·611	.	.	.	.	10	0·019	1,429	2·732	18	0·034	.	.	.	.	.	.	150	0·286	150	0·286	.	.	.	.	2,077	3·971
Nov.	.	327	303	0·926	10	0·03	.	.	13	0·04	987	3·018	12	0·036	.	.	.	.	.	.	21	0·064	30	0·091	9	0·027	62	0·189	1,447	4·425
Dec.	.	155	135	0·87	.	.	.	.	.	.	583	3·761	.	.	.	.	.	.	.	.	.	.	4	0·025	.	.	23	0·148	745	4·806
Totals,	382	2,930	5,221	1·576	35	0·01	.	.	377	0·113	5,035	1·52	66	0·019	.	.	16	0·004	.	.	1,292	0·39	271	0·081	42	0·012	397	0·119	12,752	3·85

TABLE D.—*continued.*—CROMARTY DISTRICT.

Months.	Number of Shots.		Cod.		Ling.		Torsk (Tusk).		Saithe (Coalfish).		Haddock.		Whiting.		Turbot.		Halibut.		Sole (Lemon Sole).		Flounder, Plaice, Brill.		Eel.		Skate.		Other kinds of White Fish.		Total of Line-caught Fish.	
	Large Boats.	Small Boats.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.
	.	655	459	0·7	.	.	.	.	14	0·021	706	1·077	4	0·006	.	.	1	0·001	.	.	.	.	.	.	2	0·003	37	0·056	1,223	1·867
Feb.	.	837	445	0·531	.	.	.	.	6	0·007	553	0·66	.	.	.	.	.	.	.	.	349	0·416	.	.	2	0·002	115	0·137	1,470	1·756
March	.	609	297	0·487	.	.	.	.	9	0·014	353	0·579	2	0·003	.	.	.	.	.	.	247	0·405	.	.	8	0·013	14	0·023	930	1·527
April	.	356	209	0·587	.	.	.	.	3	0·008	314	0·882	3	0·008	.	.	.	.	.	.	29	0·081	.	.	14	0·039	93	0·261	665	1·868
May	.	509	408	0·801	.	.	.	.	35	0·068	332	0·652	4	0·007	.	.	.	.	.	.	90	0·176	.	.	53	0·104	75	0·147	997	1·958
June	.	575	299	0·52	.	.	.	.	.	.	304	0·528	2	0·003	.	.	½	.	.	.	108	0·187	.	.	14	0·024	45	0·078	772½	1·343
July	2	144	47	0·321	.	.	.	.	9	0·061	192	1·315	5	0·034	.	.	.	.	.	.	43	0·294	.	.	6	0·041	16	0·109	318	2·178
Aug.	59	150	44	0·21	.	.	.	.	.	.	218	1·043	3	0·014	.	.	.	.	.	.	64	0·306	.	.	.	.	43	0·205	372	1·779
Sept.	.	525	108	0·205	.	.	.	.	.	.	673	1·281	2	0·003	.	.	.	.	.	.	104	0·198	.	.	.	.	51	0·097	938	1·786
Oct.	.	689	226	0·328	.	.	.	.	.	.	992	1·439	8	0·011	.	.	.	.	.	.	87	0·126	.	.	.	.	78	0·113	1,391	2·018
Nov.	.	483	234	0·484	.	.	.	.	.	.	603	1·248	9	0·018	.	.	.	.	.	.	11	0·022	.	.	.	.	75	0·155	932	1·929
Dec.	.	614	444	0·723	2	.	.	.	16	0·026	693	1·128	10	0·016	.	.	.	.	.	.	9	0·014	.	.	.	.	84	0·136	1,258	2·048
Totals,	61	6,146	3,220	0·518	2	.	.	.	92	0·014	5,811	0·95	52	.	.	.	1½	0·002	.	.	1,180	0·183	.	.	99	0·015	726	0·116	11,183	1·815

TABLE D.—*continued.*—FINDHORN DISTRICT.

Months.	Number of Shots.		Cod.		Ling.		Torsk (Tusk).		Saithe (Coalfish).		Haddock.		Whiting.		Turbot.		Halibut.		Sole (Lemon Sole).		Flounder, Plaice, Brill.		Eel.		Skate.		Other kinds of White Fish.		Total of Line-caught Fish.	
	Large Boats.	Small Boats.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.
Jan.	428	1,232	2,232	1·344	48	0·028	.	.	134	0·08	2,310	1·391	3	0·001	.	.	17	0·01	.	.	9	0·005	25	0·015	66	0·039	19	0·011	4,863	2·929
Feb.	384	1,126	2,536	1·679	44	0·029	.	.	64	0·42	1,753	1·16	3	0·002	.	.	14	0·009	.	.	399	0·264	7	0·004	36	0·023	15	0·009	4,871	3·225
March	752	629	3,139	2·273	47	0·034	.	.	41	0·029	1,038	0·751	4	0·002	.	.	23	0·016	.	.	405	0·293	2	0·001	101	0·073	8	0·005	4,808	3·481
April	158	568	592	0·815	56	0·077	.	.	42	0·057	461	0·635	.	.	.	.	15	0·02	.	.	214	0·294	.	.	73	0·1	10	0·013	1,463	2·015
May	25	720	270	0·362	39	0·052	.	.	72	0·096	685	0·919	13	0·017	.	.	6	0·008	.	.	87	0·117	.	.	21	0·028	12	0·016	1,205	1·617
June	20	771	87	0·109	.	.	.	.	4	0·005	898	1·135	33	0·041	.	.	.	.	.	.	39	0·049	.	.	.	.	9	0·011	1,070	1·352
July	1,219	492	30	0·017	.	.	.	.	12	0·007	447	0·261	83	0·048	.	.	.	.	.	.	62	0·036	.	.	.	.	4	0·002	638	0·372
Aug.	1,976	557	12	0·004	.	.	.	.	.	.	1,038	0·409	131	0·051	.	.	.	.	.	.	22	0·008	.	.	.	.	3	0·001	1,206	0·476
Sept.	72	957	104	0·103	.	.	.	.	.	.	1,804	1·787	71	0·07	.	.	.	.	.	.	210	0·208	.	.	.	.	5	0·005	2,194	2·174
Oct.	119	1,559	223	0·132	.	.	.	.	46	0·027	3,502	2·087	20	0·012	.	.	.	.	.	.	347	0·206	.	.	.	.	12	0·007	4,150	2·473
Nov.	117	1,324	281	0·195	.	.	.	.	29	0·02	2,349	1·63	16	0·011	.	.	.	.	.	.	172	0·119	.	.	.	.	6	0·004	2,853	1·979
Dec.	107	968	433	0·402	.	.	.	.	7	0·006	2,015	1·874	14	0·013	.	.	.	.	.	.	32	0·029	.	.	.	.	3	0·002	2,504	2·329
Totals,	5,377	10,883	9,939	0·611	234	0·014	.	.	451	0·027	18,300	1·125	391	0·024	.	.	75	0·004	.	.	1,998	0·122	34	0·002	297	0·018	106	0·006	31,825	1·957

TABLE D.—*continued.*—BUCKIE DISTRICT.

Months.	Number of Shots.		Cod.		Ling.		Torsk (Tusk).		Saithe (Coalfish).		Haddock.		Whiting.		Turbot.		Halibut.		Sole (Lemon Sole).		Flounder, Plaice, Brill.		Eel.		Skate.		Other kinds of White Fish.		Total of Line-caught Fish.	
	Large Boats.	Small Boats.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age
Jan.	544	1,085	3,031	1·86	264	0·162	3	0·001	300	0·184	3,737	2·294	.	.	.	.	48	0·029	.	.	.	.	29	0·017	240	0·147	18	0·011	7,670	4·708
Feb.	446	865	2,682	2·045	86	0·065	.	.	132	0·1	2,685	2·048	.	.	.	.	41	0·031	.	.	5	0·003	2	0·001	150	0·114	.	.	5,783	4·411
March	569	267	3,019	3·611	97	0·116	5	0·006	173	0·207	758	0·906	.	.	.	.	39	0·046	.	.	6	0·007	16	0·019	269	0·321	79	0·094	4,461	5·336
April	53	614	905	1·356	92	0·137	8	0·012	37	0·055	376	0·563	.	.	.	.	42	0·062	.	.	.	.	.	.	103	0·154	23	0·034	1,586	2·377
May	1	1,212	605	0·498	32	0·026	.	.	23	0·019	1,189	0·98	.	.	.	.	4	0·003	.	.	.	.	.	.	9	0·007	.	.	1,862	1·535
June	.	524	297	0·566	.	.	.	.	222	0·423	364	0·694	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	883	1·685
July	.	271	28	0·103	.	.	.	.	24	0·088	181	0·668	14	0·051	.	.	.	.	.	.	.	.	7	0·025	.	.	.	.	254	0·937
Aug.	.	174	18	0·103	.	.	.	.	.	.	302	1·735	51	0·293	.	.	.	.	.	.	6	0·034	15	0·086	.	.	.	.	392	2·252
Sept.	10	316	163	0·5	.	.	.	.	.	.	1,247	3·825	4	0·012	.	.	.	.	.	.	10	0·03	.	.	.	.	.	.	1,424	4·368
Oct.	74	1,259	533	0·399	.	.	.	.	.	.	3,860	2·895	3	0·002	.	.	.	.	.	.	18	0·013	.	.	.	.	.	.	4,414	3·311
Nov.	124	983	375	0·338	.	.	.	.	.	.	2,839	2·564	.	.	.	.	.	.	.	.	.	.	2	0·001	6	0·005	.	.	3,222	2·91
Dec.	119	906	1,008	0·983	.	.	.	.	.	.	1,967	1·919	7	0·006	.	.	.	.	.	.	.	.	10	0·009	19	0·018	12	0·011	3,023	2·949
Totals,	1,940	8,476	12,584	1·215	571	0·054	16	0·001	919	0·087	19,518	1·872	79	0·007	.	.	174	0·016	.	.	45	0·004	81	0·007	796	0·076	132	0·012	34,915	3·357

TABLE D.—*continued.*—BANFF DISTRICT.

Months.	Number of Shots.		Cod.		Ling.		Torsk (Tusk).		Saithe (Coalfish).		Haddock.		Whiting.		Turbot.		Halibut.		Sole (Lemon Sole).		Flounder, Plaice, Brill.		Eel.		Skate.		Other kinds of White Fish.		Total of Line-caught Fish.	
	Large Boats.	Small Boats.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.	Cwt.	Aver-age.
Jan.	232	1,058	1,419	1·1	436	0·338	.	.	48	0·037	1,187	0·92	36	0·027	.	.	40	0·031	.	.	22	0·017	21	0·016	150	0·116	98	0·076	3,457	2·68
Feb.	268	1,347	766	0·474	179	0·110	.	.	29	0·017	1,793	1·110	20	0·012	.	.	33	0·02	.	.	12	0·007	8	0·004	75	0·046	104	0·064	3,019	1·869
March	234	755	444	0·448	56	0·056	.	.	25	0·025	1,080	1·092	6	0·006	.	.	12	0·012	1	0·001	11	0·011	4	0·004	18	0·018	39	0·039	1,696	1·714
April	78	520	135	0·225	2	0·003	.	.	38	0·063	584	0·976	6	0·01	.	.	.	.	.	.	12	0·02	.	.	.	.	43	0·071	820	1·371
May	.	272	84	0·308	25	0·091	.	.	229	0·842	460	1·691	27	0·099	.	.	10	0·036	.	.	5	0·018	.	.	8	0·029	23	0·084	871	3·202
June	.	257	82	0·319	5	0·019	.	.	403	1·568	270	1·05	31	0·120	.	.	.	.	.	.	4	0·015	.	.	.	.	17	0·066	812	3·159
July	.	198	15	0·075	2	0·01	.	.	63	0·318	346	1·747	31	0·156	.	.	.	.	.	.	2	0·01	.	.	.	.	5	0·025	464	2·343
Aug.	.	266	10	0·037	2	0·007	.	.	15	0·056	683	2·567	96	0·361	.	.	.	.	.	.	7	0·026	.	.	.	.	20	0·075	833	3·131
Sept.	13	989	265	0·264	.	.	.	.	.	.	3,091	3·084	119	0·118	.	.	.	.	.	.	17	0·016	.	.	.	.	119	0·118	3,611	3·603
Oct.	57	1,651	582	0·340	5	0·002	.	.	.	.	4,087	2·392	158	0·092	.	.	.	.	.	.	36	0·021	.	.	.	.	103	0·06	4,971	2·91
Nov.	100	1,306	461	0·327	5	0·003	.	.	.	.	2,269	1·613	94	0·066	.	.	.	.	.	.	74	0·052	2	0·001	5	0·003	96	0·068	3,006	2·138
Dec.	126	1,356	705	0·475	31	0·021	.	.	.	.	2,089	1·409	111	0·074	.	.	.	.	.	.	34	0·022	11	0·007	33	0·022	101	0·068	3,115	2·101
Totals,	1,108	9,975	4,968	0·448	748	0·067	.	.	850	0·376	17,939	1·618	735	0·066	.	.	95	0·008	1	0·00009	236	0·021	46	0·004	289	0·026	768	0·069	26,675	2·406

TABLE E.—TOTAL QUANTITIES OF FISH CAUGHT BY LINE IN 1899 WITHIN THE MORAY FIRTH (INSIDE A LINE BETWEEN DUNCANSBY HEAD AND RATTRAY POINT), AND THE NUMBER OF SHOTS OF THE BOATS BY WHICH THE FISH WERE CAUGHT.

Districts.	Number of Shots.		Cod.		Ling.		Torsk (Tusk).		Saithe (Coalfish).		Haddock.		Whiting.		Turbot.		Halibut.		Sole (Lemon Sole).		Flounder, Plaice, Brill.		Conger Eel.		Skate.		Other kinds of White Fish.		Total of Line-caught Fish.	
	Large Boats.	Small Boats.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.	Cwt.	Average.
Wick, .	1,865	3,249	14,084	2·754	1,293	0·252	66	0·012	6,330	1·237	706	0·138	.	.	60	0·011	394	0·077	5	0·0009	254	0·049	261	0·051	2,061	0·403	602	0·117	26,116	5·106
Lybster,	1,932	1,149	2,737	0·888	.	.	.	.	364	0·118	768	0·249	.	.	.	.	7	0·002	.	.	.	.	48	0·015	.	.	385	0·124	4,309	1·398
Helmsdale,	382	2,930	5,221	1·576	35	0·01	.	.	377	0·113	5,035	1·52	66	0·019	.	.	16	0·004	.	.	1,292	0·39	271	0·081	42	0·012	397	0·119	12,752	3·85
Cromarty,	61	6,146	3,220	0·518	2	0·0003	.	.	92	0·014	5,811	0·955	52	0·008	.	.	1½	0·0002	.	.	1,180	0·183	.	.	99	0·015	726	0·116	11,183	1·815
Findhorn,	5,377	10,883	9,939	0·611	234	0·014	.	.	451	0·027	18,300	1·125	391	0·024	.	.	75	0·004	.	.	1,998	0·122	34	0·002	297	0·018	106	0·006	31,825	1·957
Buckie,	1,940	8,476	12,584	1·21	571	0·054	16	0·001	919	0·087	19,518	1·872	79	0·007	.	.	174	0·016	.	.	45	0·004	81	0·007	796	0·076	132	0·012	34,915	3·357
Banff, .	1,108	9,975	4,968	0·448	748	0·067	.	.	850	0·076	17,939	1·618	735	0·066	.	.	95	0·008	1	0·00009	236	0·021	46	0·004	289	0·026	768	0·069	26,675	2·406
Totals,	12,665	42,808	52,753	0·952	2,883	0·052	82	0·001	9,383	0·169	68,075	1·229	1,323	0·023	60	0·001	762½	0·013	6	0·0001	5,005	0·089	741	0·013	3,584	0·064	3,116	0·056	147,775	2·666

II.—CONTRIBUTIONS TO THE LIFE-HISTORY OF THE EDIBLE CRAB (*Cancer pagurus*, Linn.).

By H. Chas. Williamson, M.A., B.Sc. (Plates I.-IV.).

CONTENTS.

The edible crab (*Cancer pagurus*, Linn.) is to be found on all the coasts of Great Britain and Ireland. It gives rise to important fisheries, the chief of which are in the English Channel, and on the east coasts of England and Scotland. Owing to the fact that the crab is found close to the shore, the fishery may be carried on with small boats. In 1877, as a result of the report of the Crab and Lobster Commission of 1876-7 the Fisheries (Oyster, Crab, and Lobster) Act was passed. With a view to develop the fishery, and to check a tendency to deterioration which was evident in certain districts, the measure prohibited the sale of (1) any crab less than $4\frac{1}{4}$ inches across the broadest part of the back, (2) any soft crab, (3) any berried crab. The first and second classes of crabs are practically unsaleable; berried crabs are seldom captured. The law, however, made an exception in the use of crabs for bait; so that while small, soft, and berried crabs could not be sold, they might be broken up for bait. The result was that the law, so far as protection was aimed at, was to a considerable extent inoperative. In certain places crab fishing is carried on more or less for the greater part of the year; in some districts, however, during autumn, when a considerable proportion of the catch consists of unsaleable crabs, viz., soft, and when the price falls in consequence of the inferior quality of some of the saleable crabs, viz. those which have just become hard, the fishermen discontinue this for some other mode of fishing. In Dunbar, a port which may be said to have devoted itself specially to crab fishing, the fishery is pursued during the whole year, with, however, intervals, during which the majority of the men take up the summer and winter herring fishing. Within the past few years the crab fisheries of England have attracted a large amount of attention from the District Committees, which were created by the Sea Fisheries Regulation Acts, 1888-1894. The shortcomings of the Act of 1877 have been recognised, and in various ways its provisions have been rendered more stringent by local bye-laws.* They have resulted in (1) an increase in the legal minimum size to 5 inches, in one district (Lancashire) to 6 inches; (2) the protection of small and soft crabs; (3) the institution of a close time, the main object of which is the protection of soft crabs. In the protection of crabs there is no difficulty such as is encountered in the case of fishes, where capture may result in serious injury. The crabs which may be protected by law can be returned to the sea uninjured.

As a necessary prelude to legislation, attention has been directed to the study of the life-history of the crab; and on this subject papers have been published by Wilson,† Meek,‡ and Cunningham.§ Much remains to be done, however, ere the life of this form and its relation to the industry can be regarded as fully known. Mr. W. E. Archer and Mr. H. M. Malan, H.M. Inspectors of Fisheries for England and Wales, in their report to the Board of Trade anent the proposal of the Northumberland Sea Fisheries Committee to institute a close season for crabs, said, *inter alia*:—"We think that if these considerations were pointed out to the Committee they might be moved to take steps to obtain more definite information respecting the life-histories of lobsters and crabs, which could not fail to be of the utmost importance, both to themselves and the country, on a question which at present gives rise to such conflicting opinions."

An important point is raised by the question whether or not an increase in the legal limit would tend to raise the average size of the crabs captured. On the East Coast the crabs are small; in Cornwall very large crabs are taken. The numbers of male crabs over 8 inches in breadth captured in the latter district is, as may be seen from Cunningham's report § (p. 20), considerable. The crabs caught at Dunbar do sometimes reach that size, one female, which came under my own observation, measuring $8\frac{3}{16}$ inches. Spence Bate ‖ was of the opinion "that the small size of the crabs on the East Coast is due to the temperature; and that Cornwall, where the largest crabs are taken, is the central habitat of the species." This is a view which is probably open to question. It may in part be due to the fact that the crab fishing is more actively pursued on the East Coast than in Cornwall. The Commissioners of 1876 reported, with regard to the fishing in Cornwall (p. x.), "that storms constantly interfere with the calling of the fishermen, and the weather itself imposes a natural close season without the intervention of Parliament." There is no evidence that the crab fishing in Scotland is declining, though very great fluctuations in the total catch appear from year to year (*vide* Table, p. 134). From 1895–1898 the number of creels owned by the fishermen increased from 71,968 to 77,157. How far the increase in gear is accountable for the increased take is an open question.

The institution of a close season with the view of protecting the soft crabs is a remedy which in the present condition of the inshore line fishing would press hardly on the fishermen of certain localities. In Dunbar, for example, the boats, which are small and undecked, are unfitted for the active prosecution of the line fishing. The boats are

* The new regulations are summarised on p. 140.

† Wilson, Northumberland Sea Fisheries Committee, Reports on the Crab Fishery, 1893 and 1895. Newcastle-on-Tyne.

‡ Meek, Northumberland Sea Fisheries Committee, Reports on the Trawling Excursions, 1897, 1898, 1899. Newcastle-on-Tyne.

§ Cunningham, Cornwall County Council, Report of the Executive Committee for Fisheries, 1897–98. Penzance, 1898.

‖ Reports on the Crab and Lobster Fisheries of England and Wales, of Scotland, and of Ireland [C. 1695], 1877. England, p. 56.

open, since, if they were decked, they would not be suitable for the transport of the large fleet of creels.

The present research* has been carried on with the view of adding to the knowledge of the life-history of the crab, upon which legislative interference with the fishery ought to be principally, if not altogether, based. A number of new facts are brought to bear upon such important questions as the size at maturity, the seasonal migrations, distribution, the season of casting, and other points.

Size of Crab at Maturity.

The Mature Female Crab.

There are three characters by which a mature female may be recognised, viz. (1) its being berried, (2) the ripeness of the ovary, (3) the presence of sperms in the spermatheca.

The first character is one which can only be applied as a test of maturity in a comparatively small number of cases, owing to the fact that the berried crab, unlike the berried lobster, is rarely captured in the creels. Cunningham† considers that the reason for this most likely is "that the movements of the female crab are hindered by the mass of spawn much more than are the movements of berried lobsters." While this may be the case to some extent, it seems probable that the berried crab is forced to keep in shelter, in some crevice or hole, where it will not be exposed to the attacks of other crabs. When not berried the abdomen (or tail) is the least vulnerable part of the body, but when it carries the large mass of eggs it is kept extended from the body, and could then be easily torn off. The berried crabs kept in the tanks at Dunbar did not appear to move about much, for the food (pieces of fish) which was scattered over the bottom of the tank was often left untouched, while in the tanks which contained unberried crabs the food was always devoured during the night, a fact probably due to the reluctance of the former to leave their retreats, where they lay half buried in the sand. This, no doubt, accounts for their absence from the creels; their occasional capture may have resulted from the fact that the creel has fallen quite close to where they lay hid. There is evidence, however, that the berried female undertakes a journey from deep water to the shallows.

If, then, the berried condition were the only standard, we should have few data upon which to found our conclusions. But, fortunately, it is possible, for several months afterwards, to recognise a crab which has borne and hatched its eggs. As Spence Bate‡ pointed out, after the eggs hatch, the empty egg-capsules remain attached to the swimmerets for some time. He added that they were got rid of when the crab cast. They are, however, in many cases thrown off before casting. The main mass of empty egg-capsules is sloughed off shortly after the eggs hatch, but a few may be detected on the bases of the endopodites (viz., on the posterior surface of base of endopodite of 1st and inner surface of base of 4th swimmeret) in some cases five months after that period. We thus have a very useful distinguishing mark of a mature female, and,

* I beg to acknowledge my indebtedness to Mr. W. Hutchison, Dunbar, for much valuable assistance. During my absence from Dunbar he took charge of the labelling experiments, and of the different crab statistics kept at Dunbar in 1899.

† Report of the Executive Committee for Fisheries, Cornwall County Council, for 1897-1898. Penzance, 1898, p. 5.

‡ Reports of the Crab and Lobster Fisheries of England, Wales, and Scotland. Buckland, Walpole and Young [C. 1695], 1877, p. 56.

moreover, one which is capable of wide application, since these crabs are common in the creels.

Wilson* has given some attention to the question of the size of the crab at maturity. He says that it had been repeatedly stated that the berried crabs that are got in the creaves (creels) are larger than 6 inches. The smallest berried female of which he had heard was one which Mr. Buglass, fishery officer, said measured about $4\frac{1}{2}$ inches, while the shell of another, $5\frac{7}{16}$ inches, was shown him by Mr. Story, fishery officer. The smallest crab which he observed with a ripening ovary was $5\frac{1}{8}$ inches across the back; none other was less than $5\frac{1}{2}$ inches. He sums up his conclusions as follows:—"After carefully examining many hundred crabs at all seasons, I am now convinced that the ordinary size of maturity of the female crabs of the Northumberland coast is above 6 inches. . . . A very small percentage are mature when under 6 inches; a considerable minority mature when between 6 and $6\frac{1}{2}$ inches; and between $6\frac{1}{2}$ and 7 inches the great majority are mature." Couch, in his "Cornish Fauna,"† says that the female crab begins to breed when the carapace is about 3 inches across. In his evidence, given before the Crab and Lobster Commission (p. 55), Mr. Roach, Plymouth, stated that he had once caught a berried crab 4 inches across, but that they are generally much larger.

The evidence which I have collected at Dunbar from the examination of berried crabs, and those having the empty egg-capsules still adhering to their swimmerets,‡ is given in the following Table; it does not bear out the conclusions arrived at by Wilson:—

SIZES OF MATURE CRABS (BERRIED CRABS AND CRABS WITH EMPTY EGG-CAPSULES).

Size. Ins.	Berried Crabs.	Crabs with Empty Egg-capsules	Total.	Size. Ins.	Berried Crabs.	Crabs with Empty Egg-capsules	Total.	Size. Ins.	Berried Crabs.	Crabs with Empty Egg-capsules	Total.	Size. Ins.	Berried Crabs.	Crabs with Empty Egg-capsules	Total.
$4\frac{7}{8}$	.	1	1	$5\frac{5}{8}$	4	3	7	$6\frac{3}{8}$	1	3	4	$7\frac{1}{8}$	.	.	.
5	.	.	.	$5\frac{3}{4}$	5	2	7	$6\frac{1}{2}$	4	2	6	$7\frac{1}{4}$	.	.	.
$5\frac{1}{8}$	.	1	1	$5\frac{7}{8}$	1	2	3	$6\frac{5}{8}$	1	2	3	$7\frac{3}{8}$	.	.	.
$5\frac{1}{4}$	.	3	3	6	3	1	4	$6\frac{3}{4}$	3	3	6	$7\frac{1}{2}$	.	2	2
$5\frac{3}{8}$	2	2	4	$6\frac{1}{8}$	.	1	1	$6\frac{7}{8}$	2	.	2	$7\frac{5}{8}$	1	.	1
$5\frac{1}{2}$	1	1	2	$6\frac{1}{4}$	3	3	6	7	1	1	2	$7\frac{3}{4}$	.	.	.

BERRIED CRABS, 32; CRABS WITH EMPTY EGG-CAPSULES, 33. TOTAL, 65.

The smallest mature crab is one at $4\frac{7}{8}$ inches. Of a total of 65 individuals, 28 were less than 6 inches across; 37 were over that size. The crabs here recorded were not selected with a view of determining the size of the smallest mature crab, and from evidence supplied by the presence of sperms in the spermatheca I have no doubt that a careful examination of small crabs would reveal a considerable number of mature individuals of less breadth than 5 inches. The crab is mature, however, at a much earlier stage than Wilson supposed. The figures are not sufficient to admit of any calculation of the proportions of

* Northumberland Sea-Fisheries Committee. Further Report on the Crab Fishery of Northumberland, Newcastle-on-Tyne, 1895, p. 6.

† Cf., 2nd edit., 1878, p. 63.

‡ Marked Eh. in Table II., p. 94.

mature crabs at the different sizes; further investigation is required ere this could be satisfactorily accomplished. While it is not impossible that the crabs on the Northumberland coast become mature at a later stage than those off Dunbar, I think it highly improbable. The conclusion, so far as the berried crabs and those with empty egg-capsules are concerned, then, is that the female crab may be mature at the size of $4\frac{7}{8}$ inches, and that a large proportion of the crabs are mature between 5 and 6 inches.

With regard to the second character, viz., the development of the ovary, it may be granted that when the ovary is ripe the crab will carry eggs before it casts; in other words, before it increases in size. Herrick,* however, has recorded two cases where the lobster had extruded its eggs immediately after casting. He regards such a process as extremely rare. The ovary must have been ripe at the time of casting. No analogous case in the crab has come under my observation. This contingency may, I think, be neglected; the presence of a ripening ovary may be regarded as a proof of maturity. Wilson,† from his examination of the ovaries, states that "nearly all the large and hard autumn crabs are ripe, or almost ripe; whereas, though, as I have found, crabs in a similar condition occur at other times of the year, they are proportionately few." In a ripe ovary all the eggs are not of one size. The diameter of the yolk mass may vary from ·3–·41mm.; in some eggs the yolk sphere is as small as ·24mm. The diameter of the *zona radiata* varies greatly from the fact that the egg in the ovary has a large perivitelline space. In the egg, when carried on the swimmerets, the perivitelline space is very slight. In the ovary the diameter of the capsule may vary from ·44–·7mm. The eggs are slightly oval. The external eggs measure—outer capsule, ·44 × ·41, ·45 × ·45, ·44 × ·46, ·51 × ·48; egg sphere, ·4 × ·4, ·38 × ·4, ·4 × ·38, ·42 × ·42. The ripe ovary is of a turkey-red colour. It is very much distended, and covers almost the whole dorsal surface of the body of the crab. It contains a large quantity of an amber-coloured fluid. I have not met with a ripe ovary in a crab at any other time than autumn and winter. The unripe ovary is of a pale colour, with often a slight greenish tinge. It contains small unyolked eggs on an average about ·1mm. in diameter. The eggs become yolked when about ·2mm. in diameter, and in consequence the ovary assumes an orange colour, at other times pink or red. Yolked eggs of ·2 and ·24mm. diameter are found also in white ovaries. The so-called coral condition of the ovary is not an indication of ripeness. In each month of the year, with the exception of March, April, and September, when I have not dissected any crab, I have found the ovary with yolked eggs, and consequently coloured either orange or red. An analysis of a number of crabs with respect to the condition of the ovary and the size of the eggs is given in the Table on p. 90. They are arranged in the months during which they were obtained and examined. The presence of a coloured ovary is, then, an indication of maturity. The developing ovary is very seldom found in a soft crab. A soft crab in August, measuring $5\frac{7}{8}$ inches had an orange-coloured ovary, with eggs of about ·15mm. That was the only case in which other than a pale white organ was found before the crab had become hard. While the number of hard crabs examined was large, they are not of sufficient diversity in size to afford much evidence on the question of the smallest

* "The American Lobster: a Study of its Habits and Development." *Bulletin U.S. Fish Commission* for 1895, p. 35.

† *Op. cit.*, p. 4.

size of maturity. The following crabs under 6 inches were found with ripening ovaries, viz. two crabs at 5 inches; two at $5\frac{1}{16}$ inches, one at each of the following sizes—$5\frac{1}{4}$, $5\frac{3}{8}$, $5\frac{1}{2}$, $5\frac{5}{8}$, $5\frac{7}{8}$; two at $5\frac{3}{4}$. In the smallest size we have a close agreement with the data afforded by the berried crabs and those with empty egg-capsules—viz., $4\frac{7}{8}$.

So far the term mature has been limited to those crabs which give proof that they have actually reproduced their species (berried) or are preparing to do so (ripening ovary). It is now necessary to include in the term mature those which are *capable* of reproducing their species. A female crab may be physiologically mature when of a certain size, and still its ovary may not ripen. The male crab does not, as in most forms, impregnate the eggs directly. It introduces its sperms into the spermatheca of the female immediately the latter casts its shell, and the sperms are retained in the specialised diverticulum of the vagina for probably in most cases about a year before they are used to impregnate the ova. It then follows that if a crab is not fertilised when it casts it cannot reproduce its species till the next cast. A crab measuring $4\frac{1}{8}$ inches across is capable of fertilisation, but many crabs measuring from $4\frac{1}{8}$ to $5\frac{3}{8}$ inches are not fertilised. The latter will not be functionally mature till they are of larger size. So far the evidence will not permit me to say that every crab at $4\frac{1}{8}$ inches is thus mature, nor is it quite certain that no crab smaller than that is mature. Of 54 crabs measuring $4\frac{1}{8}$–$5\frac{3}{8}$ inclusive, 29 were fertilised and 25 unfertilised. No fertilised crab was found among the 27 less than $4\frac{1}{8}$ inches across; and every crab above $5\frac{3}{8}$ inches, viz. 76 in number, was fertilised.

Fertilised and Unfertilised Female Crabs.

Analysis of 157 Female Crabs, measuring from 3–$8\frac{1}{8}$ inches.

Inches.	3–4	$4\frac{1}{8}$	$4\frac{1}{4}$	$4\frac{3}{8}$	$4\frac{1}{2}$	$4\frac{3}{4}$	$4\frac{7}{8}$	5	$5\frac{1}{8}$	$5\frac{1}{4}$	$5\frac{3}{8}$	$5\frac{1}{2}$–$8\frac{1}{8}$
Unfertilised .	27	4	5	.	3	2	3	3	2	1	2	.
Fertilised . .	.	2	1	1	1	2	2	7	3	7	3	76

A female crab which is capable of being fertilised differs structurally from an actually immature specimen, in that the vagina of the former is of large diameter, and the spermatheca is a sac of considerable size; in the latter the vagina is narrow and the spermatheca is so small that it is with difficulty made out. The latter condition has been found in crabs $3\frac{1}{4}$, $3\frac{1}{2}$ (2), $3\frac{3}{4}$, (3) $4\frac{1}{16}$, $4\frac{1}{4}$ (2) inches. These crabs could not be fertilised because the vagina would not admit the penis of the male.

Fertilisation.

The male crab, it is very probable, only has connection with the female at the moment the latter casts its shell, and while the new shell is still pliable. The male copulatory organ is paired, as also are the vagina and spermatheca paired. Each penis consists of two elements—the anterior, which is tubular, situated on the first abdominal segment; the posterior, which is solid, rod-like, situated on the second abdominal segment (Plate I., fig. 8). The posterior element is received into the tube of the anterior. The penis is inserted into the spermatheca and the spermatophores are by it conveyed there. In the female the genital organs consist of two vulvæ, two vaginæ, and two spermathecæ. When the female casts, the inner lining of the vagina and spermatheca are shed with the old shell. At this time the glands of the spermatheca are active and pour a profuse gelatinous secretion into the spermatheca. This fluid when treated with sea-water coagulates and turns white. After fertilisation has taken place the vagina is found to be plugged, a large white body effectually closing up the mouth of the spermatheca and the vagina.* This body is much constricted at the mouth of the spermatheca (fig. 6 *ib.*). It may be readily split longitudinally into two halves (fig. 3). It is, without doubt, formed from the secretion of the glands of the spermatheca. The fluid very probably flows out into the vagina when the penis is introduced, and on the withdrawal of the latter it solidifies and remains as a plug. This plug is to be seen in all soft female crabs which have been fertilised, with a few exceptions. Occasionally the plug is found in one vagina, while it is absent from the other. Two male crabs were found which had attached to their penes portions of the plug. In one case a crab $5\frac{11}{16}$, which was still soft when obtained in October, had one of the halves of a plug attached to the penis (fig. 8); while another, a crab of 5 inches, which had been labelled (No. 826), had in November what appeared to be a small portion of a plug on the base of the penis. The absence of the plug from the vagina of the female may thus be accounted for. The plugs remain some considerable time in the vagina, but disappear about the time the crab becomes hard. Occasionally traces of the head of the plug are apparently made out in the spermatheca. The vulva then closes, a condition which is effected by its muscular structure. Up till this time, and even later, the secretion remaining in the spermatheca has retained a fluid consistency; but it has nevertheless become more viscid, and of a deeper amber colour. It eventually solidifies completely, and the spermatheca shrinks. The mass of sperms, which shows very white through the wall of the spermatheca, lies close to the opening of the oviduct. Shortly after fertilization spermatophores are to be made out in the spermatheca along with independent sperms and fat-globules, which are evidently derived from the colourless fluid of the vas deferens. The capsule of the spermatophore seems to rupture soon after it reaches the spermatheca, for even before the crab has become hard the sperms are all found to be free. When the spermatheca shrinks, it contains the amber-coloured solid in its distal part (fig. 9 *ib.*), and just inside the mouth, at the opening of the oviduct, are massed the sperms. When the female extrudes her eggs, certain of the eggs are occasionally left behind in the spermatheca, and they are to be seen in the amber solid. In a female crab which has hatched its eggs, the solid substance in the spermatheca is usually of two distinct kinds. It is very probable that that is due to some of the ovarian fluid which is present at the time the ovary is ripe lodging in the spermatheca and there solidifying.

Cano,† in referring to Milne Edwards' observation of the white plug in the female edible crab, states that "it is no other than the remains of the secretion which serves to glue the eggs at the moment of their extrusion." Milne Edwards' supposition that the plug was the terminal portion of the membranous penis of the male is of course quite erroneous; but Cano is also at fault in his explanation.

It has been stated that the male crab after it has fertilized the soft female retires to shelter in order to cast. Cano ‡ says that, "in Decapod Crustacea, coupling is always preceded by casting, first of the male, then

* Present also in *Carcinus mænas.*

† Cano, "Morfologia dell' apparecchio sessuale femminile, glandole del cemento e fecondazione nei Crostacei Decapodi." *Mittheilungen aus der Zoologischen Station zu Neapel*, Bd. IX., p. 510 *Note*, 1889–1891.

‡ *Op. cit.*, p. 530.

of the female." Mr. Hutton,* Customs Officer, Peterhead, stated before the Crab and Lobster Commission that when the female becomes a "peelert," that is a soft crab, which she does yearly in the end of July, and in August and September, the male crab, which does not cast its shell at this time, mates."

The reason why some mature females are not fertilised is that when they cast no mature male had been present. A crab of, say, $4\frac{1}{4}$ inches had been before it cast probably $3\frac{1}{2}$ inches across. It was then in what may be called for convenience the $2\frac{1}{2}$–4 inches group. This group contains no mature females, but it contains a few mature males (*see* below). There is good reason for believing that the crabs will be found grouped according to size in defined areas of the sea bottom. It is not improbable that these are age groups. The habitat of the $2\frac{1}{2}$–4 inches group is not known, but it is believed to be just outside low-water mark. The crabs on casting out of the last immature group ($2\frac{1}{2}$–4 inches) enter the adult group, to which belong the crabs which are caught in the creels; the latter measure from below 4 inches up to 8 inches (*vide* Table IX. for sizes of creel crabs). In the adult group, owing to the fact that practically all the males are mature, the fertilisation of the female is almost certain; but when a female in the immature group casts, the chances of being fertilised by one of the few mature males are of course very much less. It is not improbable that all of the unfertilised females of $4\frac{1}{8}$–$5\frac{3}{8}$ inches had before casting belonged to the immature group. If this is so, a great variation in growth is apparent. It is probable that the capacity for fertilisation, or, in other words, the maturity of the crab, depends upon its age, not its size. The greatest variation appears in the growth of the crab, and a difference of even $1\frac{1}{4}$ inches in breadth is probably not infrequent between large individuals of the same age.

The crabs smaller than the adult group, *e.g.*, below $4\frac{1}{8}$ inches, cast at least once a year. This is apparent from the fact that, with very few exceptions, their shells are always clean. Any Ectozoa found upon them are small, *e.g.*, *Serpula*, *Spirorbis*, and Zoophytes. Only rarely do we find one of these small crabs with a large amount of Ectozoa. A male crab measuring $2\frac{3}{4}$ inches across, and which had a large *Sacculina* attached to its abdomen, was dirty, and appeared not to have cast for a year or two.‡ Another, $3\frac{3}{16}$ inches across, a female, was covered with large *Anomia*; on the swimmerets were a large *Saxicava* and an *Anomia*, which kept the abdomen away from the thorax. All the hairs of the third and fourth swimmerets were rubbed off. It appeared not to have cast for a considerable time, more than one year, previously. A third crab, a male, $3\frac{15}{16}$ inches, was very black and dirty. The liver was very small, and scattered through it were small black rod-like and large red spherical bodies.† These appeared to be encysted parasites. A female, $3\frac{5}{16}$ inches, had evidently not cast for some time, judging from the dirty condition of the shell. Casting among the immature crabs, then, appears to be inhibited by parasites, which interfere with the nourishment of the creature. In the mature group reproduction inhibits casting, and for an analogous reason, namely, the employment, for the development of the sexual organs, of the nourishment which would otherwise have been used up in the growth of the crab. The crabs over $4\frac{1}{8}$ inches which are capable of reproduction, but which have not been fertilised, are to all intents and

* Report of the Crab and Lobster Commission, 1877. Evidence for Scotland, p. 12.

† *Vide* Cuénot, "Études physiologiques sur les Crustacés décapodes," *Archives de Biologie*, T. xiii., 1895.

‡ It is well known that crabs infested by *Sacculina* do not moult. (Cf. Delage, "Evolution de la Sacculine," *Arch. Zool. Expér.* (2), II., 1884, p. 666.

purposes still immature. They will therefore probably cast again the next year. In those crabs which are fertilised the ovaries will develop, in response to the stimulus supplied by the presence of the sperms in the spermatheca. As to how long an interval elapses between casting and the extrusion of the eggs my evidence is not complete. But, while a large number of the crabs will not become berried until at least about 12 months after they have cast, still there is a certain amount of evidence that a crab may extrude its eggs in the winter immediately following the summer when it cast. A number of soft crabs were kept in confinement at Dunbar from September 25th till early in December. They were, with the exception of one ($5\frac{3}{8}$ inches), over $5\frac{1}{2}$ inches in breadth. Two of these crabs, $5\frac{7}{8}$ and $7\frac{1}{8}$ inches, were on 9th December not quite hard; the former had a white ovary with yolked eggs measuring ·2mm. in diameter; in the latter the ovary was orange-coloured and contained eggs ·2 and ·24mm. Certain crabs which are hard, of clean appearance, and white on the under surface, are known as "China crabs"; they are got towards the end of the year, and are, without doubt, crabs which have cast during the summer. One of these examined in December was $5\frac{15}{16}$ inches across, and had a scarlet ovary with eggs ·35mm., that is to say, very near, if not quite, ripe, and certainly as large as many of the eggs in a ripe ovary. Another of the same, measuring $6\frac{7}{16}$, showed a pink ovary, with eggs ·15 and ·24mm. in diameter. Many of the casters of one year are certainly not berried until the winter of the following year. During the summer following the cast they are found to be clean and light-coloured, and with coloured developing ovaries, which will be ripe in the succeeding October. Several of these clean crabs were obtained in May and others in July. They were placed in the tanks at Dunbar, and of the survivors one was berried in November; another was ripe in December, but was killed before it extruded its eggs; a third had yolked eggs ·24 and ·27mm. in diameter; and a fourth, killed in February, was ripe. (*Vide* Table, pp. 92, 93.) The conditions of captivity were probably not very favourable for spawning; but, in any case, it is the fact that many of the female crabs of mature size, which cast in any year, are hard, full crabs, with ripening ovaries in the following summer, and extrude their eggs in the winter; that is to say, about 14 months after casting. Those crabs which cast early in the year—in July, for example—would be more likely, then, to have ripe ovaries at the end of the year than those which cast in September. If now, for clearness, we give an age to the crab of the mature group, expressed in a number of months counted from its cast, we may conclude that certain crabs may be berried in six months, while others are not berried until over twelve months afterwards.

Annual Spawning.

A crab does not always cast immediately it hatches its eggs. It very often carries eggs two years in succession. The supply of sperms which it receives when soft is not all used up in fertilising the first batch of eggs, and so long as the sperms are present in the spermatheca the crabs will probably not cast. In fact, everything points to the probability of the crab usually carrying two batches at least before it casts again. This is demonstrated by an examination of those crabs which are berried and those which have recently hatched their eggs. The particulars of a number of these crabs will be found in Table II., p. 94. The ovary of a berried crab just after it has extruded its eggs is small and pale in colour, a slight greenish tinge being, however, sometimes noticed. The eggs are small, transparent, non-yolked, about ·1mm. in diameter. Here and there through the ovary appear ripe eggs which have not been extruded with the main mass. In May and July, in three examples dissected, yolked eggs were found; two of the ovaries were white, the third red. In the crabs which have just hatched their eggs the ovaries were found to be of a red colour. (Table II., p. 94, July.) In August seven examples came under observation; they, with one exception, showed developing ovaries and varying quantities of sperms in the spermatheca. In October and December 1899, of the nineteen dissected crabs which showed by the presence of the empty egg-capsules on their swimmerets that they had hatched their eggs during the summer immediately preceding, many had ripe eggs. A number of crabs which had hatched their eggs in the tanks at Dunbar were kept there until November. One measuring $5\frac{5}{8}$ inches across had an orange ovary. Four which survived till December had ovaries pink or orange in colour, and containing eggs measuring from ·15–·27mm. in diameter. On December 1st a female measuring $5\frac{1}{8}$ inches across was found to have a few empty egg-capsules on the base of the swimmerets. On December 9th it extruded a quantity of eggs. A berried crab, 6 inches across, which was got from Dunbar on December 9th, 1899, was examined on its death in February. Empty egg-capsules were found at the base of the endopodite of the fourth swimmeret. They were to some extent concealed by the mass of the new eggs which was attached to the limb. The actual proof supplied by the last two crabs—that the female may carry eggs in two successive years—is led up to by the evidence afforded by the condition of the ovaries of the crabs which had lately been berried. We have, then, in the female crab, reproductive periods of two years at least, separated by growth (or casting) intervals. Those crabs which are not preparing to carry another batch of eggs appear to cast very soon after the brood hatches; but it is not improbable that some do not cast till the following summer. A certain amount of evidence bearing upon this question in the lobster has been published. Herrick* writes as follows:—"Females usually moult shortly after the hatching of a brood." Of several lobsters which had hatched their eggs, and which were placed in confinement by Cunningham† in September, two cast their shells—one on November 27th and the other about February 9th. Meek‡ records a female lobster which was brought to Cullercoats Laboratory, "evidently after hatching; she cast her shell in the tank during 17–18th August."

With regard to the frequency of spawning in the lobster, there has been considerable divergence of opinion. Thus, Ehrenbaum§ was of the opinion that the European lobster becomes productive only once in four years. Fullarton‖ considered that the lobster did not spawn two years in succession. Herrick¶ accepts the position of Garman, viz., "that the female lobster lays eggs but once in two years, the laying periods being two years apart." Herrick found immature ovaries in 21 lobsters which had recently hatched their eggs, and concludes—"That the spawning periods are thus two years apart is a valid inference drawn from the study of the reproductive organs" (p. 71). Allen** in this connection says—"An examination made at the end of July of the ovary

* *Op. cit.*, p. 35.

† *Op. cit.*, pp. 40, 41.

‡ Northumberland Sea Fisheries Committee. "Report on the Trawling Excursions, &c," 1899, p. 54.

§ "Der Helgolander Hummer," *Wissenschaftliche Meeresuntersuchungen*, Neue Folge, I Bd., Hft. 1, Kiel, 1894.

‖ *Fourteenth Annual Report of the Fishery Board*, Part III., p. 186.

¶ *Op. cit.*, p. 70.

** "The Reproduction of the Lobster," *Journal of the Marine Biological Association*, N. S., Vol IV., No 1, pp. 60-69.

of a female whose brood had just been hatched did not appear to me in itself to offer evidence for or against the view that eggs would not be laid during the summer. . . . If no further evidence of a different kind were forthcoming one would, I think, have been inclined to expect that the eggs would have been laid during the same summer." Prince* combated the theory of biennial spawning on histological and other grounds. In a footnote (p. 72) Herrick adds—"The best way to test the question by experiment would be to take a female which had recently hatched a brood, and keep her alive until the following summer, when the next batch of eggs would be due, in case the spawning period is a biennial one." This has been done by Cunningham,† and the result of the experiment has been to disprove the contention of Ehrenbaum, Herrick, and Fullarton. Of five lobsters which had hatched their eggs, and which were put into a floating box in September, one was berried on October 14th; another examined on February 9th evidently had a ripe ovary, but having apparently failed to extrude the eggs, the latter were being absorbed. Two of the remaining lobsters cast their shells; the fifth escaped from the box. These facts, then, point to the conclusion that, as in the case of the crab, the lobster may carry eggs two years in succession. The lobsters which Herrick dissected were probably about to cast, and when growth is taking place the ovaries would appear to be quiescent. The crab will not, I believe, prepare for casting so long as a supply of sperms remains in the spermatheca; in other words, it will keep on having successive batches of eggs until the supply of sperms is exhausted.‡ A crab on casting throws off the inner lining of the spermatheca and vagina in addition to its exoskeleton, and therefore the contents of the spermatheca are also discarded at that time. The presence or absence of sperms is what decides the direction in the former case of the nourishment to the ovary; in the latter to the general tissue, and especially the subdermal areolar tissue. This is, no doubt, what takes place generally; but the absence of sperms from the spermatheca does not in all cases prevent the development of the ovary. Thus, two crabs with empty egg-capsules, one $4\frac{7}{8}$ inches, got in October, and another $6\frac{11}{16}$ inches in December, had red ovaries which were practically ripe, although the spermatheca showed no sperms. Another $5\frac{5}{16}$ inches (October) had an orange-coloured ovary with eggs ·2mm. There was in respect to certain characters some evidence that these crabs were preparing to cast. Again, in one crab which was soft, mentioned above, an orange-coloured ovary, with small eggs however (·15mm.), was observed. Herrick mentions two cases of the lobster extruding its eggs shortly after casting. In such circumstances the ovaries must have been ripe before the casting. It is very probable the ripening of the ovary while the crab is preparing to cast may be due to the fact that the crab had had the advantage of a large food supply, and therefore had an excess of nutritive material, which was laid up in the ovary. In most cases it is, however, the case that the ovary at casting is little developed. The stage of development of the ovary at the time the crab casts will, no doubt, have the effect of shortening or lengthening the period between casting and spawning. Thus, if a crab has a ripe ovary when it casts, in summer, say, it would in all probability extrude its eggs within the next four or five months; whereas, if the ovary is at that time very immature, spawning will not be likely to take place until after an interval of about 14 months.

* Report of the Canadian Lobster Commission, 1898 (No. 11 C.), Ottawa, 1899.

† *Op. cit.* pp., 40-41.

‡ Coste found that *Maia squinado* spawned twice after a single impregnation (*Comptes Rendus*, XLVII., p. 49, 1858). According to the observations of Mitchell recorded by Miss Rathbun (*Proc. U.S. Nat. Mus.*, XVIII., p. 369, 1895), the females of *Callinectes sapidus* are impregnated in their third summer, after which they cease to moult, and the single impregnation suffices for all subsequent spawnings. The first spawning takes place in the fourth summer—a year after impregnation.

The evidence as to the maturity of the female crab may be summed up as follows:—A female crab becomes potentially mature when it measures about $4\frac{1}{8}$ inches across the broadest part of the back. At that size the vagina and spermatheca are for the first time sufficiently developed to admit of the introduction of the sperms into the spermatheca. The actual maturity or reproductive activity of a crab depends upon its being fertilised at the moment of casting. Of crabs between $4\frac{1}{8}$ and $5\frac{3}{8}$ inches in greatest breadth, a considerable proportion (*vide* p. 82) are not fertilised, and are consequently functionally immature. All crabs over $5\frac{3}{8}$ inches which were examined were found to be fertilised. While, then, all females over $5\frac{3}{8}$ inches are probably active in reproduction, a proportion, possibly greater than the half, of those between $4\frac{1}{8}$ and $5\frac{3}{8}$ inches, are also mature. With regard to spawning, a crab, as a rule, carries at least two batches of eggs in succession. It then casts, possibly soon after the hatching of the last lot of eggs, and may again spawn within the following four or five months, or not until after an interval of about 14 months. The latter seems to be more often the case. And as to casting, certain facts seem to point to the possibility of the crab not casting until a considerable time after hatching has taken place. We thus have a reproductive period of at least two successive years, followed by an interval of growth to be succeeded by another reproductive period—annual spawning; biennial or triennial growth.

Times of Spawning and Hatching.

The crab, according to Wilson,* spawns in November, December, and January. The observations of Meek and Cunningham confirm this statement. A crab extruded its eggs in the beginning of December in the tank at the Bay of Nigg, another which had been kept in the creek at Dunbar was found to be berried in December. The crab spawns offshore in deep water, and in summer migrates to the warm water near the shore. In June, Mr. Buglass, Berwick-on-Tweed, informs me, berried crabs are caught in considerable numbers in creels shot on a sandy bottom near the shore. According to information supplied by fishermen of Dunbar, they are to be found in July on the sandy bottom of Belhaven Bay. A proof of the inshore migration of the berried crab is mentioned by Meek.† Mr. Douglas of Beadnell, marked a berried crab, and set it free 3 miles from the shore in March. It was re-caught about a quarter of a mile offshore in July, and was then clean hatched.

The newly-spawned eggs of the crab are orange in colour. In May and June the orange colour has given place to a more or less reddish colour. The large black eyes of the embryo are in most cases already prominent. When the eggs are ready to hatch they have a dirty grey appearance. Of 24 berried crabs which were kept in the tanks at Dunbar, 17 hatched out in July, and two during the first half of August; the remaining five died. When the larva hatches it is not very active; within fifteen minutes after its escape from the egg it moults, and appears as a zoëa of the second stage, which is represented in Fig. 4, Pl. I. The zoëa of the shore crab (*Carcinus mænas*) resembles much the larva of the edible crab, but differs from it in not possessing the large lateral spine of the carapace (Fig. 2). Meek concluded that on the Northumberland coast hatching takes place in July and August. The same seems to hold good for the Dunbar district. The period of incubation would thus be seven to eight months.

When the eggs are ready to hatch the female moves its abdomen

* *Op. cit.*, 1893, pp. 5, 6, 7.

† *Op. cit.*, 1899, pp. 52, 53.

slowly backwards and forwards, in this way facilitating the escape of the larvæ. The swimmerets seem to move independently of one another; the bunch of eggs attached to each swimmeret is sharply separated from those on either side of it. This is not the condition in the crab which has just extruded its ova. At that time the eggs form a large spherical mass in which there is no sign of division between the masses of eggs of the different swimmerets.

During the progress of this research it was discovered that the Fishery Board had not the power, which is possessed by the District Committees in England, to permit the possession of berried crabs for purposes other than for bait. A number of berried crabs were obtained in ignorance of this difficulty, and the evidence which they bring to bear upon the different questions treated has been incorporated in the paper.

Number of Eggs of the Crab.

Spence Bate found in one she-crab 2,000,000 ova; Buckland states, as the result of a calculation made by his secretary, that the crab carries no less than 1,441,000 eggs. An approximate calculation of the number of eggs carried by different crabs is given below. The number varies greatly with the individual. The method adopted in the estimation was as follows. The swimmerets with the eggs attached were preserved in spirit. They were then dried in a water bath and weighed. From the weight thus obtained was subtracted the weight of the dried swimmerets of a crab of the same size, but which was not berried. The weight of the eggs was thus found approximately. The weight of the hardened cement by which the eggs were attached to the swimmerets was neglected. The number in a small weight of the eggs was counted, and from that datum the total was deduced.

THE NUMBER OF EGGS CARRIED EXTERNALLY BY DIFFERENT CRABS.

	Size of Crab.—Greatest Breath.	Estimated Number of Eggs.
1	$5\frac{3}{4}$ inches.	460,000
2	$5\frac{3}{4}$ ”	750,000
3	$5\frac{15}{16}$ ”	1,010,000
4	6 ”	940,000
5	$6\frac{5}{19}$ ”	1,480,000
6	$7\frac{11}{16}$ ”	3,000,000

From the data given above there appears to be an increase in the number of eggs with an increase in the size of the crab. In the case of two crabs measuring $5\frac{3}{4}$ inches, the numbers of eggs were found to be 460,000 and 750,000 respectively, while in the crab $7\frac{11}{16}$ inches in breadth the number of the eggs attached to the abdomen was estimated at about 3,000,000. Herrick * found that the larger lobsters carried a far greater quantity of eggs than the smaller specimens. A lobster, 8 inches in length was found to have on an average 5000 eggs, while in those measuring 15–19 inches 80,000 to 90,000 were observed in certain examples, the averages in that range of size being 46,000 to 77,000 eggs. From an examination of 4645 berried females Herrick deduced the following law :—“The numbers of eggs produced by female lobsters at each reproductive period vary in a geometrical series, while the lengths of the lobsters producing these eggs vary in an arithmetical series.” How far this law is applicable to the crab extended investigation is required to show.

* *Op. cit.*, pp. 51, 52.

TABLE I.—DISSECTION OF FEMALE CRABS CAUGHT IN CREELS, 1897-1900.

S. designates a soft crab; H. a hard crab; H, a crab which is very nearly, but not quite, hard.

Month.	Number of Specimens.	Condition of Shell.	Sizes in Inches. Greatest Breadth.	Ovary.	Eggs. (Size in mm.)	Spermatheca.	Secretion of Spermatheca.
May.	1	S.	$7\frac{3}{16}$.	—	—	Plugged.	—
Aug.	12	S.	$3\frac{9}{16} : 3\frac{3}{4} : 3\frac{13}{16} : 3\frac{13}{16} : 3\frac{7}{8} : 4\frac{1}{16} : 4\frac{1}{8} : 4\frac{1}{4} : 4\frac{1}{4} : 4\frac{5}{16} : 4\frac{1}{2} : 4\frac{15}{16}$.	Immature	—	Not plugged; unfertilised.	Small amount fluid.
,,	3	S.	$4\frac{1}{4} : 4\frac{13}{16} : 4\frac{15}{16}$.	,,	Small, transparent.	Plugged; large amount sperms.	Large amount fluid.
,,	8	S.	$4\frac{1}{2} : 4\frac{7}{8} : 5\frac{1}{16} : 5\frac{1}{2} : 5\frac{1}{2}$* $: 5\frac{7}{8} : 5\frac{15}{16} : 6\frac{1}{4}$.	White.	·15—·17.	,, ,, †	Varied amount fluid.
,,	6	S.	$5\frac{1}{16} : 5\frac{1}{4} : 5\frac{3}{8} : 5\frac{11}{16} : 5\frac{13}{16} : 5\frac{15}{16}$.	Immature.	Small, transparent.	,, ,,	Bright amber fluid.
,,	1	S.	$5\frac{9}{16}$.	,,	Largest—·12.	,, ,, †	,, ,,
,,	1	S.	$5\frac{7}{8}$.	Orange coloured.	·15.	Plugged.	Semi-fluid.
Sept.	3	S.	$5\frac{9}{16} : 6\frac{3}{16} : 7$.	—	—	Plugged; large amount sperms. †	—
Oct.	9	S.	$4\frac{3}{8} : 5\frac{1}{4} : 5\frac{5}{8} : 5\frac{3}{4} : 6$ (*) $: 6\frac{1}{4} : 6\frac{5}{16} : 6\frac{5}{16} : 6\frac{5}{8}$.	Pale orange.	—	,, ,,	Large amount; gelatinous.
,,	5	S.	$6\frac{1}{4} : 6\frac{1}{4} : 6\frac{5}{16} : 6\frac{15}{16} : 7\frac{1}{8}$.	White.	·1—·15.	,, ,,	,, ,,
,,	2	S. & H.	$6\frac{1}{16} : 5\frac{3}{16}$ (No. 863).	Pale white.	—	No plugs; small amount.	Shrunk; disc-like.
,,	2	H.	$5\frac{3}{16}$ (No. 991) : — (No. 837).	,,	·1 (No. 991).	,, unfertilised.	Small amount.
,,	2	S.	$5\frac{3}{16} : 5\frac{3}{8}$ (No. 903).	,,	—	,, ,,	Small and large amounts respectively.
Nov.	3	S.	$5\frac{1}{16}$ (No. 1029) : $5\frac{5}{16}$ (No. 1167) : $6\frac{1}{4}$ (No. 1025).	,,	·1—·12 (No. 1025).	Plugged; large amount.	Large; gelatinous.
,,	1	S.	$6\frac{7}{16}$ (No. 1118).	,,	—	,, ,, *	Becoming hard.
,,	2	H. & S.	$5\frac{1}{8} : 5\frac{15}{16}$.	,,	—	No plugs; ,,	Pale amber.
,,	2	S. & H.	$5\frac{1}{16}$ (No. 1045) : $5\frac{3}{8}$ (No. 880).	Small.	—	,, unfertilised.	—

* Plug in right vagina alone. † Spermatophores also present in certain specimens.

The crabs, to which the numbers in brackets are attached, were labelled crabs used in the migration experiments, p. 119.

TABLE I.—DISSECTION OF FEMALE CRABS CAUGHT IN CREELS, 1897-1900—*continued.*

S. designates a soft crab ; H. a hard crab ; H, a crab that is almost hard.

Month.	Number of Specimens.	Condition of Shell.	Sizes in Inches. Greatest Breadth.	Ovary.	Eggs. (Size in mm.)	Spermatheca.	Secretion of Spermatheca.
Nov.	2	H. (C.)*	5 (No. 697) : $5\frac{3}{8}$ (No. 1019).	Pale white.	—	No plugs ; fair amount.	Shrunk to solid condition.
Dec.	7	S.	$5\frac{1}{4}$: $5\frac{13}{16}$: $5\frac{7}{8}$ (No. 1144) : $6\frac{7}{16}$: $6\frac{13}{16}$: $7\frac{1}{4}$: $7\frac{15}{16}$.	,, ,,	—	Plugged : large amount.	Fluid solidifying and solid.
,,	3	S.	6 (No. 1063) : $6\frac{1}{8}$ (No. 1153) : $6\frac{7}{16}$.	,, ,, ($6\frac{7}{16}$).	·15 ($6\frac{7}{16}$).	No plugs ; small amount. ‡	Shrunk (No. 1063).
,,	3	H. (C.)	$5\frac{3}{4}$ (No. 1018) : $5\frac{7}{8}$ (No. 1020) : $6\frac{5}{16}$ (No. 1014).	White.	·2 (No. 1014).	,, fair amount.	Semi-solid and solid.
,,	1	H. (C.)	$7\frac{1}{8}$ (No. 1013).	Orange.	·2—·24.	,, ,,	Darkening fluid.
,,	1	H. †	$5\frac{15}{16}$.	Scarlet.	·34.	,, ,,	Solidified.
,,	1	H. †	$6\frac{1}{4}$.	Immature.	—	,, considerable amount.	—
,,	1	H. †	$6\frac{7}{16}$.	Pink.	·15—·24.	,, ,,	Considerable amount of fluid in right ; solid in left.
,,	1	H.	$4\frac{1}{2}$ (No. 841).	Pale white.	—	,, unfertilised.	—
Jan.	1	H. clean	$4\frac{1}{8}$.	—	—	Large amount of sperms.	Shrunk and disc-shaped.
,,	2	H. ,,	5 (No. 957) : $5\frac{5}{16}$ (No. 892).	Pale.	—	Unfertilised.	—
,,	14	H. ,,	3 : $3\frac{1}{8}$: $3\frac{3}{8}$: $3\frac{1}{2}$: $3\frac{9}{16}$ (S.) : $3\frac{9}{16}$: $3\frac{9}{16}$: $3\frac{9}{16}$: $3\frac{5}{8}$: $3\frac{5}{8}$: $3\frac{5}{8}$: $3\frac{5}{8}$: 4 : $4\frac{1}{8}$.	,,	—	,,	—
Feb.	2	H. ,,	$5\frac{13}{16}$: $7\frac{1}{16}$.	Orange.	·15, ·2, ·22.	Large amount of sperms.	Shrunk.
,,	2	H. ,,	$5\frac{11}{16}$: $5\frac{3}{4}$.	Pale.	—	,, ,,	,,
,,	1	H. ,,	$4\frac{7}{8}$.	,,	—	Unfertilised.	—
May.	4	H. ,,	$6\frac{7}{16}$: $6\frac{5}{8}$: $6\frac{13}{16}$: $6\frac{13}{16}$.	Red and scarlet coral.	—	Fertilised.	—
,,	1	H. ,,	6.	Reddish.	—	—	—

The crabs marked (C.) had been kept for some time in confinement. † "China" crab. ‡ No sperms in left spermatheca of No. 1063.

TABLE I.—DISSECTION OF FEMALE CRABS CAUGHT IN CREELS, 1897-1900—*continued*.

S. designates a soft crab ; H. a hard crab.

Month.	Number of Specimens.	Condition of Shell.	SIZES IN INCHES. Greatest Breadth.	Ovary.	Eggs. (Size in mm.)	Spermatheca.	Secretion of Spermatheca.
May.	1	H. clean	$6\frac{3}{8}$.	—	Small eggs.	—	—
June.	3	H.	$5\frac{5}{16} : 5\frac{3}{4} : 6$	Immature.	—	Fertilised.	—
,,	4	H.	$5\frac{7}{8} : 6\frac{7}{16} : 6\frac{9}{16} : 6\frac{15}{16}$.	Red coral.	—	,,	—
,,	1	H.	$5\frac{3}{16}$.	Unripe.	—	—	—
,,	1	H.	$4\frac{15}{16}$.	,,	—	Unfertilised.	—
July.	6	H.	$5\frac{1}{32} : 5\frac{3}{4} : 6 : 6\frac{1}{2} : 7\frac{1}{16} : 8\frac{3}{16}$.	Scarlet ; Pink ($8\frac{3}{16}$).	—	Fertilised.	—
,,	1	H.	$5\frac{1}{4}$.	Immature.	—	,,	—
,,	2	H.	$4\frac{1}{2} : 5$.	,,	—	—	—
,,	8	H.	$3\frac{1}{8} : 3\frac{1}{2} : 3\frac{5}{8} : 3\frac{11}{16} : 4 : 4\frac{1}{8} : 4\frac{1}{8} : 4\frac{1}{4}$.	,,	—	Unfertilised.	—
Aug.	5	H.	$5\frac{9}{16} : 5\frac{11}{16} : 5\frac{13}{16} : 6\frac{1}{2} : 6\frac{13}{16}$.	Large ; red coral.	·22—·29.	Fair amount of sperms.	Shrunk.
,,	1	H.	$5\frac{3}{8}$.	Orange.	·2, ·22, ·24.	—	,,
,	3	H.	$4\frac{1}{2} : 4\frac{3}{4} : 4\frac{13}{16}$.	White.	·1.	Unfertilised.	—
Oct.	2	H.	$5\frac{3}{32} : 6\frac{3}{8}$.	Red.	·39—·44.	Fertilised.	A quantity of fluid.
,	2	H.	$5 : 5\frac{1}{4}$.	Pink and yellow.	·15—·2.	,,	Solidified.
,,	1	H. dirty	$4\frac{3}{16}$.	—	—	,,	,,
,,	4	H.	$3\frac{5}{16} : 3\frac{13}{16} : 3\frac{15}{16} : 4\frac{5}{16}$	Immature.	—	Unfertilised.	—
Nov.	2	H. (C.)*	$5\frac{7}{16}$ (No. 632) : $5\frac{3}{8}$.	Orange.	—	Empty.†	

* The crabs marked (C.) had been kept for some time in confinement.

† Left vagina absent.

TABLE I.—DISSECTION OF FEMALE CRABS CAUGHT IN CREELS, 1897-1900—*continued.*

S. designates a soft crab; H. a hard crab.

Month.	Number of Specimens.	Condition of Shell.	Sizes in Inches. Greatest Breadth.	Ovary.	Eggs. (Size in mm.)	Spermatheca.	Secretion of Spermatheca.
Dec.	1	H.	$\frac{3}{16}$.	Immature.	—	Fertilised.	[Apparently about to cast.]
,,	1	H.	$4\frac{13}{16}$.	—	—	,,	—
,,	1	H.	$5\frac{1}{16}$.	Pale white.	– –	Unfertilised.	—
,,	1	H. (C.)*	$6\frac{1}{16}$.	Orange.	·24—·27	Fertilised.	Shrunk.
,,	1	H. (C.)	$6\frac{1}{4}$.	Ripe.	Ripe	,,	,,
,,	1	H. (B.)† (C.)	$5\frac{15}{16}$.	Pale.	—	Fair amount.	—
Feb.	1	H. (C.)	$6\frac{3}{16}$.	Ripe.	·39.	Large amount.	—

* The crabs marked (C.) had been kept for some time in confinement. † B. signifies berried.

TABLE II.—DISSECTION OF BERRIED CRABS AND CRABS WHOSE EGGS HAD HATCHED LATELY.

1898-1900. Month.	Size in Inches.		Condition of Shell.	Ovary.	Eggs. (Size in mm.)	Spermatheca.	Secretion of Spermatheca.
November.	$6\frac{5}{16}$.	B.*	Yellow : dirty.	Large, red.†	—	—	—
,,	$5\frac{3}{4}$.	B.	Clean.	Whitish: 4 ripe eggs left in ovary.	—	Large quantity of sperms.	Shrunk.
,,	$5\frac{3}{4}$.	B.	Dirty.	Greenish.	About ·1.	Considerable quantity of sperms.	—
December.	$5\frac{1}{8}$.	B.	,,	White, with ripe eggs left in ovary.	—	Little white patches.	—
February.	6.	B.	Clean.	Pale white: red eggs in ovary.	—	Very few sperms.	—
May.	$7\frac{11}{16}$.	B.	,,	Red coral.	—	A quantity of sperms.	—
July.	$5\frac{11}{16}$ (No. 646).	B.	—	White.	—	Little in left : large quantity in right.	—
,,	$5\frac{7}{16}$ (No. 649).	B.	Rather dirty.	White, with tinge of red.	Fairly large.	A few sperms in right spermatheca.	—
,,	$5\frac{7}{8}$ (No. 695).	E. h. ‡	—	Pale pink.	—	Large quantity of sperms.	—
,,	$6\frac{1}{2}$ (No. 694).	E. h.	—	Red coral.	—	,, ,,	—
,,	$6\frac{1}{2}$ (No. 639).	E. h.	—	Large : red coral.	—	,, ,,	—
August.	$5\frac{3}{4}$.	E. h.	—	Orange.	—	—	—
,,	$6\frac{5}{16}$.	E. h.	Rather dirty.	Pink.	—	Fairly large amount.	Shrunk.
,,	$6\frac{1}{2}$.	E. h.	,,	Greyish.	About ·15.	Large quantity of sperms.	—
,,	$6\frac{3}{4}$.	E. h.	Fairly clean.	Pink.	About ·2.	,, ,,	Shrunk.
,,	$6\frac{13}{16}$.	E. h.	—	Orange.	About ·2—·22.	Fair amount ,,	Shrunk : a little fluid.
,,	$6\frac{15}{16}$.	E. h.	,,	Large : red coral.	Large and small eggs.	,, ,,	,,

* B. signifies berried. † Apparently in the act of extruding the ova.

‡ E. h. signifies that the eggs had hatched lately, the proof of this being the presence of empty egg-capsules on the swimmerets.

TABLE II.—DISSECTION OF BERRIED CRABS AND CRABS WHOSE EGGS HAD HATCHED LATELY—*continued.*

1898-1900. Month.	Size in Inches.		Condition of Shell.	Ovary.	Eggs. (Size in mm.)	Spermatheca.	Secretion of Spermatheca.
August.	$6\frac{15}{16}$.	E. h. *	Fairly clean.	Large ; red coral.	—	Large amount.	Shrunk.
October.	$4\frac{7}{8}$.	E. h.	Dirty.	Red.	About ·34.	Sperms not found.	Small ; gelatinous.
,,	$5\frac{1}{4}$.	E. h.	,,	Pale green.	Small.	Small amount of sperms.	Shrunk.
,,	$5\frac{5}{16}$.	E. h.	,,	,,	—	A few sperms in left.	Pale amber-coloured fluid.
,,	$5\frac{5}{16}$.	(?)	Dark brown.	Orange.	About ·2.	No sperms.	A quantity of fluid.
,,	$5\frac{3}{8}$.	E. h.	—	Bright red.	,, ·49—·51.	Numerous sperms.	Shrunk.
,	$5\frac{7}{16}$.	E. h.	—	Orange.	,, ·37—·441.	,, ,,	—
,,	$5\frac{5}{8}$.	E. h.	Dirty.	Red.	—	Small amount of sperms.	Shrunk.
,,	$5\frac{11}{16}$.	E. h.	Yellowish.	Reddish.	{ Red eggs, ·17—·22. White eggs, ·15—·2.	,, ,,	,,
,	$5\frac{11}{16}$.	E. h.	Fairly clean.	Red.	·34—·37.	,, ,,	—
,,	$5\frac{13}{16}$.	E. h.	Dirty.	Pale white.	—	—	—
,,	$6\frac{1}{4}$.	E. h.	,,	Orange.	·39.	Some sperms.	—
,,	$6\frac{3}{8}$.	E. h.	,,	Large ; bright red.	·32.	Small amount of sperms.	Shrunk.
,,	$6\frac{3}{8}$.	E. h.	Clean.	,, crimson.	·39.	,, ,,	,,
,,	$7\frac{1}{2}$.	E. h.	,,	Orange.	·39—·41.	Sperms.	,,
November.	$5\frac{5}{8}$.	E. h. (C.)†	—	Orange.	—	—	—
December.	$5\frac{15}{16}$.	E. h.	Dirty.	Ripe ; red.	·44 ; capsule, ·49—·7.	Fair amount of sperms.	Shrunk, hard.

* E. h. signifies that the eggs had hatched lately, the proof of this being the presence of empty egg-capsules on the swimmerets.
† The crabs marked thus (C.) had been kept in confinement from the preceding June when they were berried.

TABLE II.—DISSECTION OF BERRIED CRABS AND CRABS WHOSE EGGS HAD HATCHED LATELY—*continued.*

1898-1900. Month.	Size in Inches.		Condition of Shell.	Ovary.	Eggs. (Size in mm.)	Spermatheca.	Secretion of Spermatheca.
December.	$6\frac{5}{16}$.	E. h. *	Dirty.	Full ; orange.	·37—·41.	Fair amount of sperms.	—
,,	$6\frac{7}{8}$.	E. h.	,,	Pale.	—	,, ,,	Copious secretion of fluid.
,,	$6\frac{5}{8}$.	E. h.	,,	Pink.	29, ·32.	Large amount ,,	—
,,	$6\frac{11}{16}$.	E. h.	,,	Reddish.	—·39.	No sperms made out.	Considerable amount of fluid.
,,	$5\frac{7}{8}$.	E. h. (C.)†	—	Large ; orange.	·24—·27.	Considerable amount of sperms.	Shrunk, hard.
,,	$6\frac{1}{2}$.	E. h. (C.)	—	Pale pink.	·15.	Large ,, ,,	—
,,	$6\frac{7}{8}$ (No. 678).	E. h. (C.)	Dirty.	Orange.	·24.	,, ,, ,,	Shrunk.
,,	$6\frac{7}{8}$.	E. h. (C.	,,	,,	·24, ·27.	Moderate ,, ,,	—

* E. h. signifies that the eggs had hatched lately, the proof of this being the presence of empty egg-capsules on the swimmerets.
† The crabs marked thus (C.) had been kept in confinement from the preceding June when they were berried.

The Mature Male Crab.

The male crab is ripe at a somewhat less size than the female. The condition of maturity in the male is the presence of ripe male elements in the vas deferens. The sperms of the edible crab are not unlike those of *Carcinus mœnas*, as described by Grobben*. They are disc-shaped when seen from above; in the centre appears a small refractile body containing a nucleus; the periphery of the disc is transparent and delicate. (Fig. 11, a, Plate I.) When seen from the side the sperm is seen to be spindle-shaped. (Fig. 11, b, *ib.*) In contradistinction to those of *Carcinus*, the edge of the disc is smooth, not serrated. The sperms are not found free in the vas deferens, but are packed in capsules—spermatophores. The opening of the vas deferens to the exterior is on the apex of a membranous papilla situated on the first joint, coxopodite, of the last thoracic limb (*cp.* Brocchi†). The presence, then, of spermatophores in the vas deferens is the character of a ripe male. They are to be found in crabs as small as $3\frac{1}{4}$ inches across the back. In crabs of this size, and certain others up to $4\frac{1}{8}$ inches, the vas deferens is of small diameter, colourless and tense as a crystalline rod. It encloses a colourless fluid, which consists essentially of minute fatty corpuscles, with a few spermatophores. Between $3\frac{1}{4}$–$4\frac{1}{8}$ inches most of the crabs exhibit vasa deferentia of this description. Above $4\frac{1}{8}$ inches, however, the vas deferens is white, the colour being due to the great numbers of spermatophores which it contains. A still further stage of development is seen in the extraordinarily swollen condition of the sperm-duct in most adult hard crabs. (In all conditions of the vas deferens the colourless fluid containing the fat corpuscles is present also.) In the adult male, when the swollen vas deferens is torn, the contents flow out profusely through the contraction of the muscular wall of the duct; and if the membranous genital papilla is pressed, spermatophores are expelled. It is very probable that this swollen turgid condition will materially aid, if it is not necessary for, the act of fertilisation. The vas deferens of a very soft male crab is of small diameter, though white in colour. In such a case no spermatophores may be extruded in response to pressure of the papilla. As the crab hardens, however, the diameter of the sperm-duct increases greatly, and there is conclusive proof that a male crab, even before it becomes quite hard, may fertilise a female (*vide* above—Fertilisation, p. 83). In hard crabs smaller than $3\frac{1}{4}$ inches across no spermatophores were made out, and in six hard crabs, measuring from $3\frac{1}{4}$ to $4\frac{1}{8}$ inches, none were noticed. (*Vide* Table III., p. 98.) Seventeen hard crabs, from $3\frac{1}{4}$ to $4\frac{1}{8}$ inches, showed colourless vasa deferentia containing spermatophores; six between these limits had white sperm-ducts; above $4\frac{1}{8}$ inches all hard crabs had white and swollen vasa deferentia. All male crabs, then, above $4\frac{1}{8}$ inches are probably mature. In the case of the female crab, the observations made so far indicated $4\frac{1}{8}$ inches as the smallest size of maturity. Certain male crabs are, however, mature at a smaller size.

In Table III. the description is given of the condition of the vas deferens in 124 crabs. These observations cover the period from May to December inclusive. I, however, have no doubt that the male crab is ripe during the whole year, the only event which will interfere with its reproductive activity being casting.

The smallest ripe male observed by Wilson‡ was 5 inches across.

* "Beiträge zur Kenntniss der männlichen Geschlechtsorgane der Dekapoden," *Arbeiten aus dem Zoologischen Institut der Universität*, Wien., T. i., 1878.

† "Recherches sur les organes génitaux males des Crustacés décapodes," *Annales des Sciences Naturelles, Zoologie et Paléontologie*, T. ii., 1875.

‡ *Op. cit.*, p. 7.

III.—Dissection of Male Crabs Caught in Creels.

S. indicates soft crab; H. hard crab.

1898–1900. Month.	Number.	Condition.	Sizes in Inches.	Vas Deferens.	Spermatophores.
May.	6	H.	$6 : 6\frac{5}{16} : 6\frac{5}{16} : 6\frac{7}{16} : 6\frac{11}{16} : 6\frac{7}{8}$.	Large ; swollen ; white.	Present.
June.	3	H.	$4\frac{5}{16} : 5\frac{1}{16} : 5\frac{3}{4}$.	,, ,, ,,	,,
July.	14	H.	$4 : 4\frac{1}{16} : 4\frac{3}{16} : 4\frac{3}{8} : 4\frac{1}{2} : 4\frac{11}{16} : 4\frac{3}{4} : 5\frac{1}{16} : 5\frac{3}{8} : 5\frac{1}{2} : 5\frac{1}{2} : 5\frac{5}{8} : 6\frac{1}{4} : 6\frac{7}{16}$.	,, ,, ,,	,,
,,	4	H.	$3\frac{9}{16} : 4 : 4\frac{1}{16} : 4\frac{3}{16}$.	Pale ; white.	,,
,,	5	H.	$3 : 3\frac{3}{4} : 3\frac{13}{16} : 3\frac{7}{8} : 4\frac{1}{8}$.	Pale.	,,
Aug.	9	S.	$4\frac{7}{16} : 4\frac{1}{2} : 4\frac{3}{4} : 5\frac{1}{16} : 5\frac{1}{16} : 5\frac{1}{8} : 5\frac{3}{8} : 5\frac{13}{16} : 7\frac{2}{8}$.	Swollen ; white.	,,
,,	5	S.	$3\frac{9}{16}$* $: 4\frac{5}{16} : 4\frac{3}{4} : 4\frac{15}{16} : 5\frac{1}{4}$.	White.	,,
,,	5	S.	$3\frac{5}{8}$* $: 3\frac{15}{16} : 4 : 4\frac{1}{8} : 4\frac{5}{16}$.	Pale.	,,
,,	4	S.	$3\frac{1}{2} : 3\frac{15}{16} : 3\frac{15}{16} : 4\frac{1}{8}$.	,,	Not made out.
,,	3	H.	$4\frac{1}{16} : 4\frac{5}{16} : 4\frac{3}{8}$.	Swollen.	Present.
Sept.	670	H.	Over $4\frac{1}{4}$.	Large ; swollen ; white.	,,
Oct.	6	S.	$5\frac{1}{16} : 5\frac{3}{8} : 5\frac{1}{2} : 5\frac{5}{8} : 5\frac{11}{16} : 6\frac{11}{16}$.	Swollen ; white.	,,
,,	6	H.	$4\frac{15}{16}$: $4\frac{15}{16}$ (No. 973) : $5\frac{1}{8}$ (No. 897) : $5\frac{1}{4} : 5\frac{3}{8} : 5\frac{3}{8}$.	Large ; swollen ; white.	,,
,,	3	H.	$4\frac{5}{8}$ (No. 831) : $4\frac{13}{16}$ (No. 994) : $4\frac{13}{16}$ (No. 886).	Pale ; white.	,,
,,	11	H.	$3\frac{11}{16}$† $: 3\frac{15}{16} : 4\frac{3}{8} : 4\frac{9}{16} : 5\frac{3}{16} : 5\frac{3}{16} : 5\frac{1}{4} : 5\frac{3}{8} : 5\frac{7}{16} : 5\frac{5}{8}$ (No. 673) : $5\frac{5}{8}$.	Large ; swollen ; white.	,,
,,	2	H.‡	$4\frac{1}{16} : 4\frac{13}{16}$.	Thin ; pale ; white.	,,
Nov.	5	S.	$5\frac{5}{8}$ (No. 1115) : $5\frac{13}{16}$ (No. 1135) : $5\frac{7}{8}$: $6\frac{5}{8}$ (No. 1084) : $6\frac{9}{19}$.	Thin ; white.	,,
,,	9	H.	$4\frac{5}{8}$ (No. 835) : $4\frac{15}{16}$: 5 (No. 1039) : $5\frac{1}{2}$: $5\frac{1}{2}$ (No. 1136) : $5\frac{7}{8}$: $5\frac{7}{8}$ (No. 1082) : $5\frac{15}{16}$: 7 (No. 1172).	Moderate thickness ; white.	,,
,,	1	H.	$6\frac{1}{2}$.	Large ; swollen ; white.	,,
,,	1	H.‡	$4\frac{13}{16}$ (No. 1000).	Small ; pale.	,,
Dec.	1	S.	$3\frac{3}{4}$.	Pale.	,,
,,	4	H.	$4\frac{15}{16}$ (No. 1140) : $5\frac{3}{8}$: $5\frac{3}{4}$ (No. 1064) : $6\frac{3}{8}$ (No. 1111).	Large ; swollen ; white.	,,
,	2	H.	$5\frac{3}{16}$ (No. 1104) : $5\frac{7}{16}$ (No. 1166).	Small ; white.	,,
,	4	H.	$3\frac{1}{2} : 3\frac{13}{16} : 3\frac{7}{8} : 4$.	,, ,,	,,
,,	8	H.	$3\frac{1}{4} : 3\frac{3}{8} : 3\frac{3}{8} : 3\frac{1}{2} : 3\frac{1}{2} : 3\frac{5}{8} : 3\frac{11}{16} : 3\frac{15}{16}$.	Small ; pale.	,,
,,	2	H.	$3\frac{5}{16} : 3\frac{5}{8}$.	Pale.	Not made out.

* Hard crab. † Vas deferens crowded with spermatophores. ‡ Just become hard.

External Sexual Characters.

The male may be readily distinguished from the female crab by three external characters. These are, in the order of their importance:—(1) The presence of intromittent organs on the first and second abdominal segments of the male, and, in the female, of four pairs of swimmerets on the abdomen, and the two vulvæ on the fourth thoracic segment; (2) the shape of the abdomen, which in the male is narrow, in the female broad; (3) the form of the carapace, which in the female is more convex and higher than in the male. In regard to the last feature, the crenate edge of the carapace of the male is broader than that of the female, and is also turned upwards. (Compare Fig. 10 (a, male; b, female), Plate I., which represents the shells of two crabs of the same size, viz., $6\frac{1}{2}$ inches.) Of the three sexual characters, the first, viz., the external genital organs, is alone diagnostic for all crabs. Thus, it is possible to distinguish the sex of a crab when it is little more than a quarter of an inch in breadth. The second and third characters are only applicable within limits. Thus, the difference in shape of the abdomen will be found sufficiently defined in crabs of $2\frac{1}{2}$ inches and upwards; while the shape of the shell as a sexual distinction is of little value except in crabs over 4 inches in breadth. In other words, the last character is of moment only in mature crabs. An additional feature which is especially noticed in crabs over 5 inches in breadth is the comparative size of the biting claws in the male and female. In the former the claws are very much larger than in the latter. Buckland mentions that in certain places the fishermen were accustomed to send the claws alone of the large male to market, the body being either used for bait or thrown away. While, then, the external organs of generation are a primary sexual character, the shape of the abdomen and shell, and the comparative size of the large claws, are secondary diagnostic sex features.

The testes and ovaries are paired; there is, however, a communication between the right and left testes, and also between the right and left ovaries.

Proportional Numbers of the Sexes.

In order to arrive at the proportional numbers of the sexes, two large groups of crabs have been examined—(1) The small crabs which are found on the beach, and (2) the crabs caught in the creels of the fishermen. The beach crabs were collected twice a month during a year; their sex and size were noted (Tables IV. and VIII.). The number of male and female crabs in 20 catches of the fishermen at Dunbar were counted. In the list each month of the year is represented (Table V.). Statistics of the catches of crabs at Crail were kept by Mr. A. W. Brown, St. Andrews.* In Table VI. the numbers of males and females in 30 catches, representing each month of the period February to September inclusive, are recorded. A distinction has been made in the case of the creel crabs between crabs of legal size, $4\frac{1}{4}$ inches, and those under that minimum. The lists of undersized crabs are not, however, likely to be so exact as those of the gauge crabs, since in some cases, for example at Crail, they are often thrown overboard at sea. At Dunbar, with few exceptions, the fishermen were asked to bring ashore every crab of the catch which was to be enumerated.

The numbers of crabs collected each month on the beach are detailed in Table IV.; the hard and soft crabs are separately recorded. Of a total of 2332 crabs (for the sizes of which see Table VIII.) collected on the beach, 1154 were males and 1178 females. This shows a slight preponderance of females. To every 100 females there were 98 males. The crabs were collected without any selection either as to sex or size, and, so far as the total number warrants, may probably be regarded as a fair sample of the crabs which make the beach their habitat.

The creel crabs (hard and soft taken together) were recorded in two divisions, gauge and under-gauge crabs. In the 20 Dunbar catches there were of the under-gauge crabs, 909 males and 623 females, *i.e.*, for every 100 females 146 males; while at Crail, where only 390

* By kind permission of Professor M'Intosh.

undersized crabs were recorded for 30 catches, 188 were males and 202 females, giving for each 100 females 93 males.

In respect of the gauge crabs, of the total of 5690 Dunbar crabs the males numbered 2916 and the females 2774, a proportion to every 100 females of 105 males. At Crail, of 4458 crabs, 2644 were males and 1814 females; the preponderance of the males was more marked than at Dunbar, 100 females being accompanied by 146 males. The Crail statistics suffer in one respect, namely, that the crab fishing is not carried on after September. There are therefore no statistics for the winter months, when the proportion of females is probably to a slight extent raised by the appearance in the creels of females which had been berried during the first half of the year. The total number of males and females among the beach crabs, and the undersized and gauge crabs of the Dunbar and Crail catches, are given in Table VII.. The number of males to 100 females in each case and each locality is recorded. If the crabs from Dunbar and Crail are added together we get slightly different results—viz., for the undersized crabs 133 males to 100 females, and for the gauge specimens 121 males for 100 females. While, then, in the small crabs of the beach measuring from $\frac{1}{4}$ up to $3\frac{7}{8}$ inches there appears to be a slight majority in females, in the adult creel crabs the majority is on the side of the males.

There remains the question as to whether or not there are during the year seasons when the numbers of the male sex usually predominate in the catches of the fishermen, and other seasons when female crabs are in the majority. Thus Meek * says, on the evidence of Mr. Douglas, Beadnell:—"There is a majority of male crabs early in the year, but this majority is small, and continues so up to the end of April; in July and August the majority of females is very great, and this is the case until the end of September, when the male leaves the female." According to Wilson,† "almost all the market crabs taken towards the end of the year are females; . . . after the end of January there is frequently a great excess of males in the creaves." Cunningham ‡ found among the market crabs of Cornwall (Cadgwith) a majority of females. The number of males, which is small at the beginning of the crab-fishing season (May to end of September), increases to a maximum in June and then declines. Cunningham institutes a correlation between the numbers of male crabs caught and the temperature of the sea water. He supposes the decline in the numbers of the males in July and August to be in consequence of their sexual activity at that season.

In the Crail catches (Table VII.) it is seen that in each month from February to September there was among those of gauge size a majority of male crabs, and this was the case in each catch with the exception of two, in which the female crabs were slightly more numerous. One catch in April consisted of 113 males and 119 females; another in August was composed of 21 males and 27 females. In the case of the Dunbar catches (Table V.) there is, however, much diversity in the proportions of the two sexes. Two catches in the same month in some cases do not show the same relation. For example, of the two February catches, in one there is a majority of males; in the other the females are the more numerous. A similar relation is seen between the two catches in July. According to Wilson, the females are in the majority in autumn and winter. In two Dunbar catches in November the males are in the majority among the hard market crabs, and also

* *Op. cit.*, 1898, p. 29.

† *Op. cit.*, 1893, p. 6, and 1895, p. 5.

‡ *Op. cit.*, p. 4.

in the total hard and soft crabs. Again, if we divide the year into two portions, January to June and July to December, we get a total of 1403 males and 1401 females in the first half of the year, and 926 hard males and 1006 hard females in the second half of the year. If, however, the soft crabs are included we have 1513 males and 1373 females. The seasonal variation, then, seems to consist in a slight majority of males in the first half of the year, and a slight majority of females among the hard crabs from July to December. There are two factors which may tend to affect the relative number of the sexes caught in the second half of the year. The crabs which hatched their eggs in July and August will either probably cast, or proceed to deep water. The latter then are added to the number of marketable crabs, while the former, remaining soft during a considerable period, will not affect that number till about the end of the year. The ranks of market crabs, however, receive an accession from the crabs which have through casting arrived at a size which admits them to the gauge group. These probably are not hard much before the middle of October.

With regard to the lobster, Herrick * says that it is very probable that but little difference will be found in the numbers of the sexes.

It is very probable that the proportion between the sexes indicated by the beach crabs is more nearly that which exists in the species. The females which are berried seldom appear in the creels, and this fact tends to raise the percentage of male crabs. The statistics of the beach crabs do not suffer from any such sexual selection, and the conclusion is probably warranted that in this species the females slightly exceed the males in number; to every hundred females there are about ninety-eight males.

Table IV.—Crabs Collected on Beach at Dunbar between Tide-marks at Low Water of Spring Tides.

	Hard Crabs.		Soft Crabs.	
	Male.	F'male.	Male.	F'male.
January 10th and 24th, 1898 ..	53	72	4	3
February 8th and 22nd, 1898 ..	70	92	..	1
March 10th and 25th, 1898	69	61	..	1
April 8th and 22nd, 1898	63	91	..	..
May 7th and 23rd, 1898; 26th, 1899	215	188	..	..
June 6th and 20th, 1898	76	62	9	5
July 4th and 19th, 1898	72	67	23	22
August 4th and 18th, 1898; 7th, 1899	41	30	47	75
September 2nd and 16th, 1898 ..	33	42	86	68
October 12th and 27th, 1897 ..	84*	71*	(28 ♂	and ♀)
	27*	28*	..	..
November 11th and 26th, 1897 ..	40	39	72	90
December 10th and 24th, 1897 ..	49	57	21	13
Totals	892	900	262	278

♂ 1154; ♀ 1178. * Includes soft crabs.

* *Op. cit.*, p. 73.

TABLE V.—Dunbar.—Statistics of Hard and Soft Crabs, Male and Female Crabs in 20 Catches.

Date.		Number of Creels.	Distance from Land and Bearing.	Direction in which Creels were Shot.	HARD CRABS. 4¼ ins. and over. Male Crabs.	HARD CRABS. 4¼ ins. and over. Female Crabs.	HARD CRABS. Under 4¼ ins. Male Crabs.	HARD CRABS. Under 4¼ ins. Female Crabs.	SOFT CRABS. 4¼ ins. and over. Male Crabs.	SOFT CRABS. 4¼ ins. and over. Female Crabs.	SOFT CRABS. Under 4¼ ins. Male Crabs.	SOFT CRABS. Under 4¼ ins. Female Crabs.	Number of Boats employed in Crab Fishing.
Jan. 13, 1899	1 Boat.	60	3 miles E.N.E.	N. & S.	47	65	14	12	6	3	9	6	14
,, 28, 1898	,,				89	146	19	14	–	–	–	–	
Feb. 15, 1899	,,	69	3 miles E. of Catcraig.	N. & S.	67	48	7	8	4	3	–	–	14
,, 28, 1898	,,				141	192	(22)		2	–	–	–	
March 27, 1899	,,	110	7 miles N.	N.N.W. & S.S.E.	156	90	2	2	–	–	–	–	14
,, 31, 1898	,,				230	210	9	11	1	–	–	–	
April 27, 1899	,,	130	3 miles N.W.: 1 mile off shore.	N.W. & S.E.	232	250	13	10	–	–	–	–	30
May 3, 1898	,,				166	146	33	19	–	1	–	–	
,, 25, 1899	,,	60	3 miles W.	E. & W.	75	76	31	19	–	–	–	–	27
,, 27, 1898	,,		1 mile off Skateraw.		62	91	16	22	1	1	–	–	
June 3, 1899	,,	160	2 miles N.N.W.: ½-mile off land.	N.W. & S.E.	124	79	7	6	–	–	–	–	9
July 12, 1899	,,	90	Off Barnsness low-water mark.	N.W. & S.E.	64	47	9	11	3	2	2	6	5
,, 14, ,,	,,	75	½-mile off shore, 8 fms.		35	42	16	17	–	–	–	–	
Aug. 4, ,,	,,	80	½-mile off Scoughal.	E. & W.	26	77	19	5	1	8	2	4	5
Sept. 23, ,,	,,	60	2 miles E. by N.		76	104	1	1	235	144	–	–	4
Oct. 27, ,,	,,	60	2½ miles E.S.E.	N.W. & S.E.	83	160	286	104	140	87	80	40	17
Nov. 5, 1898	,,		3–4 miles off Skateraw, Mud, 24 fms.		269	206	4	1	64	32	46	49	
,, 17, 1899	,,	60	2½ miles E.S.E.	N.W. & S.E.	117	60	60	46	66	48	112	56	17
Dec. 13, ,,	,,	60	3 miles E. by N.	N.W. & S.E.	196	200	86	114	56	42	10	18	17
,, 20, 1897	,,				60	110	8	13	22	4	8	9	
Totals, .					2,315	2,399	640	435	601	375	269	188	

The average number of Market Crabs per Creel for the 13 catches in 1899=2·4 Crabs.

TABLE VI.—Crail.—Statistics of Hard and Soft Crabs, Male and Female Crabs in 30 Catches.

Date. 1899.	Number of Boats the catches of which are recorded.	Number of Creels.	Distance from Land and Bearing.	Direction in which Creels were Shot.	HARD CRABS. 4¼ ins. and over. Male Crabs.	HARD CRABS. 4¼ ins. and over. Female Crabs.	HARD CRABS. Under 4¼ ins. Male Crabs.	HARD CRABS. Under 4¼ ins. Female Crabs.	SOFT CRABS. 4¼ ins. and over. Male Crabs.	SOFT CRABS. 4¼ ins. and over. Female Crabs.	Number of Boats employed in Crab Fishing.
February 18, . . .	5 Boats.	143	1–2 miles E. or S.E.	E. & W.	279	145	5	4	–	–	20
March 18, ...	4 ,,	273	1–2½ miles E. or S.E.	S.W. & N.E.	252	119	7	9	–	–	20
April 22, ...	3 ,,	223	1 mile.	E. & W.	431	394	14	6	–	–	20
May 13, ...	2 ,,	210	300 yards.	–	807	701	72	84	–	–	19
June 10, ...	3 ,,	197	300 yards.	–	364	137	21	38	–	–	18
July 8, ...	3 ,,	144	At low-water rocks.	–	177	87	3	3	1	–	6
August 5, ...	6 ,,	308	,, ,,	–	258	181	66	58	9	12	6
September 2, . . .	4 ,,	158	,, ,,	–	66	38	–	–	–	–	4
Totals, .	30	1,656			2,634	1,802	188	202	10	12	—

Number of Market Crabs for each Creel=2·67 Crabs.

TABLE VII.—PROPORTION OF MALES TO FEMALES AMONG HARD AND SOFT CRABS.

	Dunbar.			Crail.			Dunbar and Crail.		
	Males.	F'males.	Number of Males to 100 Females.	Males.	F'males.	Number of Males to 100 Females.	Males.	F'males.	Number of Males to 100 Females.
Beach Crabs .	1154	1178	97·9	.	.	.	.	.	.
Creel Crabs. Undersized	909	623	146	188	202	93	1097	825	133
Creel Crabs. Gauge Size	2916	2774	105	2644	1814	146	5560	4588	121

EXUVIATION, CASTING, SHEDDING.

The crab, as is well known, can only increase in size by getting rid of its hard integument. This process, which is known as "casting" or "shedding," has been described for the edible crab by Jonathan Couch,* and for the lobster by Herrick.† I am indebted for the Report containing Couch's paper to the kindness of Edward Kitto, Esq., Falmouth. Within a short time after casting the shell increases in size, and after calcification the only increase which takes place in the animal is in its weight. The histological description of this process in a number of decapod crustacea has been fully described by Vitzou.‡ This part of the subject it is not proposed to enter upon at present.

When a crab is preparing to cast, the dermal areolar tissue (*tissu conjonctif* of Vitzou) is permeated with a viscid fluid, which, in addition to rendering this layer tense and elastic, gives it a characteristic amber colour. This layer extends all over the body, and is especially thick at the edge of the dorsum. When the crab casts, the shell opens along the suture between the epimera and the inturned edge of the carapace; two of the layers of the new shell (viz., the cuticle and the pigment layer) are already formed, and a slight calcification has taken place round the periphery of the carapace. During the process of casting the crab lies hid, and in the case of an adult female it is at this time fertilised. It apparently leaves its retreat only after a certain amount of calcification has taken place; it then seeks actively for food. Crabs in this condition are caught in great numbers in the crab-creels during autumn and winter. A considerable amount of attention was paid by the Royal Commission of 1876 to the destruction of the soft crabs which takes place during these seasons of the year. Buckland§ says.—"A soft crab may mean two different things. Firstly, it may mean a crab which has just cast its shell and is soft to the touch like putty; or it may mean a crab whose shell is very brittle like thin glass, in which condition it is called 'soft crab,' 'caster,' light-footed crab,' 'light crab,' 'white-bellied crab,' 'peelert,' 'puller,' 'metick,' 'seeding-crab,' 'watery crab,' 'white crab,' 'ripe crab,' 'pale crab,' 'sheer' or 'sick crab.' I myself prefer to call it 'glass crab.' These crabs have not recovered their condition after casting; they are, in fact, 'kelt' crabs. I have dissected several, and find that they contain very little else but the stomach, liver, lungs, and other viscera, but always a great deal of

* "On the Process of Exuviation and Growth in Crabs and Lobsters, etc." *Eleventh Annual Report of the Royal Cornwall Polytechnic Society*, 1843, Falmouth.

† *Op. cit.*, p. 84.

‡ "Recherches sur la Structure et la Formation des Teguments chez les Crustacés Décapodes." *Archives de Zoologie Expérimentale et Générale*, T. 10, 1882, Paris.

§ *Op. cit.*, p. 12.

water." The body fluid of the crab is not water; it is richly albuminous. On exposure to air for a little time it becomes black; and if a quantity of it is treated with picro-sulphuric acid it coagulates into a solid mass. A soft crab is characteristically coloured; the dorsum is a light brick red, the under-surface (epimera) is white; the dorsal surface of the great claws is red, the under-surface white. In a hard crab the white portions have a creamy or yellow colour. A crab remains "soft," legally, as long as it is possible to push the thumb through the shell in the gill region or near the great claws; this it is still possible to do three months after the time when the crab casts. When it is quite hard through increase in thickness and calcification of the shell, four months after casting, the general appearance of the crab has changed a little; the white portions have taken on a slight creamy colour, but otherwise the colours are bright and the shell clean. The crab is then known as a "china crab."

A crab which is not uncommon at Dunbar in autumn and winter, but found only during these seasons, is known as a "milker." It is to all appearance a hard crab; the white portions of the shell and claws have taken on a distinct cream colour. On testing it, however, the shell is found to be thin and brittle. There is a considerable amount of body fluid, but this, in contradistinction to the colourless body fluid of the normal soft crab, is white like milk. On treatment with picro-sulphuric acid it does not coagulate into a solid mass, but settles down as a somewhat flocculent precipitate. Microscopic examination reveals great numbers of small bodies which are probably the same *micrococci* described by Cuénot* as having been found in *Carcinus mœnas*. The crab itself is usually small, and the hardening process has been checked by these parasites.

The Occurrence of Soft Crabs.

As to the time of the year when casting takes place, while there is evidence that the principal time of casting is from July to September (both inclusive), still, from the occurrence of soft crabs, it is to be inferred that casting takes place during a large portion of the year, viz. from May to November inclusive. I have records of adult soft crabs for every month of the year except April. In Table V., p. 102, are given statistics of catches of crabs during each month of 1899. In addition to these, I received in May two female soft crabs measuring $4\frac{1}{2}$ by $6\frac{3}{4}$ inches; and in June Mr. Hutchison, Dunbar, observed a large soft male; in March he noted a soft crab $5\frac{1}{2}$ inches across. Cunningham† records a crab which cast in April. In the case of the small beach crabs—the statistics of which (Table IV., p. 101) were kept by myself—some were found soft in each month of the year except April and May. One soft crab alone was found in February, and it had just cast. It would then appear that casting is not confined to the summer months; but the crabs which cast at other times of the year are probably a very small minority. The largest number of soft crabs is seen to occur in the months August to November inclusive. The statistics for October are deficient. It is not known how long a small crab remains soft, but, judging from the time which is known to elapse before hardening is completed in the adult crab, it is probably not less than two and a half months. It is also possible that a crab which casts late in the year will take longer to harden than those which cast early, say July. A large number of those found soft in November, then, might

* Cuénot, "Études physiologiques sur les Crustacés Décapodes." *Archives de Biologie*, T. XIII., 1895.

† *Op. cit.*, p. 42.

have cast in September, and those found in December and January may have cast in October. Of those got in July, August, and September, a number in each month were observed to have "just cast." As for the creel-caught crabs, comparatively few soft examples are got in July; at that time the few boats still engaged in the fishing are working close inshore. In August a number of soft crabs are to be got in shallow water along with the large dirty females, which show, by the presence of the empty egg-capsules on their swimmerets, that they have recently hatched their eggs. The soft crabs are then for the most part of small size. For example, in a catch of 176 crabs on August 6th, 1899, of the 57 soft crabs 44 were between $3\frac{1}{2}$ and $5\frac{2}{8}$ inches, while 11 only were above $5\frac{3}{8}$ inches in size. These crabs were for the most part crabs which had cast out of the immature group. When, however, the fishermen begin in the latter half of September to shoot their creels two to three miles off shore in over 20 fathoms water, they get immense numbers of soft crabs over gauge size, and including at that time a considerable proportion of very large crabs up to 7 inches. After September, with each month there is a rapid reduction in the numbers of soft crabs over $4\frac{1}{4}$ inches in size, till in January they practically disappear from the creels. In the case of the soft crabs under $4\frac{1}{4}$ inches, a larger number are taken in the creels in October than in any other month. As will be pointed out below, the small crabs appear to migrate to deep water a little later in the year than the gauge crabs. The statistics of the large crabs are probably therefore of more importance on the question under discussion. Among the crabs $4\frac{1}{4}$ inches and over in breadth, the percentage of soft crabs during the last four months of the year and January were respectively:—September, 80 per cent.; October, 55 per cent.; November, 42 per cent.; December, 22 per cent.; January, 2 per cent. (Table XIII., p. 143). From the fact that after September the numbers of large soft crabs decline rapidly, it is evident that there can be in October no considerable accession, to the ranks of the soft crabs, of crabs that cast in that month; and similarly in the following months the number of crabs which are, through becoming hard, being withdrawn from the soft class is very much greater than the number of those which are joining the same. A great number of crabs which are soft in September are hard in October. There is good reason for allowing for the hardening process during the winter months about $3\frac{1}{2}$ to 4 months; it may be taken for granted that the period will not be longer during the summer months. Thus, the large number of crabs which became hard in October very probably cast their shells some time in July; then those which cast in August and September should be hard again in November and December respectively. From the great reduction in the number of the soft crabs each month after September, it might be possible, given the average time required for hardening, by counting backwards to arrive at the month when the crabs just hardened had cast their shells. From the facts already known, however, we can get at the main casting period with fair accuracy, and this, there appears to be little doubt, is a period of three months—July, August, and September. If this is the case, we should expect to find the greatest number of soft crabs in September, because during that month we should have the soft crabs of the whole period. Those that cast in July and August would in September be still soft; in October the July crabs would become hard; in November the August casters would probably again be marketable; and so with the September crabs in December. After December and until the following August the number of soft crabs is practically negligeable. Wilson* says that casting goes on in July and August. Buckland† quotes the evidence of Mr. Hutton, Customs

Officer, Peterhead, to the effect that the female casts yearly in July, August, and September.

The question as to how long an interval elapses between casting and the complete hardening of the new shell is of considerable importance. As has been mentioned, the legal test of hardness is the impossibility of pushing the thumb through the shell. There is, so far as I am aware, only one recorded case of a crab which had been kept in confinement from the moment of casting until it was completely hard. This crab, which Meek‡ mentions, cast on August 12th, and was found at the end of December to be hard; "thus four to five months are necessary for the hardening process." This specimen was kept in a "hullie" by Mr. Douglas, Beadnell. While it is very probable indeed that confinement will retard the process, still, from a certain amount of indirect evidence which is supplied through the labelling experiments at Dunbar, the above-mentioned interval would appear to be not very much in excess of the period required by some of the crabs at least. The Dunbar labelling experiments were carried out in the first instance with a view to testing the summer and autumn migrations of the crab. For this purpose a large number of soft crabs—999 in all—were labelled and set free in the months of July, August, September, October, November, and December; of these, about 11 per cent. were recovered after various intervals of freedom. On recapture, the condition of the shell of the crab, in addition to other characters, was carefully noted. In Tables X. and XI., the particulars referring to the condition when set free, the interval of freedom, the condition on recapture of each crab, are given in detail. In some cases also the sex and size of the crab are recorded. The crabs of each lot, although designated soft, were not all in the same stage of hardening; in other words, they had not cast their shells at the same time. While some of them were so soft and clean that they had doubtless cast within the previous few days, the shells of others had already undergone a considerable amount of calcification. Thus it happens that certain of the crabs were found to have become quite hard after an interval of 60 days (in one case after only 38 days), while six others were found to be still soft at the end of 74, 82, 83, 83, 94, and 100 days of freedom respectively. The latter crabs, while they were almost completely hard and would possibly have passed as marketable, could still have been broken over the gill cavity. In testing a crab of this stage, there is a considerable risk of lacerating the thumb on the sharp edges of the broken shell. The following Table shows the month in which the soft crabs were labelled, the time of freedom, and their condition when recaptured. The crab when it has almost completely recovered its hard condition is marked ʜ, while the soft crab is represented by S, and the legally-hard crab by H.

* *Op. cit.*

† *Op. cit.*, p. 12.

‡ Northumberland Sea Fisheries Committee, 1898, "Report on the Trawling Excursions," Newcastle-on-Tyne, 1898, p. 28.

Month when Set Free.	Condition of Shell on Recapture.	Intervals of Freedom—Days.
July.	S	34.
	H	...
	H	86, 103.
August.	S	24, 26, 42, 49.
	H	54, 54, 60, **82**, **83**.
	H	**59**, 66, 70, 113, 119, 119, 129.
September.	S	2, 2, 2, 2, 2, 3, 3, 5, 6, 11, 14, 16, 19, 21, 24.
	H	23, 28, 31, 31, 33, 49, 54, **94**.
	H	**38**, 52, 59, 92, 115.
October.	S	9, 16, 18, 20, 20, 22, 25, 29, 32, 52.
	H	24, 37, 47, **83**, **101***, **103**.
	H	**61**, 80, 103, 128, 177.
November.	S	9, 9, 11, 11, 12, 14, 18, 24, 26, 26, 27, 40, 40, 41, 42, 52.
	H	54, 63, 68, **74**.
	H	97, 165, 165, 165, 184.
December.	S	10, 11, 30, 30.
	H	16, 56.
	H	...

* The crab here referred to was captured after an interval of 86 days; after 15 days in confinement, it was still not quite hard enough for market.

The crab which was not completely hard after 101 days was set free in October. All these crabs had been caught in the creels. We do not know how soon after casting a crab leaves its retreat in search of food; but the primary calcification, which renders it capable of defending itself, appears to ensue within a few days. While, then, the facts supplied by the labelling experiment do not entitle us to fix the limits of the period of hardening, we have at least evidence of the time a crab may remain soft, viz. 90 to 100 days. Since it is not improbable that the shell had been about a week old when the crab was taken first of all, and since another week would doubtless at least be required for complete hardening, we get a period of 115 days, which is practically four months. The conclusion, then, to be drawn from these data is that a crab which is soft in October may require four months before it is legally hard. We are unable to judge how far the season of the year in which casting takes place operates in aiding or retarding the process of hardening. One thing is certain, that the rapidity of recovery must be dependent on the amount of food which the crab secures, and, as this necessarily varies with the individual, there is reason to suppose that the length of the period of softness is subject to considerable variation. Although the evidence is very incomplete, I am of opinion that a crab which casts in July will recover its hardness in a shorter time than the crab which casts in September.

In the case of the lobster Herrick* considers that six to eight weeks are necessary for hardening to the condition of the old shell. Prince†

* *Op. cit.*, p. 95.

† *Op. cit.*, p. 10.

says that "a lobster is not completely hard for seven or eight weeks after moulting." A lobster which cast its shell in the tanks at Cullercoats Laboratory during the night 17th-18th August "was found" by Meek* "to be apparently quite hard on 26th August; so that the hardening appears to be a relatively quick process in the lobster." One of the lobsters confined in a floating box by Cunningham† cast on November 23rd, and was found to be hard on February 9th.

Frequency of Casting.

In its earliest stages there is reason, from the analogous case of the lobster, for believing that the young crab moults more than once a year, but in the stage immediately preceding the adult condition, from 3 to 4 inches in breadth, it probably casts only once a year. The shells of these crabs are on the whole clean, and have few ectozoa attached to them. The latter are always small; the commonest being *Serpula*, *Spirorbis*, and *Anomia*. Certain of these crabs, which have been referred to above (p. 84), and which gave evidence of not having cast during the preceding year, were found to be apparently in a diseased condition. It is very probable, indeed, that the great majority do cast once a year. A considerable number (525) of crabs measuring 3 to $4\frac{1}{8}$ inches were labelled and set free in December, January, February, March, April, May, June, and July, and of these very few were recovered. This may in a great measure be due to the fact that, owing to their annual shedding, they got rid of the labels in summer. Of the 16 which were recaptured, two were obtained in July, one in August, and one in September. None were obtained later in the year than September, that is to say after the casting period. The crab captured in August, although it was hard when set free, was then brittle and was evidently preparing to cast.

The mature crabs above $4\frac{1}{8}$ inches in breadth, there is abundant evidence to show, do not cast every year. Certain female crabs measuring from $4\frac{1}{8}$ to $5\frac{3}{8}$ inches which are unfertilised may, however, do so. The shells of the adults are found covered with a varied collection of ectozoa—viz., *Balanus*, *Serpula*, *Anomia*, *Membranipora*, zoophytes. I have also on two occasions found, in cases of injury to the gill chamber, mussels and *Saxicava* attached to the gills. Large oysters have been found attached to the backs of crabs. The size of these molluscs in certain cases proves that the crabs, their hosts, had not cast for three and four years. Buckland ‡ mentions two large crabs, a male $6\frac{3}{4}$ and a female $7\frac{3}{4}$ inches, which had on their backs oysters 3 inches across. The crabs could not have cast for three years. In the *Fish Trades Gazette* for December 9th, 1899, a crab was recorded upon which was fastened a four-year-old oyster. It is now in Ipswich Museum. While from the fact that the female crab usually carries two lots of eggs in successive years we know that the female does not probably cast oftener than once in two years, we have here collateral evidence indicating even a longer abstention from casting. From an examination of the labelled crabs which were put away when soft, it is seen that certain of the ectozoa, zoophytes especially, attach themselves to the crab earlier in the year than October. All the soft crabs which had been set free up to and including the month of September, when recaptured had large growths of zoophytes, and also showed *Anomia* and *Serpula*; whereas the soft crabs of October were almost

* *Op. cit.*, p. 54.

† *Op. cit.*, p. 41.

‡ *Op. cit.*, p. 11.

devoid of ectozoa; occasionally a small zoophyte was discovered. One crab which was soft in November was found in the following May to have on its dorsum an *Anomia* $\frac{1}{4}$-inch (6·5mm.) across, and a *Serpula* $\frac{3}{8}$-inch (11mm.) long.

The labelling experiments afford some evidence with regard to the frequency of casting of the mature male. Thirty-five large hard crabs (male and female) were labelled in June and July 1899. They were set free at the mouth of the harbour, Dunbar. Of the June specimens, four males were recovered—viz., one in July, close to the harbour; one in September, 2 miles N.E. from Dunbar in 22 fathoms; two in October, 2 miles N.E., 22 fathoms, and $1\frac{1}{2}$ miles E. by S., 18 fathoms, respectively. One of the July lot, a male, was got in December 3 miles N.E. of Dunbar. These crabs then shew that the large male crabs also do not cast oftener than once in two years. As a rule, the shell of the old female crab is much more dirty than that of the male. The white parts of the shell of the male turn a deep amber colour, but it remains on the whole very free from mud. The female, however, probably from its habit, when carrying eggs, of lying half-buried in the mud, becomes very dirty, the hairs on the epimera, the fringes of the abdomen, and the exopodites of the swimmerets being often quite black.

Increase in Size on Casting.

So far the law of growth of the crab has not been investigated, and for the determination of the increase which takes place at certain sizes we are dependent on a few recorded cases. These are set out in the following Table:—

	Original Size in Inches.	Size of Soft Crab.	Increase. Inch.	Ratio of Increase.	Authority.
1	$\frac{4}{5}$	1	$\frac{1}{5}$	$\frac{1}{4}$	Mar. Lab., Dunbar.
2	$1\frac{3}{8}$	$1\frac{3}{4}$	$\frac{3}{8}$	$\frac{1}{3·6}$	,,
3	$2\frac{1}{16}$	$2\frac{7}{16}$	$\frac{3}{8}$	$\frac{1}{5·5}$	,,
4	$2\frac{5}{8}$	$3\frac{1}{16}$	$\frac{7}{16}$	$\frac{1}{6}$	,,
5	$2\frac{3}{4}$	$3\frac{5}{8}$	$\frac{7}{8}$	$\frac{1}{3·1}$	J. Couch.
6	$2\frac{8}{10}$	$3\frac{7}{10}$	$\frac{9}{10}$	$\frac{1}{3·1}$	,,
7	$3\frac{7}{8}$	5	$1\frac{1}{8}$	$\frac{1}{3·4}$	Buckland.
8	4	$5\frac{1}{16}$	$1\frac{1}{16}$	$\frac{1}{3·7}$	Gatty Lab., St Andrews.
9	$4\frac{3}{8}$	$5\frac{1}{2}$	$1\frac{1}{8}$	$\frac{1}{3·9}$	Wilson.
10	$5\frac{1}{4}$	$6\frac{5}{8}$	$1\frac{3}{8}$	$\frac{1}{3·7}$	Meek.
11	$6\frac{3}{4}$	$7\frac{1}{2}$	$\frac{3}{4}$	$\frac{1}{9}$	J. Couch.
12	$7\frac{1}{4}$	$8\frac{3}{4}$	$1\frac{1}{2}$	$\frac{1}{4·8}$	Cunningham.

In the majority of cases the ratio of increase is $\frac{1}{3}$ to $\frac{1}{4}$ of the original size. In Nos. 3 and 4 the ratios were $\frac{1}{5 \cdot 5}$ and $\frac{1}{6}$. These crabs were, however, measured immediately on casting, and while the skin was still pliable and putty-like. In the cases of Nos. 1 and 2 the shell had hardened sufficiently to be quite firm and resistant at the time it was measured. From the published descriptions of the remaining crabs, with the exception of Couch's specimens, I gather that they were measured some time after casting, when the shell had hardened more or less. Herrick* found, in the lobster which he observed cast its shell, that the size shortly after the moult was 12 inches, while four days afterwards it measured a little short of $12\frac{1}{2}$ inches. So far, then, it seems probable that the increase in size after casting takes place not merely immediately after the escape from the shell, but also during hardening. Until further observations have been made upon this point, the average ratio cannot be known. This question has a direct and important bearing upon the rate of growth of the crab. While, without doubt, considerable variation will be found in the increase, the cases given in the above Table, with four exceptions, point to the ratio of increase being about $\frac{1}{3}$ to $\frac{1}{4}$ of the original size.

Regeneration of Limbs—Repair of Injuries.

One of the features of the life-history of crustaceans which has attracted much attention is the renewal of limbs which have been accidentally lost. This process is intimately associated with the activity of the dermis, which results in the renewal of the whole skeleton when it has been discarded on casting. From evidence afforded by the examination of the small edible crabs, which are found between tide-marks, I am led to the conclusion that the regeneration of the appendages only takes place when the crab is preparing to cast. This view, although not expressly stated, is more or less borne out by previous investigators; it is in part suggested in the case of the larval lobster by Herrick. Thus, Réaumur† said that the new limbs of the crayfish "grow more or less rapidly, like plants, according as the season is more or less favourable; the warmer days are those which hasten the more their formation and growth. Sometimes new legs sprout out in three weeks, sometimes not till after six; and when the legs are broken off in winter, they do not grow again till summer." Chantran† found in the crayfish that "in the first year of life 70 days are necessary for the regeneration of new limbs. The adult female requires three to four years, the male one and a half to two years, to repair its limbs; and we are told that the adult male moults twice and the female but once a year." . . . "The eyes of the crayfish when cut off in October, at the end of the season of moulting, are not regenerated until the following May, when a series of moults begin." Herrick‡ says that in the 4th and 5th larval stages of the lobster—"at the moment the limb is broken off blood immediately oozes out and coagulates, forming a dense crust over the stump. In a short time a small white papilla, which represents the rudiment of the new limb, appears in the midst of the brown hardened clot. The papilla continues to grow independently of the moulting process, though covered with a cuticular membrane, until a miniature appendage is formed." "The time required for the renewal of a limb thus depends upon the time at which an injury occurs with reference to the moult, and also upon the physiological condition of the

* *Op. cit.*, p. 85.

† From Herrick's Monograph on the American Lobster, pp. 103, 104.

‡ *Op. cit.*, pp. 104, 105.

animal. If the tips of the large chelipeds are clipped off, autotomy does not always or usually occur, and the limb is completely repaired after one moult." Couch* in this connection said—"I am led to believe that when a limb has been lost at some moderate time previous to exuviation, the restoration is much more rapid and perfect at the next succeeding time of the process than if left to the more ordinary proceeding of nature."

The crab can throw off an injured limb, or it may when seized by a foe, in order to escape—purchase freedom at the voluntary expense of a limb. It is then severed at what is known as the fracture-plane, which is marked externally by a suture, extending round the second or basi-ischiopodite joint. Within the segment there are at this point two closely-applied diaphragms which, except for a small foramen, shut off the short proximal from the longer distal part of the limb. The foramen piercing the two diaphragms gives passage to the nerves and vessels that supply the appendage.† (Plate I., Fig. 7.) The fracture takes place between the two septa, the proximal diaphragm remaining as a covering to the broken second joint, the other going with the cast-off limb. The foramen is immediately closed with a small clot of blood. The edge of the shell and the diaphragm soon turn black; a new skin develops within, and the outer black layer, which is now dead tissue, is gradually rubbed off, exposing the new skin. Within this skin, when the crab is preparing to cast, a new limb is formed, and, as it grows, bulges the external covering out in the form of a bud. The scars which mark the lost limbs are found in many different stages—(1) Immediately the limb is lost the scar is white; (2) then the outer skin (the diaphragm) dies and becomes black—this is accompanied by the formation of a new skin beneath it; (3) the black dead tissue is rubbed off through time, or on the bulging out consequent on the formation of the bud; (4) the live skin, when exposed by the removal of the dead tissue, becomes brown. The formation of a bud soon after the limb is lost, and while the dead tissue still covers the scar, is dependent on the nearness of the casting period.

These conclusions are founded upon the observations made upon the beach crabs during each month for a year. Buds of new limbs were noticed mainly during the casting period—viz., June (4 individuals), July (21 individuals), August (10 individuals), and September (3 individuals). In the case of very small crabs, less than 1 inch across, the papilla which is the rudiment of the new limb has been observed in September, October, December, January, and February; while buds have been noticed in November, December, February, March, May, and July. Two crabs measuring 3 inches and $1\frac{3}{4}$ inches respectively shewed in December and January small papillæ on the scars of lost limbs. The crabs under 1 inch in breadth doubtless cast more than once in the year. The only crab which was found soft on the beach in February was one measuring $\frac{4}{5}$ inch. It had just cast. I have no data bearing upon the time required for the formation of the new limb, but it appears that only in the case of a limb lost some considerable time before casting will regeneration be completed at that time. Thus, a crab measuring $1\frac{3}{8}$ inches across cast in a tank at Dunbar in September. Two of its limbs were missing, and a third was injured. The dactylopodite of one biting claw had been broken off, and the injury was covered by a black scar. The soft crab was without three limbs, and had both chelae perfect. Two soft crabs

* *Op. cit.*, p. 11.

† L. Fredericq gives a detailed description and figures of this part of the limb in *C. pagurus* with reference to the phenomena of autotomy. He describes, however, only one diaphragm, his "membrane obtenatrice" corresponding to the proximal of the two described above. "Nouv. Rech. s. l'autotomie chez le crabe," *Arch. Biol.*, XII., 1892, p. 177 *et seq.*

obtained in August showed small buds of new limbs. These had been evidently present when casting took place. The loss of the limbs had in these cases occurred too soon before casting to enable the new limb to be completely formed.

In adult crabs also, which, from their dirty condition, could not have cast for two or three years, the brown scar on the second joint has been found to be covered with large barnacles, *Anomia*, and zoophytes, which clearly indicated that the renewal of the limb was not a process which was inaugurated immediately on the injury being sustained.

A crab does not always throw off an injured limb. Many crabs are found which have lost the last joint of a limb, viz. the dactylopodite. In these cases a black scar covers the place of injury. Sometimes the muscle is shrunk away from the shell, leaving it to project in front of the black scar. This not unfrequently happens in cases of injury to the last joint of the biting claw. A soft crab showed a rather unusual condition. A limb had been broken off near, but not at, the fracture plane. The shell had grown inwards over the scar, reducing the aperture very much. A female in one of the tanks at Dunbar had received an injury to one of the walking limbs; it had been broken off about the middle of the fifth joint, the propodite. The muscle was decaying; there was no appearance of a scar. Even in this case the crab had not got rid of the injured member.

As to the repair of injuries to the carapace, this seems to be dependent on the activity of the chitinogenous epithelium, and only occurs at the time of casting or while the crab is still soft. When the fishermen are testing the soft crabs in autumn they are more than likely to push the thumb through the shell. The crab is then often thrown into the water, and numerous examples of the repair of the injury have come under my notice. It is not at all difficult to get during the winter, in the catches of the fishermen, some of the crabs which had been thus treated. Some of these show a complete, and others a partial repair of the shell. Old-looking crabs are from time to time captured which show more or less severe injuries to the carapace. In these the parts where the flesh has been exposed are covered simply by a soft black scar, beneath which a thin live skin is found. It is therefore apparent that the renewal of the shell over the injured part does not take place during the whole interval between two castings, but only during the time the dermis is active in thickening the shell, a period of, on the average, four months probably. Again, the chance of repair to the injury will be the greater the sooner it occurs after casting. Even on casting the old injuries are not always completely repaired. The injured area may, in the soft crab, be of less extent, but cases have been noticed where soft crabs showed injuries which had evidently been present before casting. In such cases it has probably happened that the chitinogenous epithelium had at that part been destroyed, and at the time of casting it had not been completely renewed by the ingrowth of the epithelium surrounding it.

The regeneration of the limbs only takes place when the crab is *preparing* to cast. The repair of injuries to the carapace only takes place at the same period, or during the time the crab is soft. The presence of buds of new limbs may be regarded as an indication that it is about to cast.

In the case of adult crabs the new limb cannot reach the size of the other limbs until after at least two moults. Crabs which have diminutive chelae are not uncommon.

Rate of Growth and Distribution.

With the view of arriving at some determination of the rate of growth of the crab, the method which has been used by Petersen in connection with the rate of growth of the plaice has been applied to a considerable number of crab measurements. The method consists in regarding the peaks which appear in the curve plotted from the measurements of a large number of individuals as marking the modal size, at intervals of one year. If, then, in a curve made from the measurements of crabs, distinct peaks were found, we should probably be entitled to look upon such intervals as approximately representing the average increase in the size of the crab following casting. The increase in size varies with the size of the crab. All the crabs have been measured across the greatest breadth of the carapace. Crabs were got from two sources—(1) 2336 crabs (1153 males and 1183 females) collected between tide-marks on the beach; (2) 3029 crabs (1507 males and 1522 females) caught in the creels of the fishermen. The beach crabs * were measured in centimetres (Table VIII), and the curves plotted from the measurements are to be found on Plate II. The curve for the males is black; that for the females red. It is at once seen that the curves of the two sexes, although each very irregular, follow one another closely. The irregularity of the curves indicates great variation in growth. Between the sizes 1·7cm. and 7cm., male and female crabs were found at every half-millimetre, except in the following cases. Females were not obtained at the following sizes—1·85, 5·45, 6·05, 6·25cm., and males were not observed at 5·55, 5·95, 6·05, and 6·65cm. Since the crab does not increase in size gradually, but by leaps, the irregularity in growth is by the preceding facts rendered very apparent. Until the rate of increase in size at each moult is determined, it is not possible to interpret curves such as we have in the present case. The curves of the creel crabs (Plate III.) also show great variation in growth. These crabs were measured in eighths of an inch; their curves are shown as dotted black and red lines. In order to admit of a comparison between the beach and creel crabs, the curves of the former have been converted to a one-eighth-inch basis, and are shown alongside the curves of the adult crabs. On reference to the former curves it is seen that the great majority of the beach crabs are between $\frac{7}{8}$in. and $2\frac{1}{4}$in. in breadth. There are very few crabs below $\frac{7}{8}$in. We, however, know that they must exist in even greater numbers than the larger crabs, and the reason for their non-appearance in the lists is probably simply their absence from that region. It is no doubt the case that these small crabs are more likely to be overlooked during their collection on the beach, but a crab of even half-an-inch in breadth is by no means inconspicuous. I am of the opinion that the majority of the crabs in the stages less than $\frac{7}{8}$in. do not make the beach their habitat. The beach crabs were almost without exception found beneath stones which were left dry by the ebb; they were usually buried as deep as the edge of the carapace in a mixture of mud and sand. Very rarely were any found where the bottom consisted of rough gravel, into which they could not burrow. A look-out was kept specially for the very small crabs, and the non-success in finding them is no doubt due to the fact that they do not come within tide-marks. While we may occasionally get there crabs about 3in. across, still from $\frac{7}{8}$in. to $2\frac{1}{4}$in. may be taken as the description of the beach group. With regard to the creel crabs, the measurements of which are detailed in Table IX., it is seen from the curves that very few measure less than 4in. across. The dates of the ten catches which were measured are —December 20, 1897; January 28, February 25, March 31, May 3, May 27, November 5, 1898; June 3, July 12, August 4, 1899. Of the 3029 crabs, 2887, that is 95 per cent., are above 4in. in breadth. The smallest crabs in the catches are two measuring respectively $2\frac{5}{8}$in. and 3in.

* For the dates of collection see Table IV., p. 101.

They were caught on July 12, when the creels were shot close inshore near low-water mark. The next smallest, viz. two at $3\frac{1}{4}$in. and $3\frac{3}{8}$in. respectively, were caught in November in 24 fathoms. The fishermen agree in saying that they never get any crabs smaller than 3in. across offshore; but that such crabs are often seen when the creels are shot in summer near low-water mark. They are, however, able to escape through the meshes of the net covering the creel. These crabs may be seen in the pools at the edge of the tide during big ebbs. The curves of the beach and creel crabs only overlap very slightly; in fact they may be said to be quite distinct. Now, it is impossible that the crabs in the beach group could by one casting enter the creel group of crabs. There is a very large gap between the two, which must be filled by another group of crabs which is not represented, except by one or two examples. This group is to be found neither on the beach nor in the creels, except when they are shot close inshore. There is every probability that these crabs, which may for convenience be labelled the $2\frac{1}{2}$ to 4 inches group, will be found just outside low-water mark, and this is rendered the more probable since certain members of the group appear among the beach crabs and occasionally with the creel crabs. They are littoral, but they do not appear to allow themselves to be left dry at low water. In the Report of the Crab and Lobster Commission, Mr Roach, a witness, said he has been to a place behind the breakwater (Plymouth) every year, and caught small crabs, but no large ones; therefore concludes that the small crabs are a distinct species: he thinks the place a nursery for them" (p. 56). To complete the cycle, then, there are two groups wanting—viz., Group I. from the *Megalopa* stage to the crab of one inch across, and Group III., those from $2\frac{1}{2}$ to 4 inches in size.

The distribution of the crab may then be tentatively described as follows:—Group I., the postlarval stages and earliest young stages up to $\frac{7}{8}$-inch in breadth, which is probably restricted to the shallow shore waters where it was hatched; Group II., the beach crabs, from $\frac{7}{8}$ to $2\frac{1}{4}$ inches, which are to be found between tide-marks, usually left dry by the ebb; Groups III., the crabs from $2\frac{1}{2}$ to 4 inches, which appear to be confined to the littoral waters just outside low-water mark; Group IV., crabs of 4 inches and upwards, which may be termed the mature group, and which are to be found in winter offshore beyond the twenty fathom line, and in spring and summer in the inshore waters sometimes even within tide-marks. The sizes which have been given to the groups are only intended as approximate. It is very unlikely that the various groups are separated sharply.

As to the age at which a crab becomes mature, I can furnish no data. That can only be determined when it is known how often a crab casts before it arrives at a size of 4 inches, and also how often the young crabs may cast each year. These facts, and the rate of increase at each cast, remain to be discovered.

The irregularity in the rate of growth may be due to two factors—(1) a difference in size between individuals in the same larval stages, which difference would be perpetuated, and probably increased, with each moult; and (2) the possibility of more frequent casting in the case of certain individuals during the early stages. The moulting is probably directly due to the supply of food, and this is no doubt subject to considerable variation in the case of different individuals.

A general description of the life-history of the crab may be here proposed. It rests directly on the conclusions come to above with regard to Groups I. and III., and remains or falls with the future proof of their reliability or error. The crab hatched in the inshore waters, when it reaches a size of about one inch, passes into the beach-group; when it has grown to a size of $2\frac{1}{2}$ inches it leaves the beach for the littoral waters just beyond low-water mark, stony or rocky ground; on arriving at a size of 4 inches it joins the mature group and takes part in the great seasonal migrations. In support of the probability that the crabs of different sizes are restricted to more or less fixed habitats, one has only to consider that, except for this distribution, the crab occupies the same position in the economy of the sea during its whole life. It is a bottom-feeder, and it is apparent that the small crabs would be extremely liable to become the prey of their larger brethren if they occupied the same habitat. And from the fact that the crabs of Groups I. and III. are to be occasionally found with Group II. on the beach, it is very probable that the habitats of the three groups are contiguous. The mature Group IV. gives rise to the crab-fishing.

[TABLE.

Table VIII.

Measurements of the Beach Crabs in Centimetres.

The Hard and Soft Crabs are taken together.

Cm.	Inches.	Male.	Female.	Male + Female.
·5	-	-	-	-
·65	$\frac{1}{4}$	-	*1*	1
·7	-	-	-	-
·8	-	-	-	-
·95	$\frac{3}{8}$	1	-	1
1	-	-	*1*	1
·1	-	1	*1*	2
·2	-	1	*5*	6
·3	$\frac{1}{2}$	5	*1*	6
·4	-	15	*10*	25
·5	-	20	*11*	31
·6	$\frac{5}{8}$	12	*12*	24
·7	-	16	*11*	27
·8	-	14	*7*	21
·9	$\frac{3}{4}$	5	*10*	15
2	-	10	*18*	28
·1	-	13	*10*	23
·2	$\frac{7}{8}$	12	*12*	24
·3	-	24	*21*	45
·4	-	21	*19*	40
·5	**1**	21	*23*	44
·6	-	27	*17*	44
·7	-	26	*19*	45
·8	$1\frac{1}{8}$	27	*24*	51
.9	-	23	*23*	46
3	-	31	*38*	69
Total,		325	*294*	619

Cm.	Inches.	Male.	Female.	Male + Female.
3·1	-	31	*30*	61
·2	$1\frac{1}{4}$	21	*34*	55
·3	-	40	*33*	73
·4	-	21	*29*	50
·5	$1\frac{3}{8}$	27	*32*	59
·6	-	27	*35*	62
·7	-	42	*33*	75
·8	$1\frac{1}{2}$	38	*28*	66
·9	-	36	*22*	58
4	-	32	*35*	67
·1	$1\frac{5}{8}$	43	*28*	71
·2	-	32	*36*	68
·3	-	29	*32*	61
·4	$1\frac{3}{4}$	28	*27*	55
·5	-	30	*30*	60
·6	-	22	*31*	53
·7	-	22	*36*	58
·8	$1\frac{7}{8}$	26	*20*	46
·9	-	17	*23*	40
5	-	21	*24*	45
·1	**2**	16	*32*	48
·2	-	12	*21*	33
·3	-	18	*17*	35
·4	$2\frac{1}{8}$	13	*11*	24
·5	-	13	*17*	30
·6	-	18	*17*	35
Total,		675	*713*	1388

Cm.	Inches.	Male.	Female.	Male + Female.
5·7	$2\frac{1}{4}$	19	*14*	33
·8	-	13	*10*	23
·9	-	14	*9*	23
6	$2\frac{3}{8}$	10	*11*	21
·1	-	13	*17*	30
·2	-	9	*4*	13
·3	$2\frac{1}{2}$	9	*7*	16
·4	-	5	*5*	10
·5	-	7	*14*	21
·6	-	1	*6*	7
·7	$2\frac{5}{8}$	4	*7*	11
·8	-	11	*6*	17
·9	-	4	*4*	8
7	$2\frac{3}{4}$	3	*10*	13
·1	-	7	*8*	15
·2	-	6	*6*	12
·3	$2\frac{7}{8}$	2	*1*	3
·4	-	3	*2*	5
·5	-	2	*2*	4
·6	**3**	2	*1*	3
·7	-	-	-	-
·8	-	2	*3*	5
·9	$3\frac{1}{8}$	1	*2*	3
8	-	1	*1*	2
·1	-	-	*4*	4
·2	$3\frac{1}{4}$	-	*3*	3
Total,		148	*157*	305

Cm.	Inches.	Male.	Female.	Male + Female.
8·3	-	-	*1*	1
·4	-	-	*1*	1
·5	-	2	*2*	4
·6	$3\frac{3}{8}$	-	-	-
·7	-	-	*1*	1
·8	-	-	*1*	1
·9	$3\frac{1}{2}$	-	*1*	1
9	-	-	*2*	2
·1	-	-	*2*	2
·2	$3\frac{5}{8}$	-	-	-
·3	-	2	*1*	3
·4	-	-	*2*	2
·5	$3\frac{3}{4}$	-	-	-
·6	-	-	*1*	1
·7	-	-	-	-
·8	$3\frac{7}{8}$	-	*1*	1
·9	-	-	*2*	2
10	-	-	*1*	1
·1	-	-	-	-
·2	**4**	-	-	-
·3	-	-	-	-
·4	-	-	-	-
·5	$4\frac{1}{8}$	-	-	-
·6	-	-	-	-
·7	-	-	-	-
·8	$4\frac{1}{4}$	1	-	1
Total,		5	*19*	24

Total, - { Males, 1153 / Females, 1183 } - - 2336 Crabs.

Table VIIIa.

Beach Crabs measured in Inches.

The Hard and Soft Crabs are taken together.

Size.		Hard and Soft Crabs.			Size.		Hard and Soft Crabs.			Size.		Hard and Soft Crabs.		
Inches.	Cm.	Male.	Female.	Male + Female.	Inches.	Cm.	Male.	Female.	Male + Female.	Inches.	Cm.	Male.	Female.	Male + Female.
1/4	·65	-	*1*	1	**1** 5/8	4·1	104	*96*	200	**3**	7·6	4	*4*	8
3/8	·95	3	*7*	10	3/4	4·4	102	*124*	226	1/8	7·9	2	*7*	9
1/2	1·3	40	*22*	62	7/8	4·8	64	*67*	131	1/4	8·2	2	*7*	9
5/8	1·6	42	*30*	72	**2**	5·1	46	*70*	116	3/8	8·6	-	*2*	2
3/4	1·9	28	*38*	66	1/8	5·4	44	*45*	89	1/2	8·9	-	*5*	5
7/8	2·2	57	*52*	109	1/4	5·7	46	*33*	79	5/8	9·2	2	*3*	5
1	2·5	74	*59*	133	3/8	6·0	32	*32*	64	3/4	9·5	-	*1*	1
1/8	2·8	112	*115*	227	1/2	6·3	22	*32*	54	7/8	9·8	-	*4*	[illegible]
1/4	3·2	82	*96*	178	5/8	6·7	19	*17*	36	**4**	10·2	-	-	-
3/8	3·5	96	*100*	196	3/4	7·0	16	*24*	40	1/8	10·5	-	-	-
1/2	3·8	106	*85*	191	7/8	7·3	7	*5*	12	1/4	10·8	1	-	1

Table IX.

Measurements of Crabs—*10 Catches. Dec. 1897 to Aug. 1899.*

Size.		Hard and Soft Crabs.			Size.		Hard and Soft Crabs.		
Inches.	Cm.	Male.	Female.	Male + Female.	Inches.	Cm.	Male.	Female.	Male + Female.
2⅝	6·7		*1*	1	**5¼**	13·3	84	*87*	171
¾	7	-	-	-	⅜	13·6	83	*60*	143
⅞	7·3		-	-	½	14·0	90	*112*	202
3	7·6	-	*1*	1	⅝	14·3	64	*77*	141
⅛	7·9	-	-	-	¾	14·6	65	*77*	142
¼	8·2	1	-	1	⅞	14·9	43	*60*	103
⅜	8·6	1	*1*	2	**6**	15·2	46	*54*	100
½	8·9	8	*8*	16	⅛	15·5	42	*39*	81
⅝	9·2	11	*13*	24	¼	15·9	17	*31*	48
¾	9·5	24	*15*	39	⅜	16·2	17	*35*	52
⅞	9·8	29	*29*	58	½	16·5	29	*24*	53
4	10·2	36	*35*	71	⅝	16·8	17	*13*	30
⅛	10·5	70	*62*	132	¾	17·1	11	*20*	31
¼	10·8	79	*72*	151	⅞	17·5	6	*5*	11
⅜	11·1	76	*64*	140	**7**	17·8	4	*12*	16
½	11·4	91	*78*	169	⅛	18·1	2	*3*	5
⅝	11·7	76	*61*	137	¼	18·4	2	*4*	6
¾	12·1	103	*95*	198	⅜	18·7	1	*1*	2
⅞	12·3	81	*77*	158	½	19·0	2	*1*	3
5	12·7	120	*109*	229	⅝	19·4	-	-	-
⅛	13·0	75	*86*	161	¾	19·7	1	-	1
Total,		881	*807*	1688	Total,		626	*715*	1341

Total—Hard and Soft Crabs, { Male, 1507; Female, 1522 } - - 3029 Crabs.

The Migrations of Crabs.

That the adult crabs undertake definite seasonal migrations—viz., in the spring to the shallow shore waters, and in autumn to the deeper offshore areas—has been long known to fishermen. During the enquiry held in Scotland by the Crab and Lobster Commission of 1876, Mr. George Findlay, of Whitehills, Banff, exhibited a chart of the sea-bottom adjacent to Banff, Macduff, and Whitehills, showing that in the autumn months the crabs are three miles from land, and in the summer months, May to August, near the land for shelling.*

With a view to arriving at more definite data regarding these migrations, a considerable number of crabs, 1567, were labelled and set free in the sea near Dunbar. Of that number 876 were put away at the mouth of the harbour,† and 691 at various distances from ½ to 3½ miles off

* Report of the crab and Lobster Commission, 1877, p. 18.

†The Crabs were labelled under the supervision of the writer, or of Mr. Hutchison. Dunbar. They were then taken to sea by a fisherman who had instructions where to set them free.

shore. Of these crabs, 131, that is 8 per cent., have been recaptured. There are certain circumstances which tend to lower the number of the crabs which may be recaptured, viz. (1) the chance of the label being torn off; (2) the risk of death following the treatment to which the crab is exposed while being brought ashore, labelled, and returned to the water. The percentage of recovered crabs is very much lowered by the very few crabs recaptured during the first part of the experiment. Of 539 crabs labelled from October 1897 to April 1898, only 12 were recaptured. Of 1028 labelled since November 1898, 119 have been recovered, viz. 11·5 per cent. The crabs were marked by attaching, by means of a silver wire, a nickel label, about $\frac{1}{2}$ to $\frac{3}{4}$ inch square, to a small hole bored in the edge of the shell, usually at the seventh septum on the left side. At first small brass labels were used; some of these were attached by fine brass snare wire to the great claw, others were attached in the same manner as the nickel labels. Two only were recovered with the label tied to the claw. Nickel labels were alone used for the crabs labelled from 1 to 1173. The number of crabs set free at one time, the date, and the place are given in Tables X. and XI. On the right side of the Table the particulars regarding the recaptured specimens, their condition when set free, and when and where recovered, the length of the interval of freedom, etc., and in a number of cases the sex and size of the crab, are detailed. Table X. contains the crabs put away at the mouth of the harbour; Table XI., those returned to the sea at various distances from shore.

The majority of the crabs used for labelling were soft gauge crabs, in number 999; 568 hard crabs, viz. 532 small crabs measuring $3\frac{1}{4}$ to $4\frac{1}{4}$, and 36 gauge crabs, were also marked. The small hard crabs were used for labelling from January to July; the large hard crabs in June and July; the soft crabs from July to December. Of nine batches, consisting of 333 marked specimens, no individual was recovered. The date and other particulars of these lots are given in the following Table.

Date.	Number of Specimens.	Description.	Mode of Attachment of Label.	Place where set free.
Oct. 29, 1897,	52	Soft,	Attached to great claw,	Mouth of harbour.
Nov. 1, ,,	51	,,	,, ,, ,,	,, ,,
Dec. 2, ,,	19	,,	,, ,, ,,	,, ,,
,, 24, ,,	35	,,	,, to edge of shell,	,, ,,
,, ,, ,,	19	*u. Hard	,, ,, ,,	,, ,,
Feb. 26, 1898,	22	,,	,, ,, ,,	4 miles N. of Dunbar.
Mar. 1, ,,	35	,,	,, ,, ,,	,, ,,
May 13, 1899,	50	,,	,, ,, ,,	3 miles E. by N. of Dunbar.
,, 25, ,,	50	,,	,, ,, ,,	Mouth of harbour.

* Under gauge size.

Very few small hard crabs were recovered, viz. 16 only out of a total of 532. This was in some measure no doubt due to the fact that the majority, if not all, of the small crabs cast during the summer. Certain soft crabs came under my notice which had evidently been labelled, for they showed a gap torn in the edge of the carapace at the part where the label was usually attached. None of the small hard crabs were recovered later in the year than September, that is to say later than the casting period ; one was captured in August, a second in September. One apparent exception to the statement is the crab No. 8 in Table XI. It had, however, been free only fourteen days when it was captured in November. The probability, then, is that casting accounts partly for the non-recovery of the small crabs.

In the Tables, in addition to the distance and direction from Dunbar of the place where each labelled crab was retaken, the depth of the water at the spot is also given. The fishermen, although able to give only very approximate particulars of distance and direction, can give within small limits the exact depth at which their creels are fishing. The direction from Dunbar and the depth of water are surer guides to the locality of capture than the distance as estimated by them.

In order to show graphically the results of the experiments, the places where the crabs have been recovered have been marked on a chart of the sea near Dunbar (Plate IV.). Two marks, each of two different colours, are employed to distinguish the different groups of crabs. Thus the black marks relate to those crabs which were recaptured in the months of August to February inclusive; the red colour designates the crabs caught in the period April to July inclusive. No crab was recaptured in March. The little discs (red and black) denote crabs which were set free at the mouth of the harbour (Table X.); the crosses (red and black) refer to crabs which were set free at some distance from Dunbar (Table XI.).

The chart, Plate IV., first of all shows that the labelled crabs caught from August to February were, with two exceptions, all got out in 18 to 25 fathoms water, while those caught in April to July were got in an average of 8 fathoms. Of the winter crabs, 101 in number, 89 were found in water of over 20 fathoms in depth, ten in 18 to 19 fathoms, one in 17, and one in 16 fathoms. The depth, then, for these crabs was 18 to 30 fathoms. Of the 27 summer specimens, 19 were found in 4 to 8 fathoms, three in 10, three in 13, and one in 16 fathoms. The crabs recaptured in the months August to February will be first discussed. If now we consider the crabs set free at the mouth of the harbour (Table X.), and represented in the chart by a disc, we see that they were mainly recaptured between a northerly and north-easterly direction from Dunbar ; and from the fact that three specimens, Nos. 28, 29, and 30, which had been free for two days only, had travelled from the harbour 2 miles and $2\frac{1}{2}$ miles respectively in a north-easterly direction, it is very probable that the massing of these crabs just beyond the twenty-fathom line, and in an area bearing N.E. from Dunbar, points to the crabs having gone out in that direction. The crab which had travelled farthest, No. 40, was found 6 miles to the north of Dunbar after 59 days. While the majority, then, had apparently moved off to deep water in a north to easterly direction, three had taken an easterly and three an east by south course. The results then point to a definite direction, viz. N.E., taken by the crabs in going from the shallow water at the mouth of the harbour out to the ground beyond the twenty-fathom line.

Most of the crabs which were put away at some distance from Dunbar were set free from 1 to 3 miles in an E. by N. direction. Two lots, numbering 30 and 26 individuals, were liberated at $1\frac{1}{2}$ miles and 2 miles respectively east of the harbour, and a third lot, 51 crabs, about 2 miles S. E. Of those set free in an E. by N. direction, 32 were found to the north of the place of liberation, that is to say they had moved along in about the same depth of water; 14 were to the south of the same; two which were set free one mile from shore were got one mile further east; while three, after intervals of freedom of 24, 26, and 83 days, were found close to where they were put away. The latter were set free—in August, two crabs, and in October one crab, out beyond the twenty-fathom line. One crab, No. 46, Table XI., was found to have travelled in 54 days to a point 8 miles from the place of liberation.* Of the crabs captured from April to July, 14 had been set free at the mouth of the harbour, and 13 offshore. Of the former, four were found near the harbour; two of these had been liberated in December, the third in April, and the fourth in June. Four which were taken at $1\frac{1}{4}$ miles N.W. (two specimens), 2 miles west (one specimen), and $1\frac{1}{2}$ miles S.E. (one specimen), had been set free in November. Two set free in January were recaptured $1\frac{1}{2}$ miles E. and $\frac{3}{4}$-mile E.S.E. of Dunbar respectively. Nine of the crabs set free offshore were found in the summer months to the south of the place where they were liberated. No. 6 (Table XI.) was, according to the report of the fishermen, got 3 miles east by south, at which place a depth of 20 fathoms is found. This was in April, at which time, I am informed, no boat is fishing in water of that depth.

It has several times happened that two crabs which were liberated together were recaptured on the same day after intervals of 9 to 122 days, and although in certain cases they have been found near one another, it has oftener happened that the places of capture were at some distance apart. One striking case is that of Nos. 11, 12, and 13, Table X, which were captured on April 19th, after an interval of freedom of 165 days. Two were got near together; the third was about 3 miles distant from the others. All the lots of crabs, with one exception, show simply a migration in one direction, which in the majority of cases is seaward, in a few cases shoreward. The exception is a collection of crabs which was set free at the mouth of the harbour in November, Nos. 6 to 14, Table X. Of these, five were recaptured during December, January, and February, at from 2 to $3\frac{1}{2}$ miles offshore. In April three were obtained close inshore in 8 fathoms, and in May a fourth was found in 7 fathoms. There is very little doubt but that the last four crabs had in November gone off to deep water with the others, and had returned in April and May to the shallows. With regard to the months in which they take place, we are able to fix the migrations within certain limits. When the take of crabs diminishes in June, the majority of the boats bring their creels ashore and prepare for the summer herring fishing, or begin line fishing. They return to the crab fishing in the middle of September or beginning of the following month, according to the bad or good result of the herring fishing. When they do so, they shoot their creels right out in deep water. The few boats which continue fishing in July and August do so close inshore, and the main portion of the catch consists of females which have just hatched their eggs. In August a considerable number of comparatively small soft crabs are also got (*see* p. 106). Many of the large crabs which have come near the land in April and May cast inshore, and move out to sea again. In order to find what crabs were offshore in August, I arranged to have ten creels shot 3 miles N.E. of Dunbar, at which place 18 fathoms were found.† Ten crabs were obtained—viz., four large hard females $6\frac{5}{16}$ to $6\frac{3}{4}$ inches across, three of which had just hatched their eggs, four small males $4\frac{1}{16}$ to

* After going to press, a crab (No. 49, Table XI.) has been got in St. Andrews Bay; it has in seven months travelled across the Firth of Forth to a point 18 miles north of the place where it was set free.

† There is here a discrepancy between the distance from shore and the depth. The distance or direction, judging from the chart, is probably at fault.

$4\frac{5}{8}$ inches, and one small hard female $3\frac{3}{8}$ inches across. Not a single soft crab was obtained. The probability is that the soft crabs had not yet migrated, but the large hard females captured on this occasion had done so; since there is little doubt but that the berried females come inshore, and the eggs hatch there in summer, July being probably the principal month. By the middle of September (13th) 1899, the soft crabs were got in great numbers in 25 fathoms. The migration of the soft crabs appeared, then, to have begun last year (1899) between the middle of August and the middle of September. The experiment described above gives some ground for the conclusion also that the large females which had lately been berried, and which are not about to cast, migrate soon after the hatching of the eggs. From the labelling experiments some little evidence is thrown upon the migration of the large hard males. A number of large male crabs were labelled and set free at the mouth of the harbour in June. On July 14th one of these, No. 19, Table X., was got close to the harbour; in September another, No. 20, was taken in a creel 2 miles N.E. in 22 fathoms, and in October two more were captured; one, No. 21, 2 miles N.E. in 22 fathoms, and the other, No. 22, $1\frac{1}{2}$ miles E. by S. in 18 fathoms. A large hard male crab, set free at the harbour in July, was found in December, 3 miles N.E. in 22 fathoms. We may probably conclude, then, that these large males had not begun to migrate in July, and by September they had done so. The migration seaward of hard and soft crabs then probably occurs during August and September. The statistics which were kept during the last four months of last year of the hard and soft crabs captured daily point to a migration of crabs less than $4\frac{1}{4}$ inches across the back taking place a little later than that of the gauge crabs. In Table XII. it is seen that up till September 29th, although there were a great number of soft gauge crabs, there was none under $4\frac{1}{4}$ inches. After that date the number of small crabs increased rapidly.

The inshore migration appears to begin usually in February. In February and March the creels are still shot in deep water, and also sometimes in shallow water. In these months the men begin to shift the creels in, but up to the end of March 1898 some of the boats were still fishing in 18 fathoms, while others were working in 8 fathoms in February. The inshore migration appears to be more irregular than its seaward counterpart. By April and May the crabs are usually close inshore. In May 1898, however, the men had to shift their creels to about a mile offshore, where there is a depth of about 14 fathoms, owing to the scarcity of the crabs inshore. It is very evident that the inshore migration is subject to considerable fluctuations. It moreover seems to be very gradual, thus differing from the seaward migration, which is apparently very rapid. Thus, three crabs which were set free at the harbour on Saturday, September 23rd, were captured on the following Monday, September 25th—one at 2 miles, the other two at $2\frac{1}{2}$ miles N.E. of Dunbar. The creels had been shot on Saturday and remained in the water till Monday. The crabs had thus travelled $2\frac{1}{2}$ miles in two days. The time taken to the journey was possibly less. The inshore migration has a very important effect on the crab fishery, for during April and May the concentration of the crabs in the shallow water of necessity restricts the fishing area, and intensifies the fishing capacity of the creel. At this time of the year the largest number of creels is employed, certain boats having as many as 200, while no boat will have less than 100. There are probably at least 3000 creels shot each day during these months. The catch is at this time the greatest. By June the takes diminish rapidly. While this fact may be in part due to the crabs retiring to cast, it is very possibly simply in consequence of the crabs being nearly all fished up. The explanation given by the fishermen is that the crabs "hole up," or "do not creep." The fact of the double migration of the crab is not accepted by all the fishermen. They are of the opinion that there are certain "bodies" of crabs restricted to deep water and other bodies to shallow water. And since during the winter they get no crabs inshore, the reason is that the inshore crabs "hole up" in winter; and since in summer no crabs are got off in deep water, it is owing to their retiral to their burrows, from which they cannot be tempted by the ordinary baits. A generally accepted belief is that crabs will not "creep" all the year round. These are merely attempts to account for the phenomena of migration. Another difficulty, which gives rise to the view that there are varieties of crabs restricted to special areas, is due to the fact that the appearance of the crab changes with the season. As the shell of the crab grows older it darkens, becomes yellow underneath; and its general appearance is affected by the ectozoa which attach themselves to it.

What, then, are the causes of the migrations of the crab? The reason for the migrations may be sought for in two directions—(1) the influence of temperature; (2) the necessity for food. The time in the crab's life when temperature will most probably affect it is (1) during the incubation of the egg; (2) during the process of casting. From the appended Table of temperatures of the bottom water of the sea at Dunbar, taken in June, July, and August, 1899, by a fisherman, it is seen that with one insignificant exception the water at 6 to 8½ fathoms was much warmer than the water offshore in 21 to 25 fathoms. During that period the eggs hatch, and as we know that warmth has the effect of hastening the development of the ovum, we may conclude that in the case of the berried crabs the migration shoreward aids the hatching of the eggs. Berried crabs extrude their eggs offshore in winter, when the bottom water is warmer than that near the shore; their presence inshore in summer pre-supposes a migration thither. Secondly, there is every ground for holding that the soft crabs cast in the shallow inshore water; the warmth possibly influences favourably this process.

Temperature of Water at Bottom.

Date.	Three Miles from Land.			Half Mile from Land.			Just outside Harbour.		
	Temperature.	Depth.	Time.	Temperature.	Depth.	Time.	Temperature.	Depth.	Time.
1899.	*Degrees.* C.	*Fathoms.*		*Degrees.* C.	*Fathoms.*		*Degrees.* C.	*Fathoms.*	
June 8	7·5	25	12.45 p.m	8	13	1.30 p.m.	9	6½	2.10 p.m.
" 15	8	25	4.30 "	9	12	2.45 "	11	7½	2.0 "
" 23	8	25½	1.40 "	9	13	11.50 a.m.	10	8	11.30 a.m.
" 30	8·5	25	5.30 "	9·5	12½	3.15 p.m.	11·5	6½	2.30 p.m.
July 6	8·5	25	5.15 "	10	13	3.10 "	12	6½	2.45 "
" 14	9·9 (10)	22	12 noon.	11·3	13	1.5 "	11·9	7	1.15 "
" 21	9·5	24	4.30 p.m	10	18	5.15 "	.	.	.
Aug. 2	11	23	6.30 "	12·5	12½	7.0 "	13	8	7.10 "
" 11	13	21	7.0 "	12·5	13	7.30 "	12·8	8½	7.45 "
" 18	13	22	8.0 "	14·5	14½	8.30 "	15	7½	8.45 "
" 25	13	22	7.15 "	15	14	8.0 "	15·5	6½	8.20 "
Se . 25	11·9	25	12.15 "	11·6	10	3.0 "	.	.	.

The migration offshore in August and September cannot, however, be explained by reference to temperature. At the end of August last year, at which time the soft crabs were probably making their way seawards, the temperature of the inshore water was still higher than that of the deep water, and on September 25th the temperature at 10 fathoms was only ·3 of a degree less than that at 25 fathoms. Moreover, small soft crabs are to be found between tide-marks on the beach all through the winter (*vide* Table IV.). It is not at all likely that the adult soft crabs would be inconvenienced by cold when the small crabs are not affected by it. The migration of the soft crab may with some reason be attributed to the necessity for food. Immediately after casting the crab feeds ravenously, and it is therefore not unlikely the shore waters may not offer them a sufficient food supply. It is not improbable that the inshore migration may also be due to a search for food. Both migrations appear to be shared by male crabs which are not about to cast. The offshore ground upon which the crabs are found in winter appears from the chart to consist of sand, with stony patches here and there, while further to sea the bottom is of mud. About 600,000 crabs are taken each year at Dunbar, and although the length of the fishing ground is considerable, probably 14 miles, its breadth will not exceed about 4 miles. The amount of food which these crabs consume must be great indeed. The crab fishing consists in simply setting a barrier of creels in front of, or in the midst of, the migrating crabs, and as the crabs move along the creels keep pace with them.

Mr. Hutchison, Dunbar, has informed me that certain fishermen at Skateraw had been accustomed to bring the soft crabs which they caught in deep water during winter to the shore in order to set them at liberty in shallow water. They did so with the view of stocking the shore waters for the summer fishing. It is very doubtful if any of these transported crabs remained inshore; they probably immediately moved right off to deep water, just as did the labelled soft crabs put away in September, October, and November.

There is evidence that long-continued frosty weather tends to diminish the catch of crabs; the cold is said to make the crabs "hole up." Similar evidence was given before Buckland.

Migration Experiments at Berwick-on-Tweed and Beadnell, Northumberland.

By the courteous permission of the Northumberland Sea Fisheries Committee, their fishery officer, Mr. Buglass, labelled 100 crabs and set them free off Berwick-on-Tweed in February and May 1898. The majority were undersized, and none were recovered.

Mr. Douglas, Beadnell, also kindly labelled 100 crabs, and of these 5 were recaptured.

Date of Liberation.	Place.	Date of Recapture.	Place.	Direction of Migration.
1898. 1. March 1	.	March 22	.	1½ miles shoreward.
2. Feb. 26	At the Haven.	May 31	Off N. Sunderland, 8 fms.	N.E.
3. ,, 21	4 miles offshore, 26 fathoms.	June 3	Close inshore, 4 fathoms.	4 miles shoreward.
4. March 8	4 miles offshore, 26 fathoms.	,, 17	Close to rocks, 4 fathoms.	,, ,,
5. Feb. 25	4½ miles offshore.	July 9	Close to rocks, 3 fathoms.	4½ ,, ,,

These five crabs are valuable additions to the material supplied by the Dunbar specimens, illustrating, as they so well do, the shoreward migration in spring and summer. The first crab fills a gap which exists in the Dunbar list, since at Dunbar no crab was recaptured in March.

TABLE X.—LIST OF LABELLED CRABS SET FREE AT THE MOUTH OF THE HARBOUR, DUNBAR.

S stands for Soft (not Marketable). H stands for Hard (Marketable). H indicates that the Crab is nearly, though not quite, hard enough to be Marketable. u indicates a Crab of under gauge size.

	Set Free.			Recaptured.								
						Place.						
	Number of Individuals.	Numbers on the Labels.	Date.	Label Number.	Date.	Distance and Direction from Dunbar.	Depth in Fathoms.	Condition when Set Free.	Interval of Freedom. Days.	Condition when Re-captured.	Size in Inches.	Sex.
1	85	—	Oct. 20, 1897	–	Feb. 25, 1898	1 mile N.	14	S	128	H	–	–
2	–	—	—	–	April 15, ,,	$2\frac{3}{4}$ miles N.W.	5–6	S	177	H	–	–
3	45	2002–2046	Dec. 17, ,,	2014	July 1, ,,	Close to Harbour.	–	uH	196	H	–	–
4	–	—	—	2033	July 12, ,,	,,	–	uH	207	H	–	–
5	18	—	April 23, 1898	3640	May 13, ,,	Off Harbour.	8	uH	20	H	–	–
6	96	0–100	Nov. 5, ,,	58	Dec. 2, ,,	$3\frac{1}{2}$ miles N.E.	26	uS	27	S	–	–
7	–	—	—	40	Dec. 17, ,,	$2\frac{1}{4}$ miles E.	20	S	42	S	–	–
8	–	—	—	19	Dec. 29, ,,	3 miles N.E.	22	S	54	H	–	–
9	–	—	—	62	Jan. 7, 1899	$3\frac{1}{4}$ miles N.E.	23	S	63	H	–	–
10	–	—	—	70	Feb. 10, ,,	2 miles E. by N.	18	S	97	H	–	–
11	–	—	—	26	April 19, ,,	$1\frac{1}{2}$ miles S.E.	8	S	165	H	–	–
12	–	—	—	63	,, ,,	$1\frac{1}{4}$ miles N.W.	8	S	165	H	–	–

13	–		—	65	,, ,,	,,	8	S	165	H	–	–
14	–	—	—	12	May 8, ,,	2 miles W.	7	S	184	H	$5\frac{13}{16}$	Male.
15	50	332–381	Jan. 26, 1899	353	Feb. 10, ,,	3 miles NE.	20	uH	15	H	–	–
16	–	—	—	333	May 10, ,,	$1\frac{1}{2}$ miles E.	10	uH	104	H	–	–
17	–	—	—	341	May 18, ,,	$\frac{3}{4}$ mile E.S.E.	7	uH	112	H	–	–
18	56	476–531	April 12, ,,	524	Sept. 28, ,,	2 miles N.E.	22	uH	169	H	–	Female.
19	40	651–690	June 23, ,,	662	July 14, ,,	Close to Harbour.	–	H	21	H	–	Male.
20	–	—	—	670	Sept. 29, ,,	2 miles N.E.	22	H	98	H	–	,,
21	–	—	—	667	Oct. 23, ,,	,,	,,	H	122	H*	$5\frac{3}{8}$	,,
22	–	—	—	673	,, ,,	$1\frac{1}{2}$ miles E. by S.	18	H	122	H	$5\frac{5}{8}$	,,
23	34	745–778	July 15, ,,	749	Oct. 26, ,,	$5\frac{1}{2}$ miles N.	18	S	103	H	$4\frac{7}{8}$	,,
24	–	—	—	770	Dec. 12, ,,	3 miles N.E.	22	H	150	H	$6\frac{7}{16}$	,,
25	48	780–827	Aug. 12, ,,	810	Oct. 10, ,,	3 miles N.N.E.	25	S	59	H	–	–
26	–	—	—	826	Nov. 2, ,,	2 miles N.N.E.	19	S	82	H	5	Male.
27	–	—	—	820	Dec. 9, ,,	$2\frac{1}{2}$ miles N.	22	S	119	H	$4\frac{1}{2}$	,,
28	76	880–956	Sept. 23, ,,	948	Sept. 25, ,,	2 miles N.E.	,,	S	2	S	–	–
29	–	—	—	954	,, ,,	,,	,,	S	2	S	–	–
30	–	—	—	946	,, ,,	$2\frac{1}{2}$ miles N.E.	25	S	2	S	–	–
31	–	—	—	951	Sept. 28, ,,	$2\frac{1}{2}$ miles E.	20	S	5	S	–	–
32	–	—	—	956	Sept. 29, ,,	2 miles N.E.	22	S	6	S	–	–
33	–	—	—	917	Oct. 7, ,,	,,	27	S	14	S	–	–

* Brittle.

TABLE X.—LIST OF LABELLED CRABS SET FREE A THE MOUTH OF THE HARBOUR, DUNBAR—*continued.*

S stands for Soft (not Marketable). H stands for Hard (Marketable). H indicates that the Crab is nearly, though not quite, hard enough to be Marketable.

	Set Free.			Recaptured.									
	Number of Individuals.	Numbers on the Labels.	Date.	Label Number.	Date.	Place. Distance and Direction from Dunbar.	Place. Depth in Fathoms.	Condition when Set Free.	Interval of Freedom. Days.	Condition when Re-captured.	Size in Inches.	Sex.
34	-	—	—	905	Oct. 9, 1899	2 miles N.E.	27	S	16	S	-	-
35	-	—	—	907	Oct. 14, ,,	3 miles N.E.	26	S	21	S	$5\frac{3}{8}$	Male.
36	-	—	—	897	Oct. 16, ,,	4 miles N.	24	S	23	H	$5\frac{1}{8}$	,,
37	-	—	—	903	Oct. 17, ,,	,,	,,	S	24	S	$5\frac{3}{8}$	Female.
38	-	—	—	891	Oct. 24, ,,	$3\frac{1}{2}$ miles E.S.E.	26	S	31	H	$5\frac{1}{4}$	Male.
39	-	—	—	886	Oct. 26, ,,	$2\frac{1}{2}$ miles N.E.	23	S	33	H	$4\frac{13}{16}$	,,
40	-	—	—	880	Nov. 21, ,,	6 miles N.	24	S	59	H	$5\frac{3}{8}$	Female.
41	-	—	—	896	Dec. 26, ,,	$2\frac{1}{2}$ miles N.	22	S	94	H	$4\frac{13}{16}$	Male.
42	-	—	—	892	Jan. 16, 1900	$2\frac{1}{2}$ miles N.E.	,,	S	115	H	$5\frac{1}{4}$	Female.
43	-	—	—	940	April 4, ,,	1 mile E.	13	S	193	H	—	,,
44	-	—	—	955	April 26, ,,	3 miles N.N.W.	7	S	215	H	5	Male.
45	-	—	—	953	May 4, ,,	3 miles W.	10	S	223	H	$5\frac{3}{8}$	Female.
46	51	1022-1072	Oct. 24, 1899	1025	Nov. 9, 1899	2 miles N.E.	20	S	16	S	$6\frac{1}{4}$	-
47	-	—	—	1039	Nov. 17, ,,	$2\frac{3}{4}$ miles N.E.	24	S	24	H	5	Male.

48	–	—	—	1045	Nov. 18, ,,	$3\frac{1}{4}$ miles N.E.	,,	S	25	S	$5\frac{1}{16}$	Female.
49	–	—	—	1029	Nov. 22, ,,	$2\frac{1}{2}$ miles N.E.	,,	S	29	S	$5\frac{1}{16}$	,,
50	–	—	—	1052	Nov. 25, ,,	2 miles N.	22	S	32	S	$5\frac{7}{8}$	Male.
51	–	—	—	1061	Nov. 30, ,,	$2\frac{1}{2}$ miles N. by E.	23	S	37	H	$5\frac{1}{4}$	,,
52	–	—	—	1063	Dec. 15, ,,	3 miles N.N.E.	25	S	52	S	6	Female.
53	–	—	—	1040	Dec. 18, ,,	$2\frac{1}{2}$ miles N.E.	24	S	55	–	$5\frac{3}{8}$	Male.
54	–	—	—	1064	Jan. 12, 1900	2 miles N.	20	S	80	H	$5\frac{3}{4}$	,,
55	–	—	—	1032	Feb. 4, ,,	—	–	S	103	H	$5\frac{5}{8}$	,,
56	–	—	—	1070	Feb. 13, ,,	4 miles N.	24	S	112	H	–	–
57	51	1123–1173	Nov. 4, ,,	1132	Nov. 13, ,,	2 miles N.N.E.	18	S	9	S	$5\frac{7}{8}$	Male.
58	–	—	—	1136	,, ,, ,,	3 miles N.N.E.	22	S	9	S	$5\frac{1}{2}$	,,
59	–	—	—	1135	Nov. 15, ,,	$2\frac{1}{2}$ miles N.E.	23	S	11	S	$5\frac{13}{16}$	,,
60	–	—	—	1167	,, ,, ,,	,,	,,	S	11	S	$5\frac{5}{16}$	Female.
61	–	—	—	1172	Nov 16, ,,	$2\frac{1}{2}$ miles N.N.E.	21	S	12	S	7	Male.
62	–	—	—	1141	Nov 21, ,,	$2\frac{1}{2}$ miles N.E.	23	S	17	S	$6\frac{3}{10}$	,,
63	–	—	—	1153	Nov 22, ,,	,,	,,	S	18	S	$6\frac{1}{8}$	Female.
64	–	—	—	1144	Nov 30, ,,	,,	,,	S	26	S	$5\frac{7}{8}$	,,
65	–	—	—	1134	Dec 2, ,,	,,	24	S	24	S	-	Male.
66	–	—	—	1151	Dec 15, ,,	,,	25	S	41	S	$5\frac{5}{16}$	,,
67	–	—	—	1130	Dec. 26, ,,	3 miles N.	20	S	52	S	$6\frac{1}{8}$	,,
68	–	—	—	1166	Jan 11. 1900	$2\frac{1}{2}$ miles N.	22	S	68	H	$5\frac{7}{16}$	,,
69	–	—	—	1140	Jan. 17, ,,	$2\frac{1}{2}$ miles N.E.	24	S	74	H	$4\frac{15}{16}$	,,

Table XI.

LIST OF LABELLED CRABS SET FREE AT SOME DISTANCE FROM DUNBAR.

S stands for Soft (not Marketable). H stands for Hard (Marketable). H indicates that the Crab is nearly, though not quite, hard enough to be Marketable. u indicates a Crab of under gauge size.

	Set Free.					Recaptured.										
	Number of Individuals.	Numbers on Labels.	Date.	Place (A). Distance and Bearing from Dunbar.	Place (A). Depth in Fathoms.	Label Number.	Date.	Place (B). Distance and Bearing from Dunbar.	Place (B). Depth in Fathoms.	Condition when Set Free.	Interval of Freedom—Days.	Condition when Recaptured.	Distance and Bearing of Place (B) from Place (A).	Size in Inches	Sex.
1	30	3201–3230	Jan. 11, 1898	1½ miles E.	16	3224	April 2, 1898	2 miles E.S.E.	10	uH	81	H	¾ mile S.E.	-	—
2	-	—	—	—	-	3218	,, 15, ,,	3 miles E.S.E.	16	uH	94	H	1½ miles S.E.	-	—
3	-	—	—	—	-	3223	May 16, ,,	3½ miles S.E.	12	uH	125	H	2½ miles S.E.	-	—
4	-	—	—	—	-	3202	,, 31, ,,	(Off Catcraig.)	6	uH	140	H	1½ miles S.	-	—
5	26	3255–3282	Feb. 8, ,,	2 miles E.	17	3260	April 7, ,,	,, ,,	-	uH	58	H	1 mile S.	-	—
6	-	—	—	—	-	3275	,, 18, ,,	3 miles E. by S.	-	uH	69	H	—	-	—
7	131	101–231	Nov. 7, ,,	2 miles E. by N.	20	182	Nov. 21, ,,	3 miles E.	23	S	14	S	1 mile E.S.E.	-	—
8	-	—	—	—	-	204	,, ,, ,,	,,	,,	uH	14	H	,,	-	—
9	-	—	—	—	-	225	Dec. 3, ,,	3½ miles E. by N.	30	S	26	S	1½ miles E. by N.	-	Female.

10	-	—	—	—	-	160	,,	27, ,,	$2\frac{3}{4}$ miles E. by N.	28	S	40	S	$\frac{3}{4}$ mile E by N.	-	—
11	-	—	—	—	-	173	,,	,, ,,	4 miles E. by N.	30	S	40	S	2 miles E. by N	-	—
12	100	232–331	Dec. 5, ,,	1 mile E. by N.	15	318	,,	15, ,,	2 miles E.	28	S	10	S	1 mile E.	-	—
13	-	—	—	—	-	282	,,	16, ,,	4 miles E. by N.	30	S	11	S	3 miles E by N.	-	—
14	-	—	—	—	-	265	,,	21, ,,	4 miles N.	19	S	16	H	4 miles N.	-	—
15	-	—	—	—	-	248	Jan.	4, 1899	3 miles N.E.	23	S	30	S	2 miles N.E.	-	—
16	-	—	—	—	-	316	,,	,, ,,	4 miles E.S.E.	,,	S	30	S	3 miles S.E.	-	—
17	-	—	—	—	-	298	,,	30, ,,	2 miles E.	21	S	56	H	1 mile E.	-	—
18	51	381–432	Jan. 26, 1899	about 2 miles S.E.	-	394	May	3,	5 miles S.E.	8	uH	97	H	3 miles S.E.	-	—
19	44	432–475	April 6, ,,	3 miles E. by N.	22	467	Aug.	7, ,,	(1 mile E. by S.)	18	uH	123	H*	$1\frac{1}{2}$ miles W.	-	—
20	47	699–745	July 15, ,,	,,	,,	709†	,,	18, ,,	3 miles N.E.	23	S	34	-	$1\frac{3}{4}$ miles N.N.W.	-	Male.
21	-	—	—	—	-	742	Oct.	9, ,,	3 miles N.N.E.	25	S	86	H	3 miles N.W.	$6\frac{1}{4}$	Male.
22	50	828–877	Aug. 18, ,,	$2\frac{1}{2}$ miles E. by N.	22	844	Sept.	11, ,,	$2\frac{1}{2}$ miles E. by N.	22	S	24	S	—	-	—
23	-	—	—	—	-	873	,,	13, ,,	,, ,,	,,	S	26	S	—	-	—
24	-	—	—	—	-	842	,,	29, ,,	2 miles E.	20	S	42	S	$\frac{1}{2}$ mile S.E.	-	—
25	-	—	—	—	-	861	Oct.	6, ,,	2 miles E.N.E.	22	S	49	S	$\frac{1}{2}$ mile W.N.W.	-	—
26	-	—	—	—	-	837	,,	11, ,,	$2\frac{1}{2}$ miles E.	25	S	54	H	$\frac{1}{2}$ mile S.	-	Female.
27	-	—	—	—	-	851	,,	,, ,,	$3\frac{1}{2}$ miles E.	26	S	54	H	1 mile E.S.E.	$5\frac{1}{4}$	Male.
28	-	—	—	—	-	831	,,	17, ,,	2 miles E. by N.	23	S	60	H	$\frac{1}{2}$ mile E. by N.	$4\frac{5}{8}$	,,

* Brittle. † Caught on a haddock line.

Table XI.

LIST OF LABELLED CRABS SET FREE AT SOME DISTANCE FROM DUNBAR—*continued.*

S stands for Soft (not Marketable). H stands for Hard (Marketable). H indicates that the Crab is nearly, though not quite, hard enough to be Marketable.

	Set Free.					Recaptured.									
	Number of Individuals.	Numbers on Labels.	Date.	Place (A). Distance and Bearing from Dunbar.	Place (A). Depth in Fathoms.	Label Number.	Date.	Place (B). Distance and Bearing from Dunbar.	Place (B). Depth in Fathoms.	Condition when Set Free.	Interval of Freedom—Days.	Condition when Recaptured.	Distance and Bearing of Place (B) from Place (A).	Size in Inches	Sex.
29	–	—	Aug. 18, 1899	2½ miles E. by N.	22	856	Oct. 23, 1899	3½ miles E. by S.	25	S	66	H	1½ miles S.E.	5 3/16	Male.
30	–	—	—	—	–	863	,, 27, ,,	3 miles N.E.	24	S	70	H	1½ miles N. by W.	5 3/16	Female.
31	–	—	—	—	–	835	Nov. 9, ,,	3 miles E.	26	S	83	H	1 mile S.E.	4⅝	Male.
32	–	—	—	—	–	867	Dec. 9, ,,	3½ miles E.	26	S	113	H	1½ miles E.S.E.	4 11/16	,,
33	–	—	—	—	–	841	,, 15, ,,	3 miles N.N.E.	25	S	119	H	2¾ miles N.N.W.	4½	Female.
34	–	—	—	—	–	864	,, 25, ,,	3½ miles E.	27	S	129	H	1 mile E.S.E.	5	Male.
35	54	957–1010	Sept. 25, ,,	2½ miles E. by N.	25	992	Sept. 27, ,,	2½ miles N.E.	22	S	2	S	1¾ miles N.W.	–	—
36	–	—	—	—	–	968	,, ,, ,,	2 miles N.E.	22	S	2	S	,, ,,	–	—
37	–	—	—	—	–	983	,, 28, ,,	,, ,,	,,	S	3	S	,, ,,	–	—
38	–	—	—	—	–	997	,, ,, ,,	2¼ miles E.	20	S	3	S	½ mile S.	–	—
39	–	—	—	—	–	998	Oct. 6, ,,	2½ miles E.N.E.	25	S	11	S	¼ mile N.N.W.	–	—
40	–	—	—	—	–	994	,, 14, ,,	4 miles N.	24	S	19	S	4 miles N.W.	4 13/16	Male.

41	–	—	—	—	–	991	,,	23, ,,	$2\frac{1}{2}$ miles N.E.	23	S	28	H	$1\frac{1}{2}$ miles N.N.W.	$5\frac{3}{16}$	Female.
42	–	—	—	—	–	973	,,	26, ,,	3 miles N.E.	25	S	31	H	$1\frac{1}{2}$ miles N. by W.	$4\frac{15}{16}$	Male.
43	–	—	—	—	–	1000	Nov.	2, ,,	2 miles N.N.E.	19	S	38	H	$2\frac{1}{4}$ miles N.W.	$4\frac{13}{16}$	,,
44	–	—	—	—	–	965	,,	13, ,,	3 miles N. by E.	22	S	49	H	3 miles N.W.	$4\frac{15}{16}$	,,
45	–	—	—	—	–	982	,,	16, ,,	2 miles N. by E.	18	S	52	H	$2\frac{1}{2}$ miles N.W.	$5\frac{1}{2}$	,,
46	–	—	—	—	–	986	,,	18, ,,	7 miles N.N.W.	27	S	54	H	8 miles N.W.	$5\frac{3}{16}$	,,
47	–	—	—	—	–	957	Dec.	26, ,,	$2\frac{1}{2}$ miles N. by E.	26	S	92	H	3 miles N.W.	5	Female.
48	–	—	—	—	–	980	April	19, 1900	2 miles N.W.	7	S	206	H	4 miles W.N.W.	$5\frac{3}{8}$	Male.
49	–	—	—	—	–	1007	,,	26, ,,	1 mile E. of Kingsbarns.†	8	S	213	H	18 miles N.	5	Female.
50	–	—	—	—	–	1002	,,	28, ,,	$1\frac{1}{2}$ miles S.E.	7	S	215	H	2 miles S.W.	5	Male.
51	–	—	—	—	–	960	May	3, ,,	$\frac{1}{4}$ mile S.E.	8	S	220	H	2 miles W. by S.	$5\frac{11}{16}$	Female.
52	51	1073–1123	Oct. 26, ,,	$1\frac{1}{2}$ miles E. by N.	17	1092	Nov.	4, ,,	$2\frac{1}{2}$ miles N.E.	25	S	9	S	$1\frac{1}{2}$ miles N. by E.	$5\frac{3}{4}$	Male.
53	–	—	—	—	–	1082	,,	13, ,,	2 miles N.N.E.	18	S	18	S	2 miles N.N.W.	$6\frac{9}{16}$	,,
54	–	—	—	—	–	1084	,,	15, ,,	$2\frac{3}{4}$ miles N.E.	24	S	20	S	2 miles N.N.E.	$6\frac{5}{8}$	,,
55	–	—	—	—	–	1118	,,	,, ,,	,, ,,	,,	S	20	S	,, ,,	$6\frac{7}{16}$	Female.
56	–	—	—	—	–	1115	,,	17, ,,	,, ,,	,,	S	22	S	,, ,,	$5\frac{5}{8}$	Male.
57	–	—	—	—	–	1099	Dec.	12, ,,	,, ,,	,,	S	47	H	,, ,,	$6\frac{7}{8}$	Female.
58	–	—	—	—	–	1104	,,	26, ,,	2 miles N.	17	S	61	H	2 miles N.W.	$5\frac{3}{16}$	Male.
59	–	—	—	—	–	1111	Jan.	7, 1900	$1\frac{1}{2}$ miles E. by N.	16	S	83	H	—	$6\frac{3}{8}$	,,
60	–	—	—	—	–	1080	,,	20, ,,	,, ,,	,,	S	86	H*	—	$4\frac{13}{16}$	,,
61	–	—	—	—	–	1076	April	26, ,,	1 mile S.E.	4	S	179	H	2 miles S.W.	$5\frac{1}{2}$	Male.
62	–	—	—	—	–	1113	May	4, ,,	S.E.	14	S	187	H	$2\frac{1}{2}$ miles S.E.	$5\frac{5}{8}$	,,

* On 4th February it was still not quite hard. † St. Andrews Bay.

The Regulation of the Crab Fishery.

The aim of regulation in the case of a fishery is usually either to arrest a decrease in its productivity, or to increase the commercial value of its returns. In discussing, then, the question of interference with the present mode of conducting the crab fishery, it is necessary to consider whether or not (1) there are signs that it is declining, (2) if by regulation the fishery might be so improved that it make a better return to those most interested—viz., the fishermen. With regard to the first question, the Crab and Lobster Commission of 1877 came to the following conclusion:—"We are ourselves of opinion that the crab fisheries on the East Coast of Scotland are almost universally deteriorating."* Wilson† reported in 1893, regarding the crabs on the coast of Northumberland, that—"there is no evidence of a steady decline in the aggregate take, except at one or two places. But that there is *at least* danger of over-fishing is indicated by the fact that the increase in gear is not yielding corresponding increase of crabs." Meek‡ was of the opinion that the crab and lobster fishery had deteriorated in the Northumberland district. The annexed Table, extracted from the Reports of the Fishery Board, gives the numbers of crabs landed in the Eyemouth and Leith districts, on the East Coast of Scotland, and also the landings for the whole of Scotland, for the period from 1883 to 1899 inclusive.

	Eyemouth District.	Leith District.	East Coast of Scotland.	East and West Coasts, Orkney and Shetland Islands.	Number of Creels owned by the Fishermen.
	Hundreds.	*Hundreds.*	*Hundreds.*	*Hundreds.*	
1883	15,841	6,196	32,196	35,393	–
1884	–	–	–	33,178	–
1885	15,550	4,780	31,061	32,499	–
1886	2,281	6,173	21,193	23,846	–
1887	3,173	6,577	21,034	22,157	–
1888	3,082	8,275	29,676	30,817	–
1889	2,720·5	6,445·5	26,090	27,743	–
1890	2,710·5	7,654	27,335·9	28,823	–
1891	2,746	7,630·5	29,753	30,924	–
1892	3,620	8,192	30,269	31,179·9	–
1893	3.819	9,084	31,638	33,050	69,331
1894	4,145	7,359	25,684	26,801	75,198
1895	3,568	6,151	24,058	25,482	71,968
1896	6,041	10,101	32,569	33,973·8	72,790
1897	3,947	9,186	32,672	34,943·9	73,651
1898	5,434	9,533	35,330	36,465·8	77,157
1899	3,765	8,600	29,611·5	31,125	76,007

* p. v. † *Op. cit.*, 1893, pp. 3, 4.
‡ *Op. cit.*, 1899, p. 41.

It is seen from the yearly totals that although very great variations occur from year to year, in 1898 the take was slightly larger than the total in 1883; these two were the years in the period in which the yield of the fishery reached 3,500,000 crabs. The number of creels owned by the fishermen has been entered for the seven years 1893–1899 inclusive. There is no evidence to show what proportion of these creels were actually employed in fishing for crabs, but as they do not last very long, but require continual repair or renewal, it is probable that a very small percentage, if any, was unemployed. If, then, it be conceded that the number of creels returned as belonging to the fishermen were actually used, we see that an increase in catching gear does not imply an increase in the take. Thus in 1893, with 69,000 creels, the catch was 3,305,000 crabs; and in 1894 and 1895, with a greater number of creels, viz., 75,000 and 72,000, fewer crabs, namely 2,548,200, were captured. Greater catches were obtained in 1896 and 1897 than in 1894 and 1899, when a larger number of creels was owned. It is therefore apparent that an increase in the catching gear is not always accompanied by an increased catch. The only conclusion which is at present permissible is that a decline in the fishing is not indicated. Nor, on the other hand, is there any indication of regular increase in the number of crabs. Everything seems to point to the probability that the fishing is carried on to its fullest extent. Previous to the passing of the Crabs and Lobsters Act of 1877, there was seemingly a deterioration; since then, judging from the period above cited, such deterioration has apparently ceased. The provisions of the Act, prohibiting the sale of soft crabs and of hard under-sized crabs, might then be regarded as having effected a desired improvement. But, nevertheless, the exemption in favour of the use of these two classes of crabs as bait left the fishing, in those districts where it is carried on during the whole year, in a state similar to what obtained previous to the passing of the Act. The ground frequented by crab-fishers is altogether littoral, seldom extending more than four to five miles from the shore, although, as one witness stated before the Commission,* crabs may be got on the haddock lines shot in the Moray Firth 10 to 15 miles offshore. The crabs which were taken by the trawlers were got during inshore trawling mainly. It is important to consider what percentage of the catch of the crabs is protected by the Act. So far as the ten catches which were measured (Table IX.) may be taken as representative, the percentage of crabs below $4\frac{1}{4}$ inches was 12·5 per cent. That proportion may, then, be taken as the extent of the protection of small crabs, if they are not used for bait. But their general destruction for this purpose renders the Act quite ineffective. The protection to soft crabs is also more apparent than real, for where the crab-fishing is pursued during autumn and winter the permission to bait their lines with soft crabs is largely taken advantage of. In regard to these two provisions, then, the Crab and Lobster Act was to a large extent inoperative. Berried crabs are afforded protection irrespective of the prohibition of their sale enacted by the Act; for, as Wilson and Cunningham point out, in this corroborating the evidence furnished to the Commission, the berried crab seldom appears in the crab-pot. At Dunbar very few berried crabs are got in the year. Notwithstanding, then, the fact of the meagreness of the protection to the mature group, the takes of crabs have not permanently decreased.

The second aim of regulation of a fishing is to increase its profit. Petersen,† in his work on the commercial flat-fishes of Denmark, says :—

* Reports on the Crab and Lobster Fisheries, 1877, evidence for Scotland, pp. 39, 40.

† *Report by the Danish Biological Station to the Home Department*, IV., 1893, Copenhagen, 1894, p. 67.

"In order to promote the plaice-fishery, *in our seas* at any rate, it is not enough to protect the *unsaleable* fish only; we must also, and particularly, protect the *saleable* fish, so that the latter becomes sufficiently saleable. I am convinced that no other way will lead us to the goal, the greatest possible profit." Such an improvement in value may be obtained by an increased catch, or by securing a higher price for each individual crab. The former need not be considered here; the latter is a line on which some progress may be made. The first point to which attention may be directed is the fact that the smallest legally saleable crabs are not accepted as full marketable crabs. The smaller crabs of the catch sell at half the price of the larger. At Dunbar, for example, although no definite size in inches is accepted as the standard by which a whole crab is measured, it may with confidence be stated that all crabs under $4\frac{3}{4}$ inches across will be counted as half-crabs. The highest price paid to the fishermen at Dunbar for crabs is 1s. 6d. per dozen—*i.e.*, each crab brings three halfpence. Crabs under $4\frac{3}{4}$ inches are sold at three farthings each. The capture of half-crabs is economically a mistake, since by leaving them in the sea until they cast again, their size would be much increased. They would on recapture bring double their former value.* In the ten catches referred to above, 2684 crabs were of marketable size ($4\frac{1}{4}$ inches and over), and of these 597 were found to be between $4\frac{1}{4}$ and $4\frac{5}{8}$ inches inclusive; *i.e.*, 22 per cent. of the crabs of marketable size were half-crabs. After one cast, all of these crabs would measure more than 5 inches across (*vide* p. 110). Then if only half of these were recaptured when they had increased in size, no loss would accrue to the fishing, since their value had doubled itself. The question arises as to how long a period will elapse before a crab between $4\frac{1}{4}$ and $4\frac{5}{8}$ would cast again. In the case of a female which was fertilised, two years at least would probably elapse between its soft period and the next casting; but during that time it is more than probable that she will carry eggs. In the case of an unfertilised female of these sizes, a year may be taken as the interval between the time of its previous cast and the following one. With regard to the male crab, it is not improbable that the similar interval will be one of two years at least. But on this point evidence is wanting. Taking everything into consideration, it would very probably be an advantage to eliminate the half-crabs from the market. And for this purpose a $4\frac{3}{4}$ inches gauge at the very least would be required. The Crab and Lobster Commission recommended for Scotland a 5 inches gauge, and instead of that size $4\frac{1}{4}$ inches was taken as the standard. In most of the fisheries districts in England (*vide* p. 140) the $4\frac{1}{4}$ inches gauge has been by local bye-law replaced by a minimum of 5 inches. This is a size which would keep out the Dunbar half-crabs; but care should be taken against instituting a gauge which is larger than absolutely necessary. A 5 inches gauge would have kept out 35 per cent. of the crabs measuring $4\frac{1}{4}$ inches and over in the sample catches which were examined (p. 119), while a $4\frac{3}{4}$ inches gauge would have caused the rejection of 22 per cent.

Even without further restriction in the matter of the minimum legal size, much good might be done by preventing the use of the small hard crabs and soft crabs for bait. The Crab and Lobster Commission in this connection reported as follows:—"There is, then, much diversity of opinion among the fishermen of Scotland as to the expediency or inexpediency of using crabs for bait. Without expressing any opinion on the propriety of the practice, we may repeat that we cannot recommend any legislative interference with its continuance, because we are

* Wilson, *op. cit.*, 1895, p. 5; Allen, "The Protection of Crabs and Lobsters," *Journal, Marine Biological Association*, N.S., Vol. IV., No. 2, p. 186.

satisfied that if such a law were made it would be impossible to enforce it. There is another matter* which we believe requires attention. The fishermen who fish in the autumn months are in the habit of destroying large numbers of 'soft' or 'light' crabs. These crabs, which have recently cast their shells, are worthless as food. We propose that it should be illegal to expose these crabs for sale. We should have been very glad to have been able to recommend that they should not be taken, and we exceedingly regret that we cannot do so, for two reasons. First, because, as we have already stated, there is no available machinery for enforcing a law of this nature on the coast, and we are unable to see how any efficient machinery for the purpose can be provided except at very great cost; and second, because these crabs are used as bait. The only practicable remedy we believe to consist in the institution of local close seasons applicable to those places where, and times when, soft or light crabs are wantonly destroyed." The difficulty of enforcing such a regulation is probably not so great now as it was when the Commission made its report. The use of crabs for bait may be considered from two points of view, (1) the efficiency of the flesh of the crab as a bait for fish, (2) what saving in the fisherman's expenditure results from the use of the crabs in this manner. It is generally considered by the fishermen that the crab is a more attractive bait than the mussel. But on this point experimental evidence is wanting. Certain data bearing upon the expenditure which is avoided by using crabs for bait have, in the case of Dunbar, been obtained. A large soft crab affords not more than four baits. To bait 400 hooks requires 100 crabs. The cost of mussels as bait for 400 hooks does not exceed ninepence, while 100 hard large crabs, if taken at the moderate value of 1s. per dozen, bring 8s. 4d. A potential return of 8s. 4d. after four months, the period required for the soft crab to become hard, is then sacrificed for a quantity of mussels of the value of ninepence. These crabs, if returned to the sea, would after four or five months have their value increased on recapture tenfold. In order that the fishermen may have returned to them the expenditure on mussels entailed by the protection of the soft crabs, it is necessary that only ten crabs out of the 100 be recaptured. As to what proportion might be expected to be recaught, some data are afforded by the labelling experiments. Of the soft crabs which were marked and then set free, 11 per cent. were recovered, and as it is no doubt the case that a proportion of these crabs succumbed in consequence of their necessary exposure to the air for longer or shorter intervals, the percentage of the survivors which were retaken is probably even greater than 11.† It may then with a considerable amount of certainty be maintained that 10 per cent. at least of the soft crabs returned to the sea immediately on being taken from the creels would be recaptured in the hard condition. In this way the fishermen would suffer no loss. An average estimate of the number of crabs used for bait by each boat during autumn and part of the winter is 100 crabs per day. 100 crabs are looked upon as a reasonable number per boat; some boats take more. Now, soft crabs are got during September, October, November, and December — four months; it is at once apparent that the destruction which may ensue through this practice is enormous. Statistics of the extent to which the crab is used for bait do not exist, but from the statistics of the catch of one boat during the last four months of 1899 (Table XII.) it is seen that, with the exception of eight days at the end of December, more than 100 soft crabs were obtained each day. For the 52 days on which the fishing was prosecuted, it was, then, permitted by custom to the one boat to

* p. xiii.

† Of some lots a very much higher percentage was recovered. Thus, in six cases, the following were the percentages recaptured, viz., 20, 20, 22, 25, 25, and 31.

destroy 5200 crabs. If this is multiplied by the number of boats engaged in the fishing, a number of crabs is obtained the destruction of which is a serious loss to the fishery. In addition to a loss through the breaking up of soft crabs, a further injury is done during the rest of the year by the use of small hard crabs for bait. A small crab supplies only two baits. It has certainly been the case to some extent lately that the fishermen have been forced to buy trawled fish bait for their creels. This was owing to the scarcity of haddocks in the inshore waters; but so long as the fish are sufficiently abundant to repay the labour of baiting the lines, crabs are used for bait.* In the North-Eastern and Eastern districts of England the use of small and soft crabs for bait is forbidden. In the Northumberland district, although no prohibition exists, the fishermen are not accustomed to use crabs for this purpose. The question then arises, in the event of this practice being prohibited, whether the only method of securing the enforcement of the law is a close time. The Commissioners appointed to inquire into the state of the crab fishery were of this opinion, but the conditions are now much different. A close time, from the 1st September of one year to the 31st day of January following, is in force in the North-Eastern district of England; and in 1898 an inquiry was held by Mr. W. E. Archer and Mr. H. N. Malan, Inspectors of Fisheries, into objections which were raised to the proposal of the Northumberland Sea Fisheries Committee to enact a close time of a similar extent in the district under their jurisdiction. In their report to the Board of Trade† Messrs. Archer and Malan summed up in opposition to the confirmation of the proposed bye-law, which would have imposed a close time of five months' duration. They say that " some of the evidence given to us might have justified our recommending a shorter period if there had been less conflict of opinion as to the months in which soft crabs are really taken in the greatest numbers." . . . "Further, from the statistics collected for the Board of Trade, it appears that during the five months in question a considerable number of crustaceans, especially crabs, are taken, and that at some stations the fishing is carried on at no inconsiderable profit all the year round."

With a view to arriving at the proportion of soft crabs in the catches during the proposed close time, and also in order to find out the value of the fishery during that period, arrangements were made for having statistics kept of the daily catch of one Dunbar boat. Mr. Hutchison, the deputy Fishery Officer, undertook the matter. The catch was divided into soft and hard crabs; each class was sub-divided into crabs of $4\frac{1}{4}$ inches and over, and crabs under that size. The statistics are arranged in Table XII. The number of creels used on each of the 60 occasions that the fishing was prosecuted was 60. The totals for each month appear in Table XIII., where the percentages of hard and soft crabs are also given. Of the gauge crabs in September an average of 80 per cent. consisted of soft crabs; in October and November the soft crabs made up 55 and 42 per cent. of the gauge crabs respectively; and in December the proportion of soft crabs had fallen to 22 per cent.; in January only 2 per cent. of the gauge crabs were soft. It is then evident that, so far as the Dunbar evidence is applicable to other districts, a close time of five months is not required for the protection of soft crabs. And since there appears to be no indication of the species being seriously reduced in numbers, any special protection which the above close time would afford the spawning crabs is not called for.

* Along with mussels, limpets, and lobworms.

† Sea Fisheries Regulation Acts, 1888-1894: Report by Mr. W. E. Archer and Mr. H. N. Malan, Inspectors of Fisheries, on an Inquiry into Bye-laws made by the Committee for the Northumberland Sea Fisheries District with respect to Lobsters and Crabs, 7th January 1899.

During these five months of the year a considerable number of saleable crabs are obtained. In this case the catch contained 20,212 crabs. In October the price of crabs was 1s. 3d. per dozen; in November 9d., 1s., in December 9d., and in January 1s. and 1s. 3d. The approximate value of the catch, then, was—September, £11 3s.; October, £23 15s.; November, £14; December, £19 2s.; January, £17. The total catch, then, for 70 days at sea brought £77, in which the four men forming the crew participate. There is thus, over the period of 19 weeks, an average of £4 7s. for the boat each week. The income is, of course, subject to deductions of the expenses of the fishing. In the event of a proposal to stop the crab fishing during the autumn and winter, some alternative mode of fishing which would recoup the fishermen ought to be available. Unfortunately the only alternative in this case is line fishing, and that has during the past few years been unremunerative. In 1895 and 1896 the value of the line-caught fish landed at Dunbar was £3150 and £3874 respectively, while in 1898 and 1899 the values were £1567 and £1704.

The institution of a close time for the protection of the soft crabs is a remedy which would press hardly in many localities. On the other hand, the impossibility of otherwise protecting the soft crabs is not proved. It is no doubt the case that soft crabs are often carelessly and even wantonly destroyed. But if the use of soft crabs for bait be prohibited, and the law which forbids their possession for any purpose other than bait enforced, some benefit would undoubtedly accrue. It is an error to suppose that the soft crabs succumb readily to slight injury. All the soft crabs which were labelled at Dunbar had to be brought ashore, and before they were labelled and returned to the sea they were in some cases out of the water for six hours. Still, many have been recovered. The majority of the soft crabs could be returned to the sea immediately; the only case when the thumb test is necessary is when the crab has become almost hard enough to be marketable. Even when this test is applied, it is not necessary to break the shell. The destruction of soft crabs takes place mainly in harbour. They are after exposure to air more liable to succumb to injuries. In the case of very soft and light crabs, when the crab has been out of water some time, the gill chamber becomes filled with air, and on the crab being thrown overboard it floats. It is often unable to get rid of the air. If, however, the crab be held in the water with its anterior edge upwards, the air escapes and the crab sinks. Many crabs recover from injuries sustained through the thumb test. Twenty-five crabs were labelled and set free after the thumb had been pushed through their shells. One was recovered.

There is good ground for the conclusion that the protection of small and soft crabs would tend to improve the crab fishery; and since it is principally the crab fishers themselves who use these crabs for bait, what they lost by the slightly increased expenditure for bait would with every probability be more than returned to them in improved catches. The increase of the legal minimum size, with a view to exclude the so-called half-crabs from the market, is also probably economically justifiable.

The Crab and Lobster Act, &c.

The Fisheries (Oysters, Crabs, and Lobsters) Act (40 and 41 Vict., ch. 42) enacted:—Section 8—A person shall not take, have in his possession, sell, expose for sale, consign for sale, or buy for sale—

(1) Any edible crab which measures less than four inches and a quarter across the broadest part of the back; or

(2) Any edible crab carrying any spawn attached to the tail or other exterior part of the crab, whether known as "berried crab," "seed crab," "spawn crab," or "ran crab," or by any other name; or

(3) Any edible crab which has recently cast its shell, whether known as a "caster," "white crab," "white-footed crab," "white-livered crab," "soft crab," "glass crab," or by any other name.

Here follows penalty:—

Provided that a person shall not be guilty of an offence under this section if he satisfies the Court that the edible crabs found in his possession, or alleged to have been sold, exposed for sale, consigned for sale, or bought for sale, were intended for bait for fishing.

The Act simply protects certain crabs from being sold; any small, soft, or berried crab may be used for bait.

Since the creation of the District Fisheries Committees in England, the provisions of the Act have been modified by local bye-laws.

Increase in the Minimum Size.—The smallest legal size has been raised to 5 inches across the broadest part of the back in Devon, Cornwall, Western, and Cumberland districts; to 6 inches in Lancashire district.

The Use of Crabs for Bait.—The exemption from Section 8, which permits of the use of under-sized and soft crabs for bait, is withdrawn in the North-Eastern and Eastern districts.

Close Time.—In the North-Eastern district there is in force a bye-law instituting a close time for crabs from 1st September of any year to 31st January of the following year. In the Eastern district there is a close time for the crab known locally as "white-footed" between 1st November of any year and the 30th June of the following year.

With regard to the return to the sea of illegally-caught shell-fish, it is enacted in the Northumberland, North-Eastern, Eastern, Western, Lancashire, and Cumberland districts that any person who takes any shellfish, the removal of which from a fishery is prohibited by any bye-law in force in the district, or the possession of which is prohibited by any Act of Parliament, shall forthwith deposit the same, without injury, as nearly as possible in the place from which it was taken.

Exemption for Scientific Purposes.—Provided that nothing in these bye-laws shall apply to the removal of crabs or lobsters for scientific, stocking, or breeding purposes by any person acting under the written authority of the local Fisheries Committee.

[TABLE.

TABLE XII.

Daily Catch of one Dunbar Boat during September to December, 1899, *and January*, 1900.

Fishing Ground.	Date.	Hard Crabs.		Soft Crabs.		Number of Boats empl'y'd in Crab Fishing.
		Gauge Size.	Under Gauge Size.	Gauge Size.	Under Gauge Size.	
½ miles E. by N. of Dunbar—25 fathoms.	1899. Sept. 13	190	-	873	-	8
	,, 14	183	-	740	-	,,
	,, 15	159	-	700	-	,,
	,, 16	138	-	680	-	,,
	,, 20	176	-	670	-	,,
	,, 21	158	-	640	-	,,
	,, 23	177	-	666	-	,,
	,, 25	206	-	727	-	,,
	,, 26	178	-	830	-	,,
	,, 27	163	-	610	-	,,
	,, 28	204	-	645	-	10
	,, 29	215	4	893	30	,,
	Oct. 4	192	16	532	24	12
	,, 5	310	140	520	170	,,
	,, 6	265	150	567	130	,,
	,, 7	274	312	200	280	,,
	,, 9	308	180	320	120	14
	,, 10	206	160	110	140	,,
	,, 11	186	170	150	130	,,
	,, 12	180	186	100	170	17
	,, 14	250	160	300	140	,,
	,, 16	336	170	400	120	,,
	,, 17	320	150	473	102	,,
	,, 18	227	210	200	170	,,
	,, 19	174	156	150	340	,,
	,, 20	130	200	110	130	,,
	,, 21	85	165	150	128	,,
	,, 23	157	156	200	140	,,
	,, 24	252	180	213	220	,,
	,, 25	276	222	360	170	,,
	,, 27	243	390	227	120	,,
	,, 30	193	184	313	200	,,
	Nov. 4	182	60	265	250	,,

TABLE XII.—*continued.*

Fishing Ground.	Date.	Hard Crabs.		Soft Crabs.		Number of Boats empl'y'd in Crab Fishing
		Gauge Size.	Under Gauge Size.	Gauge Size.	Under Gauge Size.	
3 miles E. by N. of Dunbar—26 fathoms.	1899. Nov. 6	168	46	273	200	17
	,, 9	236	58	220	170	,,
	,, 13	234	64	370	156	,
	,, 15	254	72	254	300	,,
	,, 16	190	42	200	150	,,
	,, 17	177	106	114	168	,,
	,, 18	148	64	80	200	,,
	,, 20	504	76	250	30	,,
	,, 21	507	68	200	100	,,
	,, 22	400	40	146	54	,,
	,, 25	440	38	230	112	,,
	,, 30	386	28	150	30	,,
	Dec. 1	309	30	175	46	,,
	,, 2	320	45	215	36	,,
	,, 5	619	74	207	12	,,
	,, 6	634	110	285	24	,,
	,, 9	510	96	206	10	,,
	,, 12	496	166	170	18	,,
	,, 13	396	200	98	28	,,
	,, 14	380	93	73	12	,,
	,, 15	396	112	55	8	,,
	,, 18	330	54	34	10	,,
	,, 19	356	60	38	6	,,
	,, 22	422	110	50	8	,,
	,, 25	308	154	45	10	,,
	,, 28	326	14	30	5	,,
	,, 30	342	65	22	8	,,
	1900. Jan. 8	386	16	14	8	9
	,, 11	364	12	8	6	,,
	,, 12	238	9	6	4	,,
	,, 13	240	7	4		,,
	,, 16*	547	18	12	9	,,
	,, 20	562	15	8	6	,,
	,, 24	672	12	8	7	,,
	,, 27	522	10	6	4	,,

* Includes the catches of the 14th, 15th, and 16th January.

PLATE I.

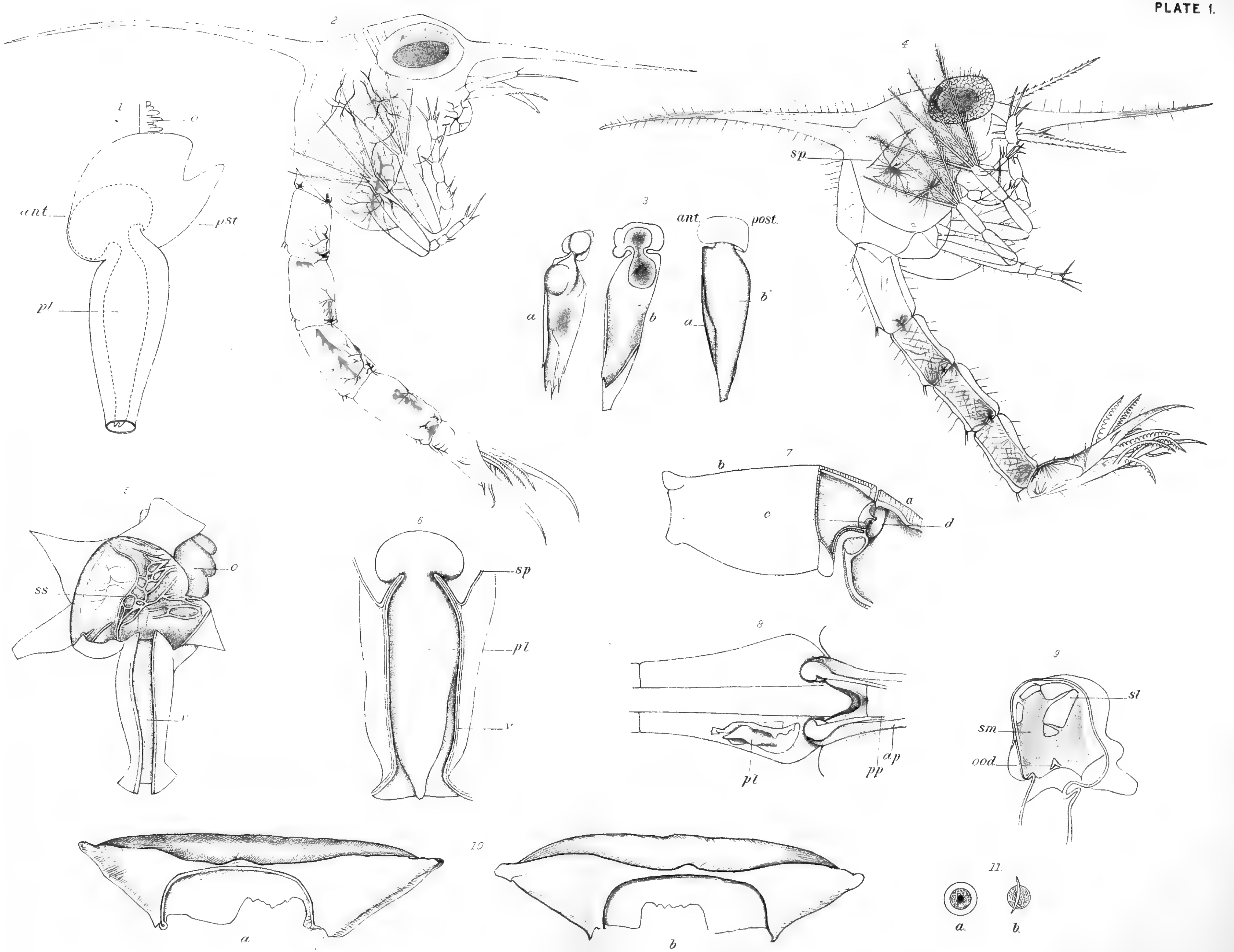
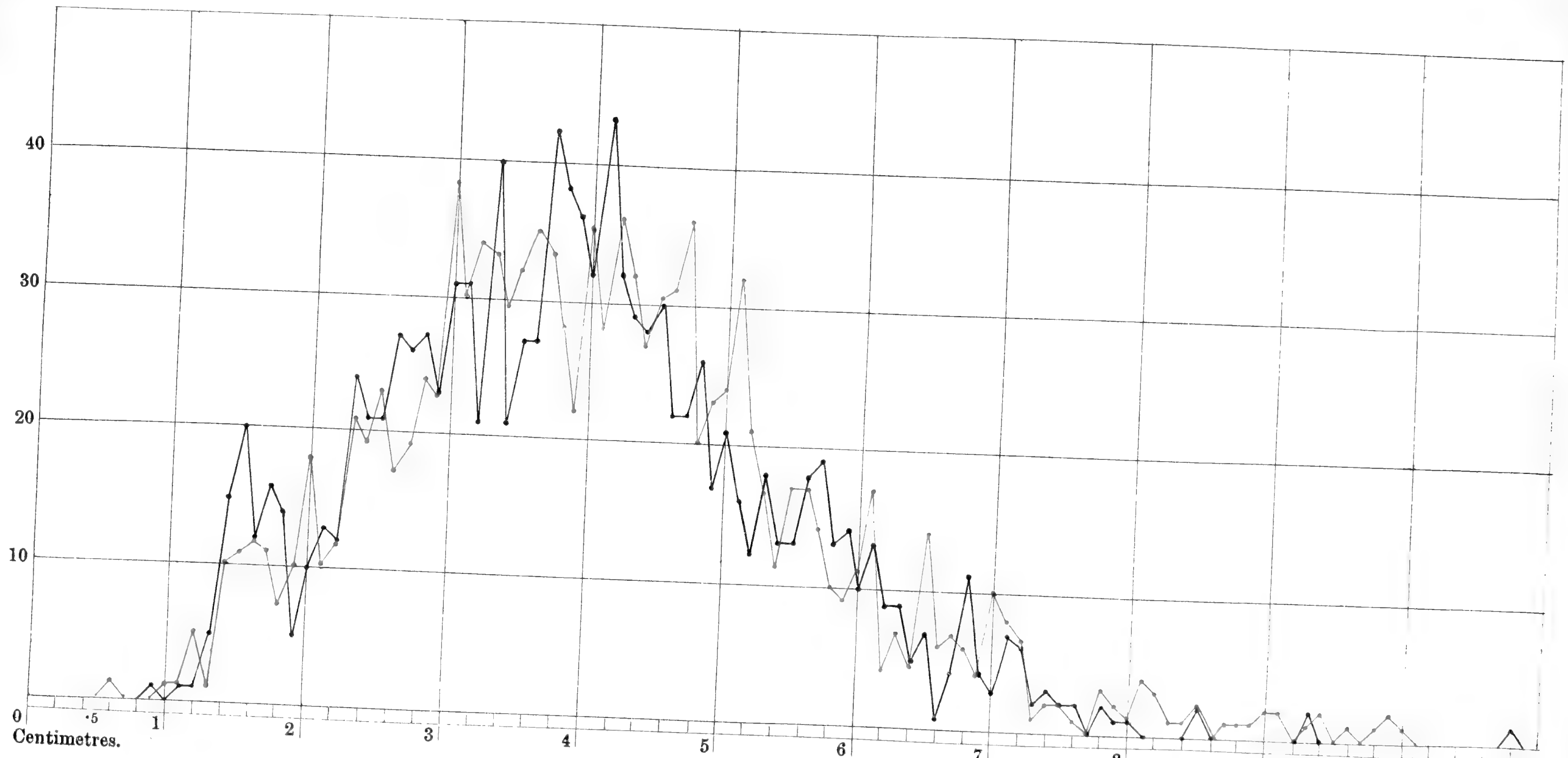
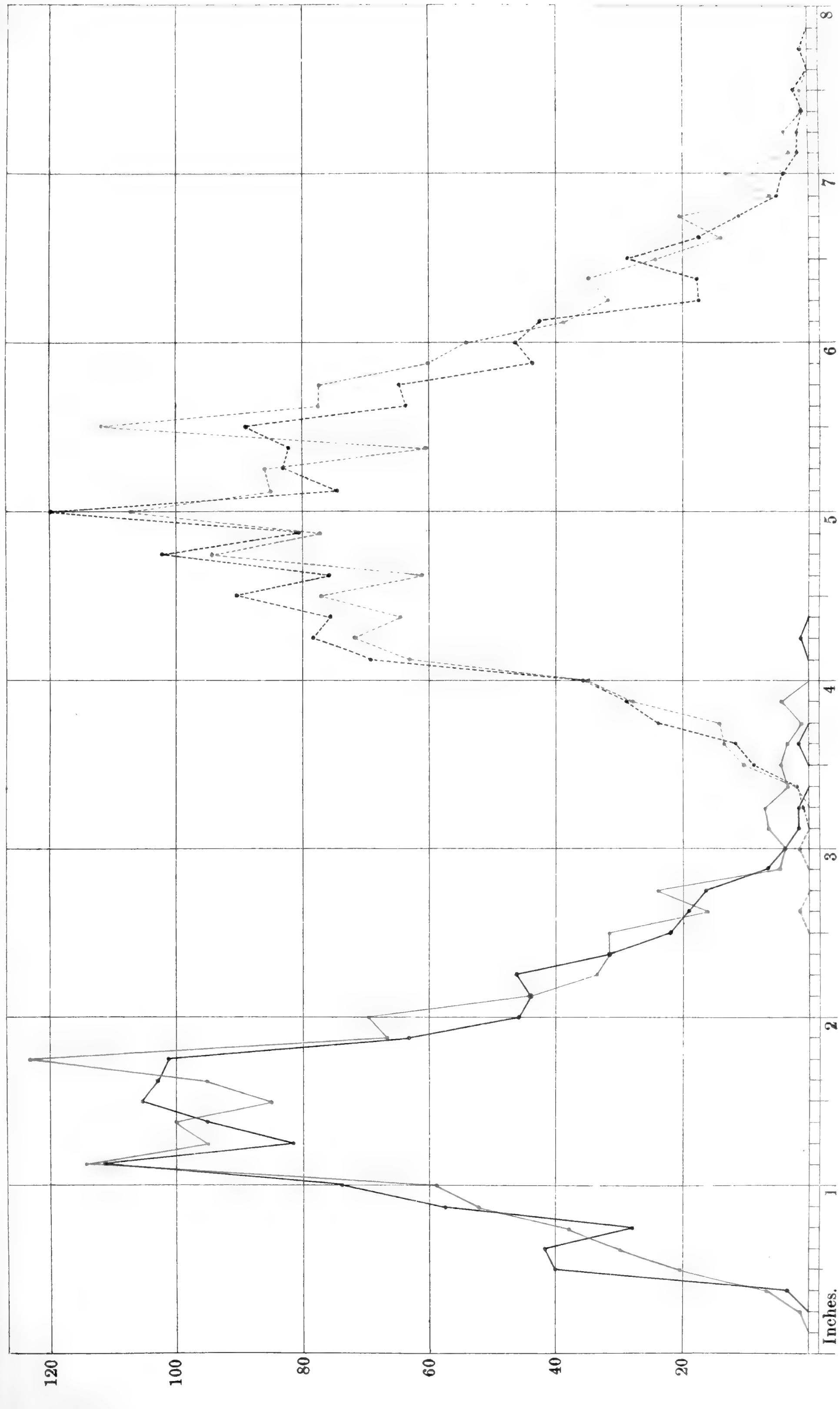

1
2
3
4
5
6
7
8
9
10
11
ant
pst
pl
ant.
post.
a
b
sp
ss
o
v
c
d
pp
ap
sl
sm
ood
a.
b.

PLATE II.



The Black Curve is the curve of the measurements of Male Crabs } Collected between Tidemarks,
The Red Curve is the curve of the measurements of Female Crabs } 2,336 in number.



Crabs from Beach. **Creel Crabs.**

The Black Curves refer to Male Crabs. The Red Curves refer to Female Crabs.

Chart of Coast from Thornton to North Berwick.

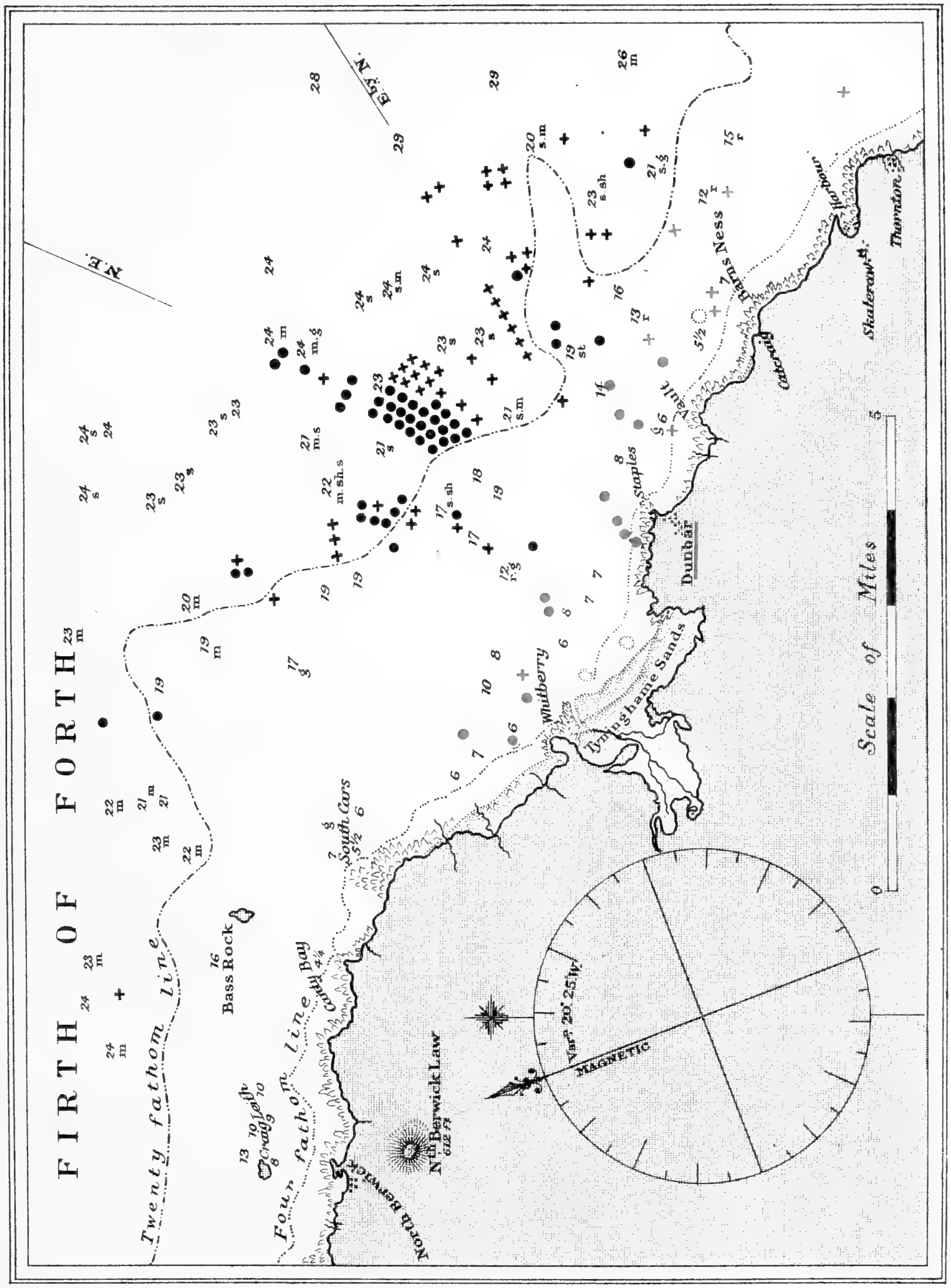


TABLE XIII.

Analysis of Daily Statistics—September, October, November, December, 1899, and January, 1900.

1899–1900.	Number of Times at Sea.	Gauge Crabs—4¼ inches and over.						Under-Gauge Crabs.	
		Hard Crabs.	Soft Crabs.	Total Number Hard and Soft.	Percentage of Hard.	Percentage of Soft.	Average Number of Soft Crabs each day.	Hard.	Soft.
September, 1899,	12	2,147	8,674	10,821	20	80	723	4	30
October, ,,	20	4,564	5,595	10,159	45	55	280	3,657	3,144
November, ,,	13	3,826	2,752	6,578	58	42	212	762	1,920
December, ,,	15	6,144	1,701	7,845	78	22	113	1,383	241
January, 1900.	10	3,531	66	3,597	98	2	8·5	99	49

DESCRIPTION OF PLATES.

PLATE I.

Fig. 1. Vagina and Spermatheca of a Soft Crab 5⅝ inches across. *o.*, ovary : *pl.*, plug : *ant.*, anterior surface : *pst.*, posterior surface.

Fig. 2. Larva of *Carcinus mœnas*, second stage. 24 hours after hatching. August 2nd, 1899.

Fig. 3. Vaginal plug. *a.*, the half next the median line of the thorax : *b.*, the half next the outer edge of the thorax.

Fig. 4. Larva of *Cancer pagurus*, second stage. 15 minutes after hatching. July 21st, 1899. *sp.*, lateral spine. The outer branches of the maxillipedes are shown on the right side only; and the inner branches of the same are alone shown on the left side.

Fig. 5. Spermatheca and Vagina of a Soft Crab 6¼ inches across. *ss.*, the secreting inner surface of the Spermatheca : *o.*, ovary : *v.*, vagina.

Fig. 6. Spermatheca and Vagina of a Soft Crab, showing plug *in situ*: *sp.*, wall of spermatheca : *v.*, wall of vagina : *pl.*, plug.

Fig. 7. Dissection of the Chela of a Crab near the fracture-plane, showing the two septa, *c.*, which remains attached to the cast-off limb : *d.*, which remains on the basi-podite. *a.*, the basi-ischiopodite joint: *b.*, meropodite.

Fig. 8. Portion of Vaginal Plug found on the abdomen of a male crab : *pl.*, plug : *ap.*, anterior element of penis : *pp.*, posterior element of penis.

Fig. 9. Spermatheca of Hard Crab; *sm.*, mass of sperms : *sl.*, secretion of spermatheca, solidified. *ood.*, opening of oviduct.

Fig. 10. The Carapace of a Male Crab, *a.*, and of a Female Crab, *b.*, natural size, 6½ inches across.

Fig. 11. Spermatozoon of *Cancer pagurus*: *a.*, seen from above, *b.*, seen from the side.

PLATE II.

Curves of the measurements of Beach Crabs. The divisions on the *abscissa* denote centimetres; on the *ordinate* are marked off the number of individuals.

PLATE III.

Curves of the measurements of Beach and Creel Crabs. The standard of measurement is an inch.

PLATE IV.

Chart of a portion of the coast near Dunbar, showing the places where the Marked Crabs were recovered (*vide* p. 121).

III.—NOTES ON SOME CRUSTACEAN PARASITES OF FISHES.

By Thomas Scott, F.L.S., Mem. Zool. Soc. de France.

Plates V.–VIII.

Contents.

INTRODUCTORY NOTE.

Parasitic habits are not restricted or peculiar to any particular class of organisms, but may be found more or less in evidence in all departments both of the animal and vegetable kingdoms. There are, however, certain groups of plants and animals whose surroundings and conditions of life seem to be specially favourable to the adoption of parasitic habits, and amongst the Crustacea such habits seem to prevail to a considerable extent, especially amongst the so-called "lower forms" belonging to that class.

Different kinds of animals have to act the part of *hosts* to these parasitic crustaceans, and the animals which are called upon to willingly, or unwillingly, act this part belong chiefly to the same class to which the parasites themselves belong and to the fishes. Fishes appear to be special favourites in this respect. Scarcely any part of a fish's body is free from the intrusion of these unwelcome or (in some cases, perhaps) welcome visitors; they are found running over the skin of the fish, they adhere to the fins, the gills and gill covers, they are found on the lips, the tongue, and the roof and sides of the throat, in the nasal fossæ, and in other and even more strange and out-of-the-way places on or about the body of the fish.

The degree of parasitism varies greatly even amongst closely-allied species; in some cases the relationship of the crustacean to the fish is decidedly that of a parasite, but in other cases it would be inaccurate to describe the association of the one with the other as truly parasitic. Sometimes, however, it is more convenient to use the terms *parasitic, parasite,* etc., in this broad sense, even though it may not in some cases be strictly correct, in order to avoid the complications that would arise by any attempt to describe, in a strictly accurate manner, the various degrees of relationships that exist between crustaceans and the fishes which have become their hosts; it is in this wider sense that such terms are used in the present paper.

The study of the parasitic crustacea is in some respects more difficult, if also more interesting, than that of the species which live under normal conditions. Their structure has, because of their parasitic habits, become more or less altered, and, in consequence of this, the forms which not a few of them have assumed are greatly at variance with those which usually characterise free-living species. Some of these parasitic crustaceans have assumed forms so strangely abnormal and grotesque that even the most experienced naturalists have failed to recognise their relationship to the crustacea, and only by the study of their development and life-history have their true affinities been determined.

Amongst crustacean parasites of fishes, the Copepoda is the group that is probably the most largely represented, and I therefore propose to devote the chief portion of this paper to the consideration of this group; a few of the Isopoda and Amphipoda that have been observed are also referred to.

A small list of Copepod-parasites of fishes was published in Part III. of the *Twelfth Annual Report of the Fishery Board for Scotland* (1894). Since that time other species, besides those enumerated in that list, have been obtained, and during the past summer special attention has been devoted to the study of these organisms, with the result that several interesting forms have now to be added to the copepod fauna of Scotland.

The crustacean parasites mentioned in the sequel have for the most part been obtained on fishes captured in the Firth of Forth, in the Firth of Clyde, or in some other part of the sea around the Scottish coasts; a few interesting species have been obtained on fishes brought to the Fish Market at Aberdeen, and with regard to these I am unable to state the place where the fishes were captured, though I believe that those on which the parasites were found were in most instances taken somewhere off the coast of Scotland.

In the preparation of these notes various works on parasitic Copepoda have been consulted, and in this respect the late Dr Baird's *History of the British Entomostraca* is still indispensable. Several valuable papers on the copepod parasites of fishes have in recent years been published by Dr. Basset-Smith, R.N., one of the latest being *A Systematic Description of Parasitic Copepoda found on Fishes, with an enumeration of the known species.* *

The classification of Gerstäcker † is that which Dr. Basset-Smith has chiefly followed in his *Systematic Description*, and as it appears to be the one which is now generally adopted, the species mentioned in the present paper are arranged as far as possible in conformity with it.

Mr. Andrew Scott, assisted by Mrs. Scott, has prepared the drawings necessary for the elucidation of the species recorded here.

I have also to acknowledge my indebtedness to Mr. Peter Jamieson, the Laboratory Assistant, for help in the collection of specimens for this paper.

The COPEPOD Parasites of Fishes.

According to recent classification the Copepod parasites of fishes have been arranged under seven families, the names and arrangement of which are as follows :—Ergasilidæ, Caligidæ, Dichelestidæ, Philichthyidæ, Lernæidae, Chondracanthidæ, and Lernæopodidæ. The Philichthyidæ is the only one of the seven families which does not seem to be represented in the British fauna; but even this family may also yet be found to have representatives amongst the Copepod fauna of our seas.

* *Proc. Zool. Soc. London*, April 1899.

† *Vide* Copepoda in Bronn's "Klassen und Ordnungen des Thierreichs," v. i, (1866–74).

Fam. Ergasilidæ.

This family has apparently only two, or at most three, genera belonging to it, but the number of species is about twenty-two. All the species are small and easily overlooked. I have notes of two species each of which represents a separate genus.

Genus *Bomolochus*, Nordmann (1832).

Bomolochus soleæ, Claus.

1864. *Bomolochus soleæ*, Claus, Zeitschrift für Wissenschaft. Zool., vol. xiv., p. 374, Pl. XXXV.
1893. *Bomolochus soleæ*, T. Scott, *Eleventh Ann. Rep. Fish. Board for Scot.* (III.), p. 212, Pl. V.

This copepod is found occasionally on the back of the common sole, *Solea vulgaris*. Those I have observed were on the coloured side, and were not easily noticed. It is a species that may readily escape detection, and may therefore be more frequent than it at present appears to be. I have found *Bomolochus soleæ* on *Solea vulgaris* captured near Grimsby, and also on the same species of fish captured in the Firth of Forth and in the Firth of Clyde. The specimen described and figured in the *Fishery Board Report*, referred to above, is from the Firth of Forth.

Genus *Thersites*, Pagenstecher (1861).

Thersites gasterostei, Pagenstecher. (Pl. V., figs. 1–7.)

1861. *Thersites gasterostei*, Pagenstecher, Arch. f. Naturg. vol. xvii., p. 118, Pl. VI., figs. 1–9.
1863. *Ergasilus gasterostei*, Kröyer, Naturh., Tidsskr., R. 3, vol. ii., p. 223, Pl. XII., fig. 2.
1892. *Thersites gasterostei*, Canu, Copep. du Boulonnais, p. 245, Pl. XXIII., figs. 13–18.
1899. *Ergasilus gasterostei*, Basset-Smith, Proc. Zool. Soc. London (April 1899), p. 444.

Description of the Female.—The cephalothorax is considerably dilated on the dorsal aspect, so that when viewed from the side or from above it appears to be almost spherical; abdomen short (fig. 1). The specimen represented by the figure carried two ovisacs, which were large in proportion to the animal.

The antennules (fig. 2) are very short, moderately stout, and five-jointed; the two end joints are each rather shorter than any of the other three, and they are all sparingly setiferous; the formula shows approximately the proportional lengths of all the joints—

Proportional lengths of the joints,	16 · 10 · 11 · 7 · 8
Numbers of the joints,	1 · 2 · 3 · 4 · 5

The antennæ are short and stout, and are each provided with a strong terminal claw (fig. 3).

The mandibles appeared to have a bilobed-pectinated biting part, but owing to the structure of the Copepod these organs were somewhat difficult to dissect out; the maxillæ were also somewhat obscure.

The anterior foot-jaws (1st maxillipedes) are simple, and provided with one or two small setæ. The posterior foot-jaws (2nd maxillipedes) have an enlarged basal part to which is articulated a more slender curved arm bearing a few strong apical spines (fig. 4).

The first three pairs of thoracic feet have both branches apparently three-jointed, but the outer branches are rather shorter than the inner ones (fig. 5 represents the first pair). In the fourth pair, the first two joints of the outer branches appear to be coalescent, so that they seem to be only two-jointed, but the inner branches, as in the preceding three pairs, are three-jointed (fig. 6). The abdomen is short but moderately stout; in the adult female it seems to be shorter than it really is, from being partly hidden by the enlarged cephalothorax; the first abdominal segment is rather broader than the next and is longer than the entire length of all the others; the caudal segments are short and the principal furcal setæ are stouter and much more elongated than those adjacent.

Length about ·8mm. ($\frac{1}{30}$ of an inch).

Habitat.—Found adhering to the inner surface of the gill-covers of a three-spined stickleback (*Gasterosteus aculeatus*), captured in Sinclair Loch, Barra, Outer Hebrides, in May 1894; and on another taken in the River Forth, near Alloa, February 1896. The same species of Copepod was also found on the inside of the gill-covers of a fifteen-spined stickleback (*Gasterosteus spinachia*), captured in Loch Etive in May 1896.

Remarks.—This Copepod has by some writers been ascribed to the genus *Ergasilus*, but it does not fit in very readily with the characters of that genus. The typical *Ergasilus* has the body moderately elongated, whereas in the present form the body is, except for the short abdomen, not only short but almost spherical in general appearance. I therefore agree with Dr. Canu's restoration of Pagenstecher's generic name, *Thersites*, for this species.

Fam. Caligidæ.

The Caligidæ contain a much larger number of genera and species than any other of the seven families amongst which the Copepod parasites of fishes have been arranged. According to Dr. Basset-Smith, the number of genera belonging to the Caligidæ is (exclusive of *Nogagus*) 25, while the number of species is 124. Two of the genera—*Caligus* and *Lepeophtheirus*—contain 49 and 26 species respectively, or 75 in all, which is fully three-fifths of the total number belonging to the whole family. As for *Nogagus*, no female Copepod which could satisfactorily be ascribed to this genus has ever been observed, and students of the Copepoda are now of opinion that the various "species" of *Nogagus* are really the males of species belonging to other genera, *i.e.*: *Pandarus*, *Dinematura*, etc.

Steenstrup and Lütken, in their valuable memoir on Copepod parasites of fishes,* include under *Caligus* the species belonging to that genus and also those belonging to *Lepeophtheirus*. The various forms belonging to these two groups have a close resemblance to each other, not only in their general appearance, but also in their structure; but there are two characters by which the species belonging to the one group are easily separated from those belonging to the other; these characters are the presence or absence of *sucking disks* or *lunulæ* on the frontal plates, and the unifid, or bifid form of the appendages described by Steenstrup and Lütken as *palpi*. In *Caligus*, *lunulæ* are always present and the *palpi* are unifid, in *Lepeophtheirus*, on the other hand, *lunulæ* are always absent and the *palpi* are bifid. The importance to be attached to these differences is, of course, very much a matter of opinion, and *Lepeophtheirus* will by authors take its place as a "genus" or be reduced to a synonym of *Caligus*, according to the value they place on these differences. In the present paper I follow Dr. Baird and Dr. Basset-Smith in regarding the two as distinct genera.

* Særskilt aftrykt Kongl. Danske Vidensk-Selsk. Skrifter, 5te Række Naturh. o. Mathemat. Afdel. 5te Bind.

Genus *Caligus*, O. F. Müller (1785).

(1) Abdomen in the female composed of one segment.

The general outline of the body is more or less oval and greatly depressed. *Lunulæ*, or "sucking disks," are present on the frontal plates; the *palpi* are thorn-like, and end in a single point. Fourth pair of thoracic feet one-branched.

Caligus curtus, Müller. (Pl. V., figs. 8–12.)

1785. *Caligus curtus*, Müller, Entomostraca, p. 130, Pl. XXI., fig. 1.

1850. *Caligus mülleri* (?) and *diaphanus*, Baird, Brit. Entom., pp. 271 and 269.*

The *Caligus mülleri* and probably also *Caligus diaphanus* of Dr. Baird's "Entomostraca" are, according to Steenstrup and Lütken, synonymous with *Caligus curtus* (Müller), and this seems to be also the opinion of recent writers on this group of Copepods. In view of this, however, it may be noted that in most, if not in all, the other species of *Caligus* and *Lepeophtheirus* the male is usually, and sometimes considerably, smaller than the female; but the *Caligus diaphanus* of Baird, which is considered to be the male of *Caligus curtus* (Müller), is frequently very much larger than the ovigerous females of that species. Some species are, however, subject to more variation than others, and this may account, partly at least, for the difference in size.

Caligus curtus is not only a common species, but may be found on various kinds of fishes, including several species of *Gadus*, ling, hake, torsk, plaice, and other flat-fishes; the grey and the long-nosed skate, etc.

A certain amount of variableness in size and general appearance is observable amongst the different specimens that have been examined; but the difference was not greatly in excess of that which has been noticed in specimens belonging to some of the other species.

Caligus rapax, M.-Edw. (Pl. V., figs. 13–19.)

1840. *Caligus rapax*, M.-Edw., Hist. Nat. Crust., vol. iii., p. 453, Pl. XXXVIII., fig. 9.

1850. *Caligus rapax*, Baird, op. cit., p. 270, Pl. XXXII., figs. 2 and 3.

This, like *Caligus curtus*, is one of the more common species, but it differs from most other *Caligi*, at least to some extent, in being much more commonly obtained as a *free-swimmer* in the open sea. We frequently find *Caligus rapax* in tow-net gatherings, collected both at the surface and at the bottom. Ovigerous females are, however, not so commonly met with as males and young females. But though it is apparently more of a free-swimmer in its habits than others, and also perhaps because of this, *Caligus rapax* is found on even a larger variety of fishes than *Caligus curtus*. There is scarcely a fish in our seas on which this *Caligus* may not at one time or another be found.

Like *Caligus curtus*, this species also exhibits a certain amount of variation in the forms and sizes of males and ovigerous females, but it is, if anything, more marked in the latter. Some females with ova from a large grey skate varied from 5·1mm. to 6·1mm. in total length; while the length of the abdomen in the same specimens varied from 0·7mm. to 1·1mm. Some difference was also observed in these specimens in the breadth of the last segment of the thorax. Two apparently adult males obtained on

*For other synonyms, see Basset-Smith's "Systematic Description" already referred to.

the same fish with the females show a difference of at least 0·7mm. in total length. These differences are more clearly exhibited in tabular form as follows :—

VARIATION IN SIZE OF *Caligus rapax* FROM *Raia batis.*

	Female Specimens.				Male Specimens.	
	No. 1.	No. 2.	No. 3.	No. 4.	No. 1.	No. 2.
Total length from forehead to the end of the caudal furca,	5·2mm.	5·1mm.	5·2mm.	6·1mm.	3·8mm.	4·5mm.
Length of abdomen,	·7mm.	·8mm.	·8mm.	1·1mm.	...	...
Breadth of last thoracic segment,	·8mm.	·8mm.	1·0mm.	1·1mm.	...	...

Though the length of these female specimens varied to the extent of a full millimetre, there appeared to be no structural difference of any importance. Perhaps it may be noted in passing that fig. 2, Pl. XXXII., in Dr. Baird's work represents a young female and not a male—an error due no doubt to an oversight on the part of the artist.

(2) Abdomen composed of two segments.

Caligus diaphanus, Nordmann. (Pl. V., figs. 20–25.)

1832. *Caligus diaphanus*, Nord., Mikrog. Beiträge, ii., p. 26 (*non C. diaphanus*, Baird).
1894. *Caligus isonyx*, T. Scott, *Twelfth Ann. Rept. Fish. Board for Scot.* (III.), p. 310.
1896. *Caligus diaphanus*, Basset-Smith, Journ. M. B. Assoc., Plymouth, p. 156.

Both male and female of this species have the abdomen two-jointed. The species is a small one; the female specimen represented by the drawing (fig. 20) is only about 4·4mm. in length; the abdomen is moderately elongate, being about one-fourth of the entire length of the animal; the last abdominal segment is small but quite distinct. The lateral margins of the last thoracic segment are convexly and evenly rounded, but posteriorly this segment is abruptly truncate, and is also not much longer than the abdomen.

The antennæ (posterior antennæ) are moderately short and armed each with a strongly but evenly hooked claw. The mandibles are slender and elongated, and the last joint is distinctly serrated on the inner edge (fig. 22). The posterior foot-jaws are robust, and furnished with strong terminal claws; the penultimate joint is also produced near the base of the inner margin into a stout triangular tooth (fig. 24). The sternal fork has moderately long and slightly divergent branches (fig. 23). The apices of the *palpi* are single and spine-like.

The fourth pair of thoracic feet are moderately stout; the branches are distinctly three-jointed, and carry five moderately long setæ (fig. 25). There is also on the last thoracic segment what appears to be a fifth pair of feet, each of which consists of a minute sub-triangular one-jointed appendage bearing a few small setæ. The caudal segments are very short.

In the male the abdomen consists of two sub-equal segments; the last thoracic segment is narrow and not much wider than the abdomen. The antennæ appear to differ slightly from those of the female, especially in possessing a supplementary tooth near the base of the terminal claw.

Habitat.—Our specimens of this species were obtained in the gill-cavity of *Trigla gurnardus* from the Firth of Forth, the Firth of Clyde, and at Aberdeen Fish Market; also on *Trigla lineata* from the Clyde, and on a specimen of *Trigla hirundo* in the collection of fishes in the Laboratory at Bay of Nigg.

Genus *Lepeophtheirus*, Nordmann (1832).

The species belonging to this genus are, in their general form, very similar to *Caligus*, but, as already said, there are no *lunulæ* on the frontal plates, and the *palpi* are furcate instead of being simple and spine-like. Six or seven species belonging to this group have been obtained on fishes examined by me.

(1) Abdomen composed of one segment.

Lepeophtheirus pectoralis (Müller). (Pl. V., figs. 26–31.)

1776. *Lernea pectoralis*, Müller, Zool. Dan., p. 41, Pl. XXXIII., fig. 7.

1850. *Lepeophtheirus pectoralis*, Baird., Brit. Entom., p. 275, Pl. XXXII., fig. 10.

The specimen of *Lepeophtheirus pectoralis* represented by the figure on Plate V. (fig. 26) measures about five millimetres (one-fifth of an inch) in length; the cephalic shield is nearly circular; the last segment of the thorax is large and sub-quadrate, but its lateral margins are very slightly curved; the abdomen is short, and somewhat constricted near the middle, so that in certain positions it appears as if it were composed of two segments; the caudal segments are very short.

The antennæ (posterior antennæ) are provided with strong terminal hooked claws. The mandibles, which are small and slender, have the inner edge of the distal joint distinctly toothed (fig. 28). The posterior foot-jaws are strong, and they are armed with stout, curved terminal claws. In the sternal fork the branches become dilated in the middle then taper to a point at the end (fig. 29). The *palpi* are furcate.

The fourth pair of thoracic feet have the branches two-jointed, and are provided with three terminal setæ, and there is also a small seta or spine on the outer distal angle of the first joint. The fifth pair, which consist of small but comparatively broad lamelliform plates, provided with two or three minute terminal hairs, are situated behind the bases of the ovisacs, and are therefore easily missed.

The male (fig. 27) is little more than half the size of the female, but the cephalic shield is proportionally larger; the last segment of the thorax is small. In the male antennæ the basal joint is rather more dilated than in that of the female, while the terminal claw is smaller and more strongly hooked.

This is one of the more common and easily identified species of *Lepeophtheirus*. The peculiar form of the sternal fork, the small fourth pair of thoracic feet, and the short abdomen seem to be fairly good specific characters. Slight differences in the general form of the animal and in some of its structural details are occasionally observed, especially in specimens from different fishes, such as the plaice and the flounder.

Habitat.—Found for the most part adhering to the underside of the pectoral fins of plaice, *Pleuronectes platessa*, from the Firths of Forth and Clyde, and at the Fish Market at Aberdeen; on flounders, *Pleuronectes flesus*, from the Firth of Forth and the Moray Firth; and on common dabs, *Pleuronectes limanda*, from the Firth of Forth.

Lepeophtheirus nordmanni (M.-Edwards). (Pl. V., figs. 32–37.)

1840. *Caligus nordmannii*, M. Edw., Hist. Nat. Crust., vol. iii., p. 455, No. 10.
1850. *Lepeophtheirus nordmannii*, Baird, Brit. Entom., p. 275, Pl. XXXII., fig. 10.

This is a moderately large species; the specimen represented by the figure measures about half-an-inch in length (12 mm.). The cephalic shield is of an oval form and is distinctly larger than the last segment of the thorax. The abdomen is short (fig. 32).

The mandibles in this species are long and slender, but the last joint is comparatively short, and has a short serrated margin (fig. 34). The branches of the sternal fork are long and somewhat slender; they are also to some extent divergent (fig. 35). The posterior foot-jaws are large and armed with long terminal claws.

The branches of the fourth pair of the thoracic feet are three-jointed, and are provided with five setæ, three of which spring from the apex of the last joint, and one from the outer distal angle of the first and second joints (fig. 37). The fifth pair, which have a sub-triangular outline, are broadly foliaceous.

Habitat.—On a short sun-fish, *Orthagoriscus mola*, landed at Aberdeen Fish Market on 1st September 1899. One specimen only was obtained.

Remarks.—The abdomen of this specimen of *Lepeophtheirus nordmanni* obtained by me appeared to be rather more elongated than that which is represented in Dr. Baird's figure. He also describes the branches of the sternal fork as "sharp-pointed," but in our specimen the branches, though slender, are somewhat blunt at the ends.

Lepeophtheirus hippoglossi (Kröyer). (Pl. V., figs. 38–42; Pl. VI., figs. 1–2.)

1838. *Caligus hippoglossi*, Kröyer, Naturh. Tidsskrift, R. i., vol i., p. 625, Pl. VI., fig. 3.
1850. *Lepeophtheirus hippoglossi*, Baird, Brit. Entom., p. 276, Pl. XXXII., figs. 1–2.

The ovigerous female represented by the drawing (Pl. V., fig. 38) was rather more than half-an-inch in length (about 13·5 mm.). The cepalic shield was large and of an oval outline, but the last segment of the thorax was comparatively small and narrow, and rather longer than broad. The abdomen was small, and slightly constricted near the posterior end. The caudal segments were very short.

In this species the mandibles are long and slender, though scarcely so much so as those of *Lepeophtheirus nordmanni.* The sternal fork differs from that of any of the other *Lepeophtheirus* recorded here in having each of the two branches distinctly biped (fig. 2, Pl. VI.). The fourth pair of thoracic feet have the branches three-jointed and furnished with four setæ, three at the apex and one on the outer distal angle of the second joint (fig. 41, Pl. V.). The fifth pair consists of small triangular plates situated behind the bases of the ovisacs.

In the adult male (fig. 39, Pl. V.) the last thoracic segment is very small, and the fifth pair of feet are more or less exposed. The male is also much smaller than the female, being scarcely half as long. In the male the antennæ appear to be also somewhat different from those of the female, the basal joint is more dilated and the terminal claw is more strongly hooked.

Habitat.—Taken on the backs of large halibut, *Hippoglossus vulgaris*, landed at Aberdeen Fish Market during the summer and autumn of 1899.

This, like other species of *Lepeophtheirus*, exhibits a certain amount of variation, but full-grown specimens may usually be distinguished by the form of the ventral fork. *L. hippoglossi* appears to be found principally on the halibut, and is not uncommon. I have found a slightly immature specimen on a torsk, *Brosmius brosme*, in Aberdeen Fish Market, but probably it had been accidentally transferred to the torsk by contact of that fish with a halibut.

Lepeophtheirus thompsoni, Baird. (Pl. V., figs. 43–45.)

1850. *Lepeophtheirus thompsoni*, Baird, op. cit., p. 278, Pl. XXXIII., fig. 2.

1899. *Lepeophtheirus thompsoni*, Basset-Smith, Proc. Zool. Soc. Lond. (April 1899), p. 455.

This is a smaller species than the last; the female represented by the drawing (fig. 43) is about one-third of an inch (8·5 mm.) in length. In this species the last segment of the thorax is sub-quadrate in outline, rather longer than broad, and increases slightly in width posteriorly. The abdomen is elongated, and its thickness increases to a slight extent for a short distance beyond the middle, when a slight decrease begins and where also a small constriction is sometimes visible. The caudal segments are very short.

The antennæ of *Lepeophtheirus thompsoni* are armed with stout and strongly-hooked claws (fig. 45). The mandibles are somewhat similar to those of *Lepeophtheirus pectoralis*. The sternal fork is also somewhat like that of the same species, but the branches of the fork are scarcely so much dilated (fig. 44). The fourth pair of thoracic feet are distinctly three-jointed, and moderately stout; they each bear three terminal setæ, and a seta or spine at the outer distal angle of the first and second joints, but that on the first joint is very minute. The fifth pair, which are oval in outline, are very small and situated below and slightly anterior to the bases of the ovisacs.

Habitat.—On the gills of turbot, *Bothus maximus*, captured in the Firth of Forth, the Firth of Clyde, and on the gills of turbot examined in the Fish Market at Aberdeen.

Lepeophtheirus strömi, Baird. (Pl. VI., figs. 3–8.)

1847. *Caligus stromii*, Baird, Trans. Berw. Nat. Club (1847).

1850. *Lepeophtheirus stromii*, Baird, Brit. Entom., p. 274, Pl. XXXII., figs. 8 and 9.

We have obtained this copepod on salmon, *Salmo salar*, captured in Montrose Bay and Bay of Nigg (Aberdeen). I have seen no specimens from the Firth of Forth or the Firth of Clyde, bnt they will doubtless be found on salmon captured within these estuaries as well as elsewhere.

Lepeophtheirus stromi has the abdomen proportionally rather more elongated than that of *L. thompsoni*, and the ovisacs are usually very long and slender. The dorsal surface in this species has a curious metallic lustre, different from most of the others of the same genus. Males appear to be comparatively scarce.

The branches of the sternal fork are moderately short and stout, and are broadly rounded at the ends (fig. 5). The fourth pair of thoracic feet have the branches three-jointed and provided with four short setæ; the outer distal angle of the first joint is apparently not provided with a seta in this species, but is simply rounded. The fifth pair of feet are broadly sub-triangular, and have three small terminal hairs arranged as shown on the figure.

Figure 8 represents a young specimen newly hatched.

Lepeophtheirus pollachii, Basset-Smith. (Pl. VI., figs. 9–15.)

1896. *Lepeophtheirus pollachius*, Basset-Smith, Ann. and Mag. Nat. Hist. (6), vol. xviii., p. 12, Pl. IV., fig. 1.
1899. *Lepeophtheirus pollachii*, Basset-Smith, Proc. Zool. Soc., Lond. (April 1899.)

The length of the specimen represented by the drawing (fig. 9) is about three-tenths of an inch (7·5mm.). The cephalic shield is sub-orbicular, but the last segment of the thorax is sub-quadrate, and is nearly as large as the cephalic shield; this segment also slightly increases in width towards the posterior end. The abdomen is about as long as the last thoracic segment, and tapers somewhat towards the extremity. The caudal segments are of moderate size.

The antennæ are armed with moderately large terminal claws strongly hooked at the end. The mandibles are elongate and slender; the last joint, which is short and about as broad as the preceding one, is serrated on the inner edge. The sternal fork has moderately short and simple divergent branches, and resembles the letter V inverted (fig. 13). The posterior foot-jaws are stout, and provided with strong terminal claws. The branches of the fourth pair of thoracic feet, which are three-jointed, are moderately elongated and slender; three spiniform setæ spring from the end of the third joint, while the first and second joints are each provided with a seta or spine on the outer distal angle (fig. 15). The fifth feet are small, sub-quadrate, and bear each three small apical setæ.

The male is about as long as the female, but the last segment of the thorax is very small; the abdomen is composed of two sub-equal segments (fig. 10). The antennæ and the posterior foot-jaws of the male also differ to some extent from those of the female.

Habitat.—Our specimens were obtained adhering to the inside of the mouth of a lythe, *Gadus pollachius*, caught in the salmon-nets in Bay of Nigg, Aberdeen, June 22nd, 1899.

This species appears to develop moderately long ovisacs.

(2) Abdomen composed of two segments.

Lepeophtheirus (?) *obscurus* Baird. (Pl. VI., figs. 16–19.)

1850. *Lepeophtheirus obscurus*, Baird, Brit. Entom., p. 277, Pl. XXXII., fig. 11.
1896. *Caligus obscurus*, Basset-Smith, Ann. and Mag. Nat. Hist. (6), vol. xviii., Pl. IV., fig. 2; Journ. M. B. Assoc. Plymouth (1896), p. 157.
1899. *Lepeophtheirus obscurus*, Basset-Smith, Proc. Zool. Soc. Lond. (April 1899), p. 456.

The length of the female specimen represented by the drawing (fig. 16) is about one-fourth of an inch (8·2mm.). The cephalic shield is sub-orbicular, but rather longer than broad. The last segment of the thorax is about two-thirds of the length of the cephalic shield, and of a sub-cylindrical form, and its posterio-lateral angles are produced into boldly-rounded lobes. The abdomen is in length equal to about three-fourths of the length of the last segment of the thorax, and is distinctly jointed near the posterior end. The caudal segments are very small.

The antennæ are armed with large and strongly-hooked terminal claws (fig. 17). The mandibles somewhat resemble those of *Lepeophtheirus pectoralis*. The sternal fork, which appears to vary to some extent, has moderately stout branches; these branches are somewhat dilated in the middle and slightly divergent (fig. 18). The branches of the fourth pair of thoracic feet appear to be only two-jointed, like those of *L. pectoralis*; each branch is, for the most part, provided with five setæ arranged as shown in the drawing (fig. 19), but some specimens want the marginal seta on the end joint; the seta at the outer distal angle of the first joint is a very small one. The fifth pair are broadly foliaceous, and situated beneath and slightly anterior to the basal part of the ovisacs.

No males have been observed.

Habitat.—On the gills, inside gill-covers, and under the pectoral fins of brill, *Bothus rhombus*, captured in the Firth of Forth and the Firth of Clyde.

It is very doubtful if the copepod described here, or the one described under the same name by Dr. Basset-Smith, be the *Lepeophtheirus obscurus* of Dr. Baird's monograph. The copepod described by Dr. Baird as *Lepeophtheirus obscurus* was a male, and was probably, as he himself suggests,* a male of *Lepeophtheirus hippoglossi*. Figure 39, Plate V., of the present paper represents an adult male of *Lepeophtheirus hippoglossi*, and if Dr. Baird's figure of *L. obscurus* be compared with it the resemblance between them will be seen to be very close. Moreover, Dr. Baird, in describing *Lepeophtheirus obscurus*, says :—"Abdomen small; not more than one-third the size of last ring of thorax. . . . Sternal fork well developed, each branch being bifurcated, the inner branch being much smaller than the other." All this, as well as the remaining parts of the description, agrees exactly with what we see in the male of *Lepeophtheirus hippoglossi*.

The *Lepeophtheirus* from the brill, described in the preceding notes, resembles *L. thompsoni* to some extent, and may probably be only a form of that species. It seems to differ, however, in having a somewhat longer abdomen; in having the abdomen more distinctly segmented; in the sternal fork being rather different in form; and in the form of the fifth thoracic feet being slightly different.

Dr. Basset-Smith describes the sternal fork of his *Lepeophtheirus obscurus* as having bifurcating branches,† but in some other respects as closely resembling *L. thompsoni*. If the bifurcate form of the sternal fork be a character more or less constant in Dr. Basset-Smith's specimens, they are likely to be different from that which I have recorded, and that notwithstanding their otherwise close similarity to *Lepeophtheirus thompsoni*, for, as already pointed out, though the form of the sternal fork in my specimen varies to some extent, in none of those examined has it been observed to have bifurcated branches.

The male specimen described by Dr. Baird as *Lepeophtheirus obscurus* may, in view of what has been stated by Dr. Basset-Smith, be after all a distinct species, the female of which is the form recorded by that author, and, if that be so, we have here another example of the want of uniformity between the sexes of the same species, which is sometimes observed amongst the parasitic Copepoda. This disparity between the sexes, however, is, I think, of less frequent occurrence amongst *Caligus* or *Lepeophtheirus* than it is amongst some of the other groups. If, for example, the female *Caligus* or *Lepeophtheirus* be distinguished by a short or a long abdomen, the male of the same species to which the female belongs has usually, though perhaps not in every case, the abdomen

* Brit. Entom., p. 363.

† *Journ. M. B. Assoc., Plymouth* (April 1899), p. 158.

correspondingly short or long. Now, in regard to the forms under consideration, it will be observed that the females of Dr. Basset-Smith's *Lepeophtheirus obscurus* have the abdomen moderately long and two-jointed, whereas Dr. Baird's male has a "small abdomen" consisting of one segment. It may be that, notwithstanding this discrepancy, the two forms belong to the one species; but I am inclined to think that Dr. Baird's own suggestion—that his *Lepeophtheirus obscurus* is the male of *Lepeophtheirus hippoglossi*—is after all the correct explanation of the difficulty.

Genus *Trebius*, Kröyer (1838).

This genus resembles *Lepeophtheirus* in its general configuration, in the absence of *lunulæ* on the frontal plates and in the possession of bifurcated *palpi*. On the other hand, the most distinctive and obvious difference between *Trebius* and *Lepeophtheirus* is that in the former the fourth pair of thoracic feet are furnished with two branches instead of only one branch, as in the case of the latter.

The only species belonging to this genus is the one described below.

Trebius caudatus, Kröyer. (Pl. VI., figs. 20–26.)

1838. *Trebius caudatus*, Kr. Naturh. Tidsskrift (1838), R. i., vol. ii., p. 30, Pl. I., fig. 4.

1850. *Trebius caudatus*, Baird, op. cit., p. 280, Pl. XXXIII., figs. 3, 4.

In the female of this species the cephalic shield, which is about as long as the entire remaining portion of the thorax, is nearly oval, and rather longer than broad. The last segment of the thorax is sub-cylindrical, its breadth being equal to about four-fifths of the length; the posterio-lateral angles are rounded and fringed on the posterior aspect with three small but stout spines. The abdomen is long and slender, and composed of two segments; a slight constriction is also observable towards the distal end of the second segment, which has in some specimens the appearance of an additional joint. The caudal segments are small.

The antennæ (posterior antennæ) are armed with strongly-hooked terminal claws (fig. 22). The mandibles are somewhat similar to those of *Lepeophtheirus*, but the end-joint appears to be rather stouter than the preceding one, and is distinctly serrated on the inner margin (fig. 24). The *palpi* are bifurcated, but the inner branch of each *palpus* is rather shorter than the other. The sternal fork is small, and the branches are simple and comparatively short (fig. 23). In the fourth pair of thoracic feet the basal joints are stout and comparatively short; both of the three-jointed branches are also short, but the outer ones are armed exteriorly with five moderately stout marginal spines, and interiorly with plumose marginal setæ. The inner branches are also setiferous, but they want the exterior marginal spines.

The male (fig. 21), which is scarcely half the length of the female, has the fourth thoracic segment very small. The abdomen consists of two segments, and is of moderate length; the two segments are somewhat unequal, the first being rather shorter than the other. The caudal segments are slightly longer than those of the female.

The length of the female specimen figured is about four-tenths of an inch (10mm.). In another specimen of about the same length the abdomen measured 3mm.; while in a somewhat larger one, the entire length of which was 11mm., the abdomen measured 4mm. in length, or fully two-thirds the entire length of the animal.

Habitat.—On the grey skate, *Raia batis*, from the Firth of Forth, the Firth of Clyde, and the Moray Firth, and on specimens of the same fish brought to the Fish Market at Aberdeen. I found *Trebius* also on a specimen of thornback, *Raia clavata*, captured in the Firth of Clyde on April 22nd, 1897.

Genus *Dinematura*, Latreille, 1829 (modified by Burmeister, 1831).

Burmeister objected to the form of the word "*Dinemoura*" used by Latreille, and changed it to *Dinematura*. This change in the form of Latreille's name appears now to be generally accepted and used.

Dinematura producta (Müller). (Pl. VI., figs. 27–31.)

1785. *Caligus productus*, Müller, Entom., p. 132, Pl. XXI., fig. 3.
1850. *Dinemoura lamnæ*, Baird, op. cit., p. 286, Pl. XXXV., fig. 7.

The *Dinemoura* (*Dinematura*) *lamnæ* of Baird's monograph, now identified as the *Caligus productus* of Müller, has been obtained by me on one or two occasions during the past autumn on young porbeagle sharks, *Lamna cornubica*, caught in the North Sea, and landed at the Fish Market at Aberdeen. The larger specimens of *Dinematura* measured fully four-fifths of an inch (20mm.) in length, exclusive of the ovisacs, which were long and slender (fig. 27). One of the porbeagle sharks, on which we obtained several specimens, was about three feet three inches in length.

The antennæ of *Dinematura producta* (fig. 28) are armed with powerful hooked terminal claws. The mandibles are elongated and very slender (fig. 29). The anterior foot-jaws (fig. 30) are moderately stout, and each terminates in a hook-like apex ; a short but stout and slightly curved appendage also springs from the inner aspect, and near the distal end of the penultimate joint. The posterior foot-jaws are short and stout, and somewhat rudimentary in structure.

The first three pairs of thoracic feet are two-branched and somewhat similar to those usually observed in the Caligidæ, but the fourth pair are large and foliaceous. The caudal segments are composed of broad quadrangular plates, the width of which is equal to about two-thirds of the length ; their outer margin is nearly straight, but the inner is gently and evenly convex ; the apex is subtruncate, and bears three small setæ, while a fourth seta springs from a notch near the distal end of the outer margin (fig. 31). No males have been observed.

The characters by which this species may be distinguished include, amongst others, the form of the dorsal plates, the abruptly-hooked antennæ, the structure of the *palpi* and of the anterior foot-jaws, the form of the fourth pair of thoracic feet, and of the caudal furca.

One of the specimens obtained at the Fish Market at Aberdeen measured three inches (75mm.) from the forehead to the ends of the long ovigerous tubes.

Genus *Echthrogaleus*, Steenstrup and Lütken (1861).

Echthrogaleus coleoptratus (Guérin). (Pl. VI., fig. 32.)

1817. *Dinematura coleoptrata*, Guérin, Icon. d. reg. Animal, vol. iii., Pl. XXXV., fig. 6.
1850. *Dinemoura alata*, Baird, op. cit., p. 285, Pl. XXXIII., fig. 8.

One or two specimens of this curious little species were found adhering to the fins of a porbeagle shark brought to the Fish Market at Aberdeen.* The specimen figured (fig. 32) measured from the front of the head to the end of the caudal furca about seven-sixteenths of an inch (11mm.), and the ovisacs, which were slender, were fully four times the length of the body—about two and one-quarter inches altogether.

The dorsal plates are adorned with small impressed circular marks, forming a more or less regular pattern, and this, together with the form of the plates, gives to them a fairly close resemblance to the elytra of certain coleopterous insects. This species appeared to be less frequent than the *Dinematura producta* already recorded.

Genus *Cecrops*, Leach (1816).

Cecrops latreillii, Leach.

1816. *Cecrops latreillii*, Leach, Ency. Brit. Suppl., vol. i., p. 20, figs. 1–5.
1850. *Cecrops latreillii*, Baird, op. cit., p. 293, Pl. XXXIV., fig. 1.
1892. *Cecrops lātreillii*, A. Scott, Trans. Nat. Hist. Soc. Glasgow, vol. iii., Part III., p. 266.

Several specimens of *Cecrops* were obtained on a short sun-fish, *Orthagoriscus mola,* captured in the Firth of Forth in October 1890. They were found adhering to the gills of the fish, and do not appear to be very uncommon on this species of *Orthagoriscus.* One or two specimens were taken from the gills of a sun-fish captured 14 miles east from Lerwick, Shetland, on 17th August 1893. The specimens recorded by Dr. Baird, which were obtained on sun-fishes captured at different parts of the coasts of England and Ireland, were also taken from the gills.

Genus *Pandarus*, Leach (1816).

The principal generic characters of *Pandarus* are, according to Dr. Baird, as follows:—(1) Several pairs of lamellar, elytraform appendages. (2) All the thoracic feet fitted to a certain extent for walking and armed near their extremities with short and thick hooks. There appears to be but one British species of *Pandarus*, viz., *P. bicolor*. The *Pandarus boscii*, described by Dr. Leach and Dr. Baird, is now considered to be a form of *P. bicolor*; indeed, Dr. Baird himself suggests that *P. boscii* is "only a variety" of the more common species.

Pandarus bicolor, Leach. (Pl. VI., figs. 33–38.)

1816. *Pandarus bicolor*, Leach, Ency. Brit. Suppl., vol. i., p. 405, Pl. XX., figs. 1–2.
1850. *Pandarus bicolor*, Baird, op. cit., p. 288, Pl. XXX, fig. 10.

Several specimens of *Pandarus bicolor* have been obtained during the past autumn on sharks which have been brought to Aberdeen Fish Market, and known by the name of tope or topers, *Galeus canis*. The parasites were found for the most part adhering to the fins of the topers, and less frequently on other parts of the fish.

The specimen figured measured about two-fifths of an inch in length, exclusive of the ovisacs, which were long and slender (fig. 33). The dorsal surface was adorned with dark chocolate-coloured blotches arranged somewhat as shown in the drawing.

The female antennæ are small and somewhat rudimentary; they are

* The specimens of *Echthrogaleus coleoptratus* recorded by Dr. Baird were obtained by Dr. Johnston also from a porbeagle shark captured in Berwick Bay.

each provided with a large gibbous, cushion-like appendage which seems to arise from the base of the antenna, and to project considerably forward on the under side (fig. 35). These appendages may probably be used as "sucking discs," seeing that the other means of attachment possessed by this copepod do not appear to be very greatly developed. The *palpi* are small but moderately stout and somewhat cone-shaped. The appendages, which appear to be the posterior foot-jaws, are greatly dilated, clumsy, and unshapely, with a broad cushion-like extremity.

The four pairs of thoracic feet are all two-branched; the first pair has the outer branches two-, and the inner apparently only one-jointed; the inner branches are also somewhat abnormal in shape. The second and third pairs have both branches moderately short and stout and composed of two joints, while in the fourth pair both branches appear to be only one-jointed.

On one of the topers examined at the Aberdeen Fish Market in October last I obtained a specimen—a male—of a *Nogagus*-like copepod, which I am inclined to consider as being the male of our *Pandarus*. (Figure 34 represents the specimen referred to). In some of its structural details this *Nogagus* closely resembles *Pandarus bicolor*. The antennæ are provided with dilated cushion-like appendages somewhat like those of the *Pandarus*, but they differ in being armed with terminal claws (fig. 36). The *palpi* are somewhat similar, and so also are the exterior foot-jaws. The posterior foot-jaws differ in possessing a distinct though small terminal claw. All the four pairs of thoracic feet are each two-branched, each branch is two-jointed, and the branches are provided with densely plumose hairs.

Nogagus, as a genus of copepods, is now to a large extent, if not altogether, obsolete. All the species of which it is composed are represented only by males. Several of these males have already been identified as the males of species belonging to other genera, and those which have not yet been satisfactorily disposed of will, it is believed, be also found to be the males of other species. The *Nogagus*-like form referred to as found on the toper in the Aberdeen Fish Market, though differing considerably in general appearance from *Pandarus bicolor*, coincides so closely with it in several of its structural details, that there seems to be little doubt of its being really the male of the *Pandarus*.

Habitat.—From what is stated both by Dr. Baird and Dr. Basset-Smith, it would appear that *Pandarus bicolor* is not confined to *Galeus canis** though it seems to be more frequent on that fish. The parasite has been recorded by these authors as occuring also on *Carcharius glaucus*, and *Scyllium catulus* (the Greater Spotted Dog-fish).

Genus *Lemargus*, Kröyer (1838).

The thoracic feet in *Lemargus* differ from those of *Cecrops* in being for the most part broadly foliaceous, and forming at the same time branchial appendages. The intermediate body-segments are smaller than either the anterior cephalic shield, or the posterior lamelliform dorsal plates. There appears to be but one British species of *Lemargus*.

Lemargus mu icatus, Kröyer. (Pl. VI., figs. 39–42.)

1838. *Lemargus muricatus*, Kr. Naturh. Tidsskrift, R. i., vol. i, p. 488, Pl. V., fig.

1850. *Lemargus muricatus*, Baird, op. cit., p. 294, Pl. XXXIV., figs. 3–4.

1892. *Lemargus muricatus*, A. Scott, Trans. Nat. Hist. Soc. Glasgow, vol. iii., Pl. III., p. 266.

* This is the same as *Squalus galeus*, Linn., mentioned by Dr. Baird, and *Galeus vulgaris* of Day.

A few specimens of *Lemargus muricatus* were obtained on a large sun-fish, *Orthagoriscus mola*, captured in the Firth of Forth in October 1890. My son (Mr. A. Scott) describes the copepods as burrowing in hollows formed in the flesh of the fish behind the anal fin; they were not, as in the case of *Cecrops*, found on the gills. T. Edward has recorded this parasite from the Moray Firth, but it does not appear to have been very frequently observed.

Lemargus has three-jointed, moderately long and well developed antennules. The antennæ are short, but they are armed with stout and strongly-hooked terminal claws. The mandibles are long and stylet-shaped, and minutely serrated at the distal end (fig. 40). The anterior foot-jaws are very small and armed with short but broad and sharp-pointed terminal claws, finely serrated on the inner edges (fig. 41). The posterior foot-jaws form strong and powerful grasping appendages, as shown in the figure (fig. 42).

The thoracic feet are all two-branched, but the first and second pairs are not so broadly foliaceous as the others, and approach more to the normal type of feet observed in this group of parasites. In the first pair the outer branches are considerably longer than the inner ones; but the branches of the second pair, which are short and two-jointed, are sub-equal in length. In the third and fourth pairs both branches consist of broad, one-jointed plates, almost devoid of spines or setæ of any kind. In the fifth pair one of the branches forms a large lamelliform plate, but the other branch is very small and bears at the apex a few minute spines.

Fam. Dichelestidæ.

This family includes, according to Dr. Basset-Smith, about 15 genera, but only three or four of them are represented in the British seas, and two are noticed in the present paper.

Genus *Clavella*, Oken (1815)

Clavella hippoglossi, Kröyer. (Pl. VII., figs. 1–6.)

1838. *Clavella hippoglossi*, Kr., Naturh. Tidsskrift, R. i., vol. i., p. 196, Pl. II., fig. 3.

This, which is so far the only species of *Clavella* I have observed, has the body very slender and of a reddish colour, the ovisacs are very elongated and of a colour similar to that of the body. We have found a number of these on the gills of large halibut, *Hippogossus vulgaris*, brought to the Fish Market at Aberdeen; they resemble the gill filaments of the fish so closely, both in form and colour, that they are easily missed. It was chiefly by accident they were first observed by us, from noticing a portion of their reddish thread-like ovisacs projecting beyond the ends of the gill filaments.

The head in *Clavella hippoglossi* is small and rounded; the neck is comparatively narrow and indistinctly segmented; the genital segment is elongated, narrow, and cylindrical, and the abdomen is extremely short. The posterio-lateral angles of the genital segment are produced into small rounded processes, about equal to the length of the abdomen, so that the posterior end has a trilobed appearance.

The entire length of the specimen figured (fig. 1), exclusive of the ovisacs, is about the seven-twentieths of an inch (9mm). The following are the measurements of another and rather larger specimen:—Entire length of the body, 9·5mm.; length of head and neck combined, 1·5mm.;

length of genital segment, 8mm.; length from forehead to end of ovisacs, 23mm.

Clavella hippoglossi has well developed and moderately stout five-jointed antennules, which are sparingly setiferous (fig. 2). The antennæ are moderately large and provided with powerful terminal hooks suitable for grasping (fig. 3). The mandibles are small, elongated and tapering, and armed with a few small teeth at the distal end of the inner margin. The maxillæ, or *palpi*, are very small, but comparatively stout, and are provided with two or three special tooth-like processes. The foot-jaws are elongated and slender. Both pairs of the thoracic feet are two-branched and both branches appear to be two-jointed (fig. 6). No males have been observed.

Genus *Cycnus*, M.-Edwards (1840).
Syn. *Congericola*, Van Beneden (1854).

The species belonging to *Cycnus* are in general appearance somewhat similar to *Clavella*; they may be distinguished, however, by the possession of four pairs of two-branched thoracic feet, instead of only two pairs, but these thoracic feet are not so fully developed as in *Clavella*. I have only observed one species of *Cycnus*, viz.:—

Cycnus pallidus (Van Beneden).

1854. *Congericola pallidus*, Van Ben., Bull. Acad. Roy. Belg., vol. 21, pt. ii., p. 583.
1896. *Cycnus pallidus*, Basset-Smith, Journ. M. B. Assoc. (Feb. 1896), p. 159.

About 30 specimens, counting adult, immature and damaged, of this species were obtained on the gills of a large *Conger vulgaris* sent from the Clyde by Mr. F. G. Pearcey, naturalist on board the "Garland." The conger was captured at Station IX., near the mouth of the estuary, on December 13th, 1899. In form and colour these parasites closely resemble pieces of the gill-filaments, and may therefore be readily overlooked. The specimens I observed were found to adhere very firmly to the gill-filaments, so much so that several specimens were damaged in the course of removing them.

None of the specimens measured reached to quite four millimetres; one specimen was about 3·7mm. in length, exclusive of ovisacs, and from the forehead to the end of the ovisacs the length was 8·2mm.; another specimen, measured in the same way, reached to 3·8mm. and 9·3mm. respectively; the same specimens measured about ·7mm. in width.

Fam. LERNÆIDÆ.

This family appears to contain a strangely mixed lot of parasitic copepods. The adult females belonging to some of the genera in this group have a somewhat abnormal appearance; development in their case is retrogressive, and to such an extent that in some instances nearly all traces of the characters which distinguish these copepods from the other orders of crustacea are obliterated. *Lernæa branchialis* may be cited as an example of extreme degradation. On the other hand, there are some species which have rather an elegant shape and possess copepod characters of a more distinctive form.

Three genera of the *Lernæidæ* are represented in the present paper.

Genus *Lernæenicus*, Lesueur. (1824).
Syn. *Lerneonema*, M.-Edw. (1840).

Lernæenicus sprattæ (Sowerby). (Pl. VII., figs. 7–10.)

1806. *Lernæa spratta*, Sowerby, Brit. Miscell., vol. ii., p. 17, Pl. LXVIII.
1850. *Lerneonema spratta*, Baird, op. cit., p. 341, Pl. XXXV., fig. 10.
1876. *Lernæenicus sprattæ*, Richiardi, Atti. della Soc. Tosc., vol. iii.
1891. *Lerneonema spratta*, T. Scott, *Ninth Ann. Rep. Fish. Board Scot.*, Pt. III., p. 306.

In August 1890 my son, Mr. John Scott, observed a sprat, or a small herring, he was not sure which, swimming about in one of the Leith Docks with a *Lernæenicus* attached to one of its eyes, but he failed to capture it. My son, Mr. Andrew Scott, has obtained the species in the Morecambe Bay district of Lancashire and has sent me one or two sprats for examination, having the parasite *in situ*, and the drawing on Plate VII. represents one of these sprats with the parasite attached to its eye (fig. 7). One of the sprats sent me for examination has no fewer than three specimens of *Lernæenicus* attached to one of its eyes. Figure 8 represents a *Lernæenicus*, which my son dissected, from the eye of a sprat. This specimen exhibits the thorax as having a moniliform structure a short distance posterior to the head. The head is provided with the barbed processes peculiar to these organisms. The head is also furnished with distinct though small antennules, but it is doubtful if these can be of any use to the animal; the antennules are represented by figure 7. The antennæ, though small, have the end-joints chelæform and well adapted for grasping (fig. 10). The length of the specimen figured is about seven-tenths of an inch (18mm.), exclusive of the ovisacs, and if the length of the ovisacs be added the total length reaches to about 43mm., or one inch and three-fourths.

Genus *Lernæa*, Linn. (1767).

This genus contains what appear to be the most degraded of the copepod parasites of fishes. It requires some stretch of the imagination to associate the large, mature, and bizarre-looking female *Lernæa* with the elegant and agile *Cyclops*, yet in their early stages of growth the two are not very dissimilar. *Lernæa* was placed by Linnæus amongst the Mollusca in the Class Vermes.

Lernæa branchialis, Linn. (Pl. VII., figs. 11 and 12.)

1767. *Lernæa branchialis*, Linn., Syst. Nat., 12th ed., p. 1092.

This well-known fish parasite is moderately common. We have records of it from various places around the Scottish coasts, as the Firths of Forth and Clyde, and the Moray Firth. Also on haddocks landed at the Fish Market at Aberdeen.

The species appears to vary to some extent. The specimen represented by figure 11 is probably the more common form; it is distinguished by having a moderately long neck, similar to that shown by Dr. Baird.* Another form with a much shorter neck is represented by figure 12.

Lernæa minuta, n. sp. (Pl. VII., fig. 13.)

Description of the Female.—Length of the specimen figured, about three-tenths of an inch (8mm.). Cephalic lobe somewhat dilated, horns

* Brit. Entom., Pl. XXXV., fig. 12.

not greatly developed. Thoracic feet, four pairs, small but distinct, and situated immediately behind the cephalic lobe. Neck short and moderately slender. Genital segment, moderately large and slightly sigmoid. Ovisacs elongated, slender, and twisted, as in *Lernæa branchialis.*

Habitat.—On the gills of the speckled goby (*Gobius minutus*).

Remarks.—Our superintendent, Dr. T. Wemyss Fulton, while examining some small fishes sent to the Laboratory from the Solway during November 1899, observed a small *Lernæa* on the gills of a specimen of *Gobius minutus.* This he kindly handed over to me along with a considerable number of specimens of the same species of goby. On making a careful examination of all these specimens—about 134 in number—three more specimens of the *Lernæa* were obtained; making in all four specimens of this parasite from 135 fishes, or about 3 per cent.

The average length of the specimen figured, exclusive of ovisacs, is a little over 7mm.

I have not been able to find any previous record of this small *Lernæa*, and have therefore described it as a new species under the name of *Lernæa minuta.*

Genus *Hæmobaphes*, Steenstrup and Lütken.

Hæmobaphes cyclopterinus (Fabr.). (Pl. VII., fig. 14.)

1780. *Lernæa cyclopterina*, Fabr., Fauna Grœnl., p. 337.
1861. *Hæmobaphes cyclopterina*, Stp. and Lütk., Bidrag til Kundskab, p. 405, Pl. XIII., fig. 30.
1891. *Hæmobaphes cyclopterina*, T. Scott, *Ninth Ann. Rept. Fish. Board Scot.*, Pt. III., p. 310.

I have only seen two specimens of this curious Lernæan, and both were found on the gills of the pogge, *Agonus cataphractus.* One was obtained at Dunbar by Mr. Jamieson, Laboratory Assistant, in April 1891, on the gills of a pogge taken from the stomach of a cod; the other was taken also from the gills of a pogge captured by the "Garland" in the Firth of Forth in February 1892. This specimen was recorded in the Annals of Scottish Natural History for April of the same year. It is represented in the present paper by figure 14 on Plate VII.; the neck and upper part of the thorax of this specimen was accidentally damaged.

I have recently examined a large number of pogges without finding a single example of this *Hæmobaphes*; probably the species is a rare one.

Hæmobaphes ambiguus, sp. n. (Pl. VII., fig. 15.)

A *Hæmobaphes*-like parasite was found on the gills of a specimen of the spotted dragonet, *Callionymus maculatus*, captured in the Solway in October 1899.

This parasite differs from *Hæmobaphes cyclopterinus* in having a very short neck, and in the abdominal portion of the genital segment being more produced; moreover, this produced part is compressed and somewhat dilated at the end, the margins are somewhat irregular in outline, and the lateral lobes are moderately prominent (fig. 15). Only one ovisac is shown in the figure; the other was accidentally destroyed.

The entire length of the specimen figured is about the seven-twentieths of an inch (11·5mm.).

I have been unable to find any published description of this form; and as it agrees with *Hæmobaphes* in some of its more prominent characters, I have decided to regard it for the present as "new."

Fam. CHONDRACANTHIDÆ.

Genus *Oralien*, Basset-Smith (Proc. Zool. Soc. Lond., April 1899, p. 489).
Syn. *Lernentoma* (pars.), Baird, Brit. Entom., p. 329.

This genus has been established by Dr. Basset-Smith for *Lernæa asellina*, Linn. (*Lernentoma asellina*, Baird), because of the marked difference in the arrangement of the cephalic appendages. In the typical *Chondracanthus* these appendages are arranged in more or less proximity, but in *Lernæa asellina* the head, which is rounded anteriorly and provided with antennules and antennæ as well as lateral lobe-like projections, is produced behind into a cylindrical and moderately elongated neck, at the base of which, where the neck joins the thorax, is situated the mouth and the several mouth organs. By this arrangement a considerable distance intervenes between the antennal appendages and the mouth parts. But besides this departure from the arrangement of the parts usually observed in the genus *Chondracanthus*, the general appearance of the animal also exhibits a marked difference from that of the other species belonging to that genus.

Oralien asellinus (Linn.). (Pl. VII., figs. 16–18.)

1761. *Lernœa asellina*, Linn., Fauna Suec., 2101.
1838. *Chondracanthus triglœ*, Kr. Naturh. Tidsskrift, R. i., vol. ii., p. 135, Pl. III., fig. 3.
1850. *Lernentoma asellina*, Baird, op. cit., p. 329, Pl. XXXV., fig. 4.

In this species the front part of the head is enlarged by the development of a lobe-like projection on each side; this part is usually buried deeply in the tissues of the fish. The antennules are short, moderately stout, simple appendages. The mandibles, which are somewhat similar to those of *Chondracanthus*, are stout and falcate, and their convex margins are fringed with short but moderately stout spines (fig. 18). The maxillæ, maxillipedes, and other appendages are somewhat similar to those of *Chondracanthus cornutus*.

The size of specimens varies to some extent; the more usual dimensions, however, seem to be as follows:—Length, exclusive of ovisacs, about 8 mm.; length from front of head to end of ovisacs, about 12 mm. A specimen from a common gurnard, *Trigla gurnardus*, measured only 5·5mm. in length of body and 8·5mm. to the extremity of the ovisacs.

I have obtained the species on the gills of gurnards, plaice, halibut, and other fishes captured on all parts of the Scottish coasts examined by us.

It is of interest to note that in the various works on the copepod parasites of fishes which I have consulted no two authors agree in their figures of this species. It may be that there is more than one species included in *Chrondracanthus asellinus*, or the differences referred to may be due to the variableness of the species.

Genus *Chondracanthus*, De la Roche (1811).
Syn. *Lernentoma* and *Chondracanthus*, Baird.

In this genus the head, though distinct, is not separated to any great extent from the thorax. The antennules are usually more or less conspicuous in front of the head, and these and the antennæ are in close proximity to the mouth organs. The genital segment is more or less cylindrical, as in *Chondracanthus cornutus*, or constricted, as in

Chondracanthus soleæ. Ten species are recorded in the sequel, but one of them is somewhat doubtful and apparently undescribed.

Chondracanthus cornutus (Müller). (Pl. VII., figs. 19–31.)

1776. *Lernæa cornuta*, Müller, Zool. Dan., vol. i., pl. 33, fig. 6.
1850. *Lernentoma cornuta*, Baird, op. cit., p. 328, Pl. XXXV., fig. 2.

This species, as represented by the figure in Dr. Baird's "British Entomostraca," has the genital segment of a cylindrical form and without any marked constriction in the middle; and in his description of the species Dr. Baird makes no allusion to any constriction of the posterior "two-thirds" of the thorax; had any constriction been observed, as conspicuous as it is, for example, in *Chondracanthus soleæ* or *Chondracanthus fluræ*, he would very likely have referred to it. Moreover, the figures of the same species by Nordmann* and Kröyer,† though showing a slight constriction of the thorax, agree fairly well with that of Dr. Baird.

Specimens agreeing in their general appearance with Dr. Baird's figure of *Chondracanthus cornutus*, except that they exhibit a slight constriction, as shown in the figure by Nordmann, have been found on the plaice, *Pleuronectes platessa*, and the common flounder, *Pleuronectes flesus*. I find on the plaice two forms of the *Chondracanthus*; the more common one (represented by figure 19) is the smaller of the two, and is also proportionally broader. The specimen of this form represented by the figure referred to measured 5·8mm., exclusive of ovisacs. The antennules of this specimen were considerably dilated, and showed little structure. The antennæ were furnished with strongly-hooked terminal claws, while the mandibles were moderately stout and tapered towards the end, where they became somewhat attenuated. The anterior foot-jaws had a moderately stout basal part, but the end-joint was more slender and was serrated on the inner edge (fig. 23).

The male of this form, which is very small, is represented by figure 24; it measured scarcely the half of a millimetre in length; the abdomen, which appeared to be distinct from the thorax, was more or less segmented.

A specimen of the less common and more elongated form is represented by figure 27; it measured nearly 7 millimetres in length. The posterior portion of the thorax in this form is long and narrow, and slightly constricted in the middle; the antennules (fig. 28) appear to be scarcely so robust as in the smaller form, but the mandibles and other appendages do not seem to differ much.

Habitat.—The smaller form has been obtained on plaice from the Firth of Forth, Firth of Clyde, Moray Firth, and at Aberdeen Fish Market. The larger form was found on the gills of a plaice in the collection of fishes in the Laboratory at Bay of Nigg, but the locality where this plaice came from is not stated on the label.

Chondracanthus annulatus, Olsson. (Pl. VII., figs. 46–51.)

1867. *Chondracanthus annulatus*, Olsson, Prodr. Faunæ Copep. Parasit. Scand., vol. v., p. 30, Pl. II., figs. 13–15.

A number of specimens of this *Chondracanthus* were obtained from the gills of a large grey skate, *Raia batis*, caught in the North Sea and landed at the Fish Market at Aberdeen, June 30th, 1899.

In this species the body is elongate, moderately narrow, and cylindrical in form; it is about four times longer than broad, and not much

*Mikrogr. Beitr., vol. ii., Pl. 9, fig. 5.
†Naturh. Tidsskr., R. iii., vol. 2, Pl. 13, fig. 7 (1864).

compressed. The head is well defined, the neck is short, and the posterior part of the thorax is slightly constricted in the middle. The abdomen is very short, and so are the posterio-lateral processes of the thorax. As the abdomen and lateral processes are about the same length, they give to the posterior end of the thorax a more or less trilobed appearance (fig. 46). The specimen represented by the figure is about 14mm. ($\frac{11}{20}$ of an inch) in length, exclusive of ovisacs, and from the front part of the head to the extremity of the ovisacs the length is about 2 inches.

The antennules in the female are very short and considerably dilated; the mandibles differ very little from those of *Chondracanthus cornutus.* The two pairs of thoracic limbs are both very short.

A male specimen, which is represented by figure 47, measured about 3 millimetres in length; its antennules were smaller than those of the female, and were rather more setiferous. The antennæ were short, but they were armed with strong, though somewhat short, terminal claws.

Chondracanthus clavatus, Basset-Smith. (Pl. VII., fig. 35–37.)

1896. *Chondracanthus clavatus,* Basset-Smith, Ann. and Mag. Nat. Hist. (6). vol. 18, p. 13, Pl. V., fig. 6.

In this species the thorax increases in width towards the posterior end; the posterio-lateral appendages are of moderate length, as shown by the figure (fig. 35). The antennules are considerably dilated and somewhat like those of *Chondracanthus cornutus* in their general appearance. The mandibles and the other appendages are also nearly the same as in that species, but the posterio-lateral thoracic processes are considerably longer, being equal to about one-sixth of the entire length of the animal.

The average length of the specimens I have measured is 6·5mm., but some are found a little smaller and some larger. The ovisacs are also not very elongate; the largest specimens I have observed scarcely reached a total length (including ovisacs) of 10mm.

Habitat.—On the gills of lemon soles, *Pleuronectes microcephalus,* caught in the Firth of Forth, in the Firth of Clyde, and on other parts of the Scottish coast. The male of this species is very like that of *Chondracanthus cornutus.*

Chondracanthus soleæ, Kröyer. (Pl. VII., figs. 41–45.)

1838. *Chondracanthus soleæ,* Kr., Naturh. Tidsskr., R. i., vol. i., p. 139, Pl. III.

1864. *Chondracanthus soleæ,* Kr., op. cit., R. iii., Pl. II., p. 330.

The specimens of *Chondracanthus* which I record under this name of Kröyer's were found on black soles, *Solea vulgaris,* captured in the Firth of Clyde in October and December 1899, and on turbot, *Bothus maximus,* captured in the Firth of Forth in July 1892. Kröyer obtained his specimens also from black soles. The species is distinguished by its comparatively small and robust form, by the comparatively elongated posterior thoracic appendages, and by the elongated posterio-lateral processes of the thorax. Moreover, the posterior portion of the thorax is distinctly constricted in the middle, as shown by the drawing (fig. 41). In comparing the antennules and antennæ, the mouth organs, and other appendages of this form with those of *Chondracanthus cornutus,* it is found that, though there is a certain amount of resemblance between them, differences are observable, which, taken in combination with the marked difference in the general appearance of the animals, present as good grounds for separating *Chondracanthus soleæ* from *Chondracanthus* *cornutus* as there are for separating *Chondracanthus clavatus* from the same species.

The male of *Chondracanthus soleæ* resembles also in some respects the male of *Chondracanthus cornutus,* but appears to differ in the form of the antennules and of the second pair of thoracic feet (figs. 44, 45); the antennules are considerably dilated and of a somewhat triangular form; and the second pair of feet have a sub-quadrate outline.

A moderately large female, obtained on a specimen of *Solea vulgaris* captured in the Clyde, measured about 8·5mm., exclusive of the ovisacs, which were as long as the specimen itself. In this specimen the lateral processes at the posterior end of the thorax were a millimetre in length, which was somewhat less than in some of the other specimens examined.

Chondracanthus flurœ, Kröyer. (Pl. VII., figs. 32–34.)

> 1864. *Chondracanthus flurœ,* Kr., op. cit., R. iii., vol. ii., pp. 323 and 330, Pl. XIII., fig. 6.

Kröyer obtained this species from the long rough dab, *Platessa limandoides* (Bl.), or *Drepanopsetta platessoides,* Fabr., as this fish is now called. Specimens of *Chondracanthus fluræ* have been obtained on long rough dabs captured in the Firth of Clyde; some of them were taken on specimens captured at Station III. (Kilbrennan Sound) in December last. This parasite has not been observed by us on any other kind of fish. *Chondracanthus fluræ,* like the one last described, has the posterior portion of the thoracic segment in the female distinctly constricted in the middle, but it is more robust, and the thoracic limbs, as well as the posterio-lateral processes, are short. Kröyer's description of the species, which accords very well with the Clyde specimens, is as follows:—"Forma crassa robustaque, latitudine fere dimidiam longitudinis partem obtinente, capite mediocri, latiore quam longiore, subsemilunato; annulis thoracicis omnibus perbene distinctis, latioribus quam longioribus, primo secundoque insequentibus multo angustioribus. Antennæ anterioris paris latitudine capitis paulo breviores, basi sejunctæ, articulo terminali conico, seta apicis instructo. Membra annuli thoracici primi et secundi minuta, eadem ferme longitudine ac latitudine, vix vel parvum furcata. Processus annuli thoracici quarti posteriores ipso annulo breviores (tertia quartave parte), crassi subconici. Abdomen dimidiam processuum longitudinem superius conicum, biarticulatum. Ovaria externa gracilia, elongata?" *

This species is smaller, but comparatively more robust, than the one last recorded. The specimen represented by the drawing measures about 4·7mm. in length; while the length of a somewhat larger specimen is 5·5mm., exclusive of ovisacs, and from the forehead to the end of the ovisacs the length is fully 10·5mm.

Chondracanthus merluccii, Holten.

> *Chondracanthus merluccii,* Holten, Mem. Soc. Hist. Nat. Copenhag., vol. v., Pl. III., fig. 2.
> 1892. *Chondracanthus merluccii,* T. Scott, *Tenth Ann. Rept. Fish. Board for Scot.,* Pt. III., p. 262.
> 1896. *Chondracanthus merluccii,* Basset-Smith, Journ. M. B. Assoc. Plymouth, p. 161.

This is a moderately common parasite on the hake, *Merluccius vulgaris.* I find it most frequently clinging to the roof and sides of the mouth, and

* Naturh. Tidsskr., R. III., Bd. 2, p. 330 (1864).

sometimes on the under side of the tongue and the inside of the gill-covers. *Chondracanthus merluccii* differs from the other species in having, besides its usual thoracic limbs, a pair of moderately long appendages near the middle of the posterior portion of the thorax, and also in the posterio-lateral processes being considerably elongated. The mandibles, which are distinctly toothed on the upper margin, and the other cephalic appendages are all more or less similar to the same appendages in other species of *Chondracanthi.*

A female specimen of average size measured about half an inch in length, exclusive of ovisacs. The males are very small, and sometimes more than one of them may be observed sticking on a female. The species varies to some extent both in its general outline and in the proportional lengths of the various appendages.

Chondracanthus lophii, Johnston.

1836. *Chondracanthus lophii,* Johnston, Loud. Mag. Nat. Hist., p. 81, fig. 16.
1850. *Lernentoma lophii,* Baird, op. cit., p. 330, Pl. XXXV., fig. 3.

This is one of the more common of the copepod parasites of fishes; it seems to be to a large extent peculiar to the angler, *Lophius piscatorius,* and is usually found adhering to the inside surface of the gill-pouches. A considerable percentage of the anglers captured by the "Garland" are more or less infested with this copepod. I have records of it from the Firth of Forth, the Firth of Clyde, and other parts of the Scottish coasts. The oviferous tubes are slender, usually elongated, and more or less twisted.

Chondracanthus zeus, De la Roche. (Pl. VIII., fig. 1.)

1811. *Chondracanthus zei,* De la Roche, Nouv. Bull. des Sc. de la Soc. Philom., vol. ii., p. 270, Pl. II., fig. 2.
1850. *Chondracanthus zei,* Baird, op. cit., p. 327, Pl. XXXV., fig. 1.

In this species the dorsum is ornamented with a number of processes, which gives the specimens a bizarre appearance not usually observed amongst the *Chondracanthi.*

I obtained a specimen of *Chondracanthus zeus* on the gills of a John Dory, *Zeus faber,* caught in the Firth of Forth in 1891; this specimen is recorded in Part III. of the *Tenth Annual Report of the Fishery Board for Scotland* (1892). A second specimen was obtained in the Firth of Forth in 1896, also on the gills of a John Dory. *Chondracanthus zeus* has also been obtained in the Firth of Clyde, on a John Dory, captured there by the "Garland."

The length of the specimen represented by the figure was about half an inch, but the species varies to some extent both in size and ornamentation.

Chondracanthus limandæ, Kröyer. (Pl. VII., figs. 38–40.)

1864. *Chondracanthus limandæ,* Kr., op. cit., R. iii., vol. ii., pp. 322 and 330, Pl. XIV., fig. 2.

Kröyer obtained this species on *Platessa limanda* (*Pleuronectes limanda,* Linn), the common dab. I have obtained on two different specimens of the common dab what appears to be the same species of copepod. The common dab from which the specimen represented by the drawing (fig. 38) was obtained was captured in the Firth of Clyde in 25-30 fathoms, November 1899. A second specimen, exhibiting even a closer resemblance to the figure, was obtained on a common dab taken by the "Garland" at Station VII. in the Moray Firth on January 24th of the present year (1900).

This species is moderately robust; the first thoracic segment is very short; the second is of moderate size, and has on each side a slightly elevated and broadly rounded knob—"annulo secundo duobus tuberculis humeralibus praèdito magnis." * The posterior portion of the thorax is more or less distinctly constricted, so that this portion of the thorax appears as if it were divided into two slightly unequal parts. The thoracic limbs are more rudimentary than those of *Chondracanthus cornutus*; in that species the second pair are distinctly bifid, but in the present form they are not so, or they show at most the merest trace of bifurcation, agreeing in this respect also very closely with Kröyer's description—"Membra annuli thoracici primi et secundi latiora quam longiora semilunaria, haud furcata, posterius par priori multo majus." The posteriolateral projections of the thorax are comparatively short and stout; the abdomen is very short and composed of two segments.

The specimen represented by the drawing is about 5mm., exclusive of the ovisacs, which are about the same length, giving a total length of about 10mm.

The male is very small; one which I measured was only 0·65mm. (scarcely one-thirty-eighth of an inch) in length.

Chondracanthus ornatus, sp. n.

I have recently obtained on the gills of specimens of the spotted dragonet, *Callionymus maculatus*, a *Chondracanthus*-like copepod, which appears so far to be undescribed. The female of this copepod viewed from above has a general outline closely similar to that of an equilateral triangle, the bluntly-rounded head forming the apex and the truncate posterior end the base; the front of the head is indistinctly tri-lobed, one bluntly-rounded lobe being in the centre, and projecting slightly in front of the two lateral lobes, which are also bluntly rounded; the neck connecting the head with the thorax is very short; along each side of the thorax (forming the sides of the triangle) there are three or four more or less distinct tubercles†, and a series of three similar tubercles extends along the middle of the dorsum; the posterior tubercle of the middle series stands well up, but each of the other two stands at a slightly lower elevation than the one immediately behind; the abdomen is exceedingly small and inconspicuous. The ovisacs are of moderate length and stoutness, like those of *Chondracanthus limandæ.*

The length of the more typical of my female specimens is as follows: From forehead to the posterior end of body, 5mm. (one-fifth of an inch); from forehead to the end of the longest of the two ovisacs, 11·5mm. (nearly half an inch); the width of the thorax at the posterior end is just a little over 5mm., so that the body of the animal, as I have already said, has a general outline closely similar to that of an equilateral triangle.

The male is very small; it scarcely reaches to 0·6mm. ($\frac{1}{40}$ of an inch) in length. I have not had time to get drawings of this interesting species prepared, but it has such a characteristic form that the description of the female I have given, together with the *habitat* of the species, should facilitate its identification. I have obtained the species on the

* Kroyer, Naturh. Tidsskr., R. III., Bd. 2, p. 330 (1864).

† The arrangement and position of these lateral tubercles seems to vary slightly in different specimens; the description refers to the *general appearance* as seen from above.

gills of *Callionymus maculatus* from the Firth of Clyde, collected in 1899, and from the Moray Firth, collected at Station VII. on January 24th, 1900. From the ornate character of the species I have called it *Chondracanthus ornatus.*

Fam. LERNÆOPODIDÆ.

This, the last of the series of seven families into which the parasitic copepods of fishes have been divided, contains ten genera, and five of these are represented in the present paper, viz.:—*Thysanote, Charopinus, Lernæopoda, Brachiella,* and *Anchorella.*

Genus *Thysanote,* Kröyer (1863).

Thysanote impudica (Nordmann). (Pl. VIII., figs. 2–5.)

1832. *Brachiella impudica,* Nord., Mikrog. Beitr., vol. ii., p. 92, Pl. VIII., fig. 3.
1899. *Thysanote impudica,* Basset-Smith, Proc. Zool. Soc. Lond. (April 1899), p. 497.

I ascribe to this species a small *Brachiella*-like parasite found on the gills of a specimen of *Trigla hirundo* (the red gurnard) in the collections of fishes in the Laboratory of the Fishery Board for Scotland at Bay of Nigg, Aberdeen. I have not been able to ascertain definitely where the fish was captured, but it was probably taken either at the mouth of the Forth estuary or in the Firth of Clyde.

Genus *Charopinus,* Kröyer (1863).

Charopinus dalmanni (Retzius). (Pl. VIII., figs. 6–10.)

1831. *Lernæa dalmannii,* Retz., Froriep's Notizen, vol. xxix., p. 617, Pl. VI., fig. 5.
1863. *Charopinus dalmannii,* Kr., Naturh. Tidsskr., R. iii., p. 280, Pl. XIV., fig. 6.
1878. *Stylophorus hypocephalus,* Hesse, Ann. Sci. Nat. (6), vol. viii., art. 15, p. 1.
1891. *Charopinus dalmannii,* T. Scott, Ninth Ann. Rept. Fish. Board for Scot., Pt. III., p. 310.

In this species the head, or anterior portion, of the thorax is ventrally and abruptly deflexed, and at the angle of the thorax thus formed there springs from each side a long, moderately slender and indistinctly annulated appendage, which becomes dilated and lunuleform at the apex. These two lunuleform apices, which, though not actually joined, fit very closely together, are buried in the tissues of the fish infested by this parasite. These appendages, by which the parasite anchors itself to the fish, are usually described as the second maxillipedes. The posterior portion of the thorax becomes gradually enlarged towards the distal end, and assumes a more or less clavate form; two moderately long and slender processes spring from the ventral aspect and just in front of the ovisacs; the two sides of the posterior portion of the thorax curve slightly inwards near the base, and each terminates in a small lobe. The abdomen, which is situated between and slightly in front of these lobes, is almost obsolete. The ovisacs are of moderate length, and saccate, and the ova are small and arranged in multiserial order. The following measurements are taken from a specimen of average size:—Length of second maxillipedes, 22mm.; length of head and thorax (anterior to the angle from whence the second maxillipedes spring), 9mm.; length of posterior portion of thorax, 15mm.; length of ovisacs, 20mm.; length of the ventral thoracic appendages, 10mm.; total length from the apices of second maxillipedes to the end of ovisacs, 55mm. (nearly $2\frac{1}{4}$ inches).

The male of this large copepod scarcely reaches beyond two millimetres in length.

The antennules in the female are apparently three-jointed, and are moderately stout. The antennæ are short, stout, and feebly clawed (fig. 8). The mandibles, which are of moderate length and somewhat slender, are serrated at the distal end of the inner margin (fig. 9). The anterior foot-jaws (maxillipedes) are stout and feebly clawed.

In the male the thorax and abdomen (fig. 7) are more or less segmented); and the maxillipedes are short and stout, and, being armed with strong terminal claws, form powerful grasping organs.

Habitat.—In the nasal fossæ (or spiracles) of the grey skate, *Raia batis.* All the specimens we have obtained have been found in the nasal fossæ of the grey skate. *Charopinus dalmanni* appears to be moderately common on the large skate brought to the Fish Market at Aberdeen; sometimes two and three specimens have been found in the same spiracle of the skate examined in the market. I have also taken this species from a grey skate captured at the mouth of the Forth estuary.

Charopinus dubius, sp. n.

I record provisionally under this name a *Charopinus* which has been obtained adhering to the gills and gill-arches of the cuckoo ray, *Raia circularis*, Couch. The fishes from which these copepods were obtained were captured in the Firth of Clyde during December 1899. No specimens of this copepod have so far been observed in the spiracles of the cuckoo ray.

This *Charopinus* resembles more or less closely the *Charopinus* of the grey skate, and may only be a form of that species. The following points, however, deserve notice:—

Charopinus dubius is distinctly smaller than *Charopinus dalmanni.* The second maxillipedes are more slender in proportion to their length, and they are joined to each other at the apex by small horn-coloured plugs, which unite to form a thin circular horny disk, hollow in the middle and with the margins slightly reflexed. This disk is usually buried in the hard substance of the gill-arches, and is difficult to dissect out while retaining its union with the maxillipedes. The ovisacs are also rather more elongate and slender.

The most obvious difference between *Charopinus dalmanni* and the present form, other than that of size, is the character of the apices of the second maxillipedes; the difference here is very distinct and must of itself be held as alone of specific value if the differences recognised by Kröyer are to be considered valid. According to that distinguished observer, the more important specific characters by which *Charopinus dalmanni* (Retz.) and *Charopinus ramosus*, Kr., are distinguished, are taken chiefly from the form assumed by the apices of the second maxillipedes. Kröyer's definitions of these species are as follow:—

" *Charopinus dalmannii.*

*Laminæ cartilagineæ, quibus affigitur femina, semilunares."

*Naturh. Tidsskr., R. 3, Bd. 2 (1863–64), p. 362.

"*Charopinus ramosus.*

Laminæ, quibus affigitur femina, exterius in ramos binos elongatos graciles, crucem fere, efficientes productæ."

My specimens differ from both of these species in the important characters specially referred to; they also differ in their habitat. *Ch. dalmanni* has been found only in the spiracles of the grey skate; *Ch. ramosus* was found by Kröyer on the gills of the Thornback skate, *Raia clavata*, Linn.,* whereas the form I am now recording was found attached to the gill-arches (chiefly) and on the gills of *Raia circularis*.

Different specimens of *Ch. dubius* differ somewhat in the proportional lengths of the parts. The following tabular statement shows the lengths of two fairly typical specimens, to which the sizes of *Ch. dalmanni* are added for comparison:—

Length of	*Charopinus dubius.* No. 1.	*Charopinus dubius.* No. 2.	*Charopinus dalmanni.*
Second maxillipedes, ...	11 mm.	11·5 mm.	22 mm.
Anterior portion of thorax and head, . .	6 ,,	5 ,,	9 ,,
Posterior portion of thorax, . . .	8·5 ,,	6 ,,	15 ,,
Posterior appendages, ...	4 ,,	4 ,,	10 ,,
Ovisacs, ...	18 ,,	damaged	20 ,,
Apex of second maxillipedes to end of ovisacs,	37 ,,	...	55 ,,
Apex of second maxillipedes to posterior end of thorax, ...	19 ,,	18 mm.	...

Genus *Lernæopoda*, Kröyer (1837).

Specimens of *Lernæopoda* have been obtained on a number of different kinds of fishes, and several species appear to be represented among them, but some of the so-called species approximate so closely as to render their identification somewhat difficult. Five species are recorded here.

Lernæopoda (?) elongata (Grant). (Pl. VIII., figs. 11–15.)

1827. *Lernæa elongata*, Grant, Brewster's Edin. Journ. Sci., vol. VII,, p. 147, Pl. II., fig. 5.

1850. *Lernæopoda elongata*, Baird, Brit. Entom., p. 333, Pl. XXXV., fig. 5.

The specimen I record under this name is rather smaller than those occasionally described, but it apparently agrees with the species named in some at least of its more important characters, *i.e.*, the form of the cephalic shield, the large and well-developed anterior pair of maxillipedes, and the very long and slender posterior maxillipedes. The abdomen is very short, and the posterior processes of the genital segment are almost obsolete.

The entire length of the specimen represented by the figure was at least three-quarters of an inch, and it was obtained on a porbeagle shark, *Lamna cornubica*. Where the fish was captured I cannot exactly say, though probably it was in the North Sea, somewhere off the Scottish coasts.

*Op. cit., p. 358.

One or two of the cephalo thoracic appendages are represented by figures 4–8.

Lernæopoda galei, Kröyer. (l. VIII., figs. 16–25.)

1837. *Lernæopoda galei,* Kr., Naturh. Tidsskr., R. i., vol. i., p. 272, Pl. III., fig. 5.

1850. *Lernæopoda galei,* Baird, op. cit., p. 334, Pl. XXXV., fig. 7.

A number of specimens of *Lernæopoda galei* have been obtained on tope (or topers, as the fish is sometimes called), *Galeus canis,* Rondel. (*Galeus vulgaris,* Flem.), occasionally brought to the Fish Market at Aberdeen. Specimens have also been sent to me by Mr. Duthie, the fishery officer at Girvan, which he had obtained on topers captured in Clyde waters and landed there. The parasites were most frequently found adhering to the skin beneath and between the ventral fins of male fishes; it appeared to be less frequent on females. *Lernæopoda galei* has also been obtained on a male specimen of the lesser spotted dog-fish, *Scyllium canicula,* caught in the Firth of Clyde, and on a specimen of the same kind of dog-fish sent from the Moray Firth. This Moray Firth specimen was also a male.

In this species of *Lernæopoda* the arms are only moderately elongated; the body becomes gradually dilated posteriorly, and is truncate at the end. The abdomen is almost obsolete, and is situated between two distinct though short and slender processes which spring from the end of the genital segment.

The antennules, antennæ, and mouth-organs are somewhat similar to those of *Lernæopoda elongata.* The specimen represented by the drawing is about 13mm. in length from the forehead to the end of the posterior appendages, and exclusive of the ovisacs and the second maxillipedes. In another specimen, which measured about 14mm., the ovisacs measured fully 9mm., and the posterior appendages about 3mm.

Lernæopoda bidiscalis, W. F. de Vismes Kane.

1892. *Lernæopoda bidiscalis,* W. F. de V. Kane, Proc. Roy. Irish Acad. (3), vol. ii., p. 203, Pls. IX. and X.

The species described under this name has hitherto been observed only on the male of the tope, *Galeus canis.* It is found adhering to the ends of the claspers, and the place where the parasites are attached is almost invariably found to be torn and bleeding. The describer of the species draws attention to this circumstance. I have found it to be almost invariably the case with topers landed at the Fish Market at Aberdeen, and Mr. Duthie, fishery officer at Girvan, finds that male topers caught in the Clyde and landed at that place have also the ends of the claspers torn and bleeding where these parasites were adhering. Whether these wounds are caused directly by the parasites or are produced by the efforts made by the sharks to shake off their tormentors is a question that does not yet appear to have received a satisfactory answer. Usually one, but sometimes two, parasites are found adhering to the same clasper, and on a few occasions we have found two parasites on each of the two claspers of the same fish. The fishes from which the parasites were obtained were chiefly adult males with well-developed claspers; we have rarely observed this *Lernæopod* adhering to the claspers of young males.

The specimens of *Lernæopoda bidiscalis* observed by us had for the most part the anterior portion of the head of a bright red or orange colour, and frequently the male was found adhering to the female.

Tope (or topers) are occasionally brought to the Aberdeen Fish Market by the steam trawlers, and it is from the fishes landed there that I have obtained most of my specimens of this parasite. Mr. Duthie has recently, however, sent me specimens of the parasite obtained on male topers captured in the seaward portion of the Clyde and landed at that port. The discovery of this species by Mr. Duthie makes an interesting addition to the Clyde Copepod-fauna.

One of the more obvious characters by which the species may be distinguished is that of the comparatively large roundish disks which terminate the short second pair of maxillipedes. The whole animal is short and robust—very different in appearance from the more elegant *Lernæopoda galei.*

One of the most typical female specimens obtained by us gave the following measurements:—From forehead to end of thorax, 5·5mm.; from forehead to end of posterior thoracic appendages, 7mm.; from forehead to end of ovisacs, 13mm.; greatest width of thorax, almost 4mm.

The male of *Lernæopoda bidiscalis* has a general resemblance to that of *Lernæopoda galei*, but the maxillipedes and other mouth-organs, and the antennal appendages, differ somewhat in structure from those of that species.

Lernæopoda salmonea (Gisler), (Pl. VIII., fig. 26.)

1751. *Pediculus salmonis*, Gisler, K. S. Vet. Ak. Handl., vol. xii., p. 171, Pl. VIII., figs. 1–5.
1761. *Lernæopoda salmonea*, Linn., Faun. Suec. (2nd edition), p. 509, No. 2102.
1850. *Lernæopoda salmonea*, Baird, op. cit., p. 335, Pl. XXXV., fig. 6.

This species was obtained on the gills of a diseased salmon, *Salmo salar*, caught in the Firth of Tay in January 1891, and also on the gills of a trout sent to the Fishery Board's laboratory from a loch in Sutherlandshire. *Lernæopoda salmonea* is a smaller species than any of the others already mentioned; the specimen represented by the figure measured only about 6mm.

In this species the arms are short and moderately stout. The cephalothorax seen from above is sub-triangular, while the posterior portion of the thorax assumes a sub-clavate form by gradually increasing in width towards the distal extremity. The posterior thoracic processes and the abdomen are very minute (fig. 26).

Lernæopoda cluthæ, sp. n. (Pl. VIII., figs. 27–37.)

The cephalothorax in this species is small and sub-triangular. A distinct and comparatively narrow neck connects the cephalothorax with the posterior portion of the body; this posterior portion is somewhat dilated and sub-cylindrical, and, in spirit specimens, shows a few pseudo-constrictions. Two short processes spring from the posterior end of the genital segment, and the abdomen, which is situated between these processes, is very small. The thoracic arms (second maxillipedes) are slender and of moderate length.

The antennules and antennæ are somewhat similar to those of species already recorded (figs. 30, 31). The mandibles are small, and their biting margins are finely and somewhat irregularly serrated, and in this respect they differ very markedly from the same appendages in *Lernæo-*

poda galei. The maxillæ (fig. 32) are small, and have the end-joint armed with two moderately elongate and stout terminal spines. The anterior foot-jaws (first maxillipedes, fig. 33) are more slender and rather more elongate than those of *Lernæopoda galei* (fig. 34).

The male of *Lernæopoda cluthæ* differs considerably from that of *Lernæopoda galei*, or *Lernæopoda bidiscalis*, and especially so in the structure of the abdomen and caudal appendages. In the male of *Lernæopoda cluthæ* the abdomen is distinctly segmented, and the caudal furca consists of two slender processes, while in the two other species named the furca assumes the form of broadly oval, or club-shaped, appendages, divergent and reflexed upon the abdomen (fig. 37).

The female specimen represented by fig. 28 measures, from the front of the head to the end of the posterior thoracic appendages, 5mm., and from the termination of the same thoracic appendages to the extremity of the elongated second maxillipedes about 8mm. The posterior thoracic appendages are scarcely 1mm. long, and the length of the ovisacs, which varies considerably in different specimens, is scarcely 4mm., in the one represented by the figure.

Habitat.—Attached to the gill-filaments of the Fuller's Ray, *Raia fullonica*, captured in the Firth of Clyde in April 1897.

This *Lernæopod* is quite distinct from any of the other species recorded here. The form of the female; the form and armature of its mandibles, maxillæ, and first maxillipedes, and the general structure of the male, all differ from any other species of *Lernæopod* known to me.

Besides the species of *Lernæopoda* recorded in the preceding notes, there are other two forms which for the present will have to stand over, as there has not been time to study their characters sufficiently to allow of their being included in the present paper. One of these forms was obtained on the gill-filaments of the grey slate, *Raia batis*; the other was obtained on the gill-filaments of the cuckoo ray, *Raia circularis*, both from the Firth of Clyde.

Genus *Brachiella*, Cuvier.

This genus differs from *Lernæopoda* in having the cephalo-thorax more or less elongated and moderately slender. The arms (second maxillipedes), are, as in *Lernæopoda*, usually separate except at the ends where they are united to a hard horny button, which serves to anchor the parasite to its host. In some of the species at least there are two pairs of caudal appendages.

The following are the species of *Brachiella* that have come under my observation:—

Brachiella rostrata, Kröyer. (Pl. VIII., figs. 38–39.)

1837. *Brachiella rostrata*, Kr., Naturh. Tidsskr., R. i., vol. i., p. 207, Pl. II., fig. 1.

1864. *Brachiella rostrata*, Kr., op. cit., R. iii., vol. 2, p. 364, Pl. XVII., fig. 8.

A number of specimens of this fine species have been obtained on the gills of large halibut, *Hippoglossus vulgaris*, brought to the Fish Market at Aberdeen. In the female of *Brachiella rostrata*, the mouth-organs have a close resemblance to those of *Lernæopoda*. The mandibles and maxillæ of this species are somewhat similar to those of *Brachiella insidiosa*. The antennæ, which are moderately stout, do not show much structural development, and the anterior maxillipedes though short have moderately strong terminal claws.

The female specimen represented by the drawing (fig. 38) is fully 17mm. in length from the head to the end of the posterior thoracic appendages. The male of this species, one of which is represented by fig. 39, measures about 2mm. in length.

Brachiella insidiosa, Heller. (Pl. VIII., figs. 40 and 41.)

1865. *Brachiella insidiosa*, Heller, Reise der Novara, p. 239, Pl. XXIV., fig. 1.
1896. *Brachiella insidiosa*, Basset-Smith, Ann. and Mag. Nat. Hist. (6), vol. xviii., p. 14, Pl. VI., fig. 2.

This is a moderately robust species, the cephalothorax is short, and so are the second maxillipedes. There are two pairs of posterior appendages to the thorax in this species; those at the posterior angles are elongated and slender, and the intermediate ones are short (fig. 40). The female specimen represented by fig. 40 measured about 12·5mm.; the male (fig. 41) is somewhat like the male of *Brachiella rostrata*.

The mandibles in the female of *Brachiella insidiosa* are more powerfully armed than those of *B. rostrata*; but the maxillæ are rather smaller.

Habitat.—On the gills of hake, *Merluccius vulgaris*, captured in the Firths of Forth and Clyde, and on hake brought to the Fish Market at Aberdeen.

Brachiella merluccii, Basset-Smith. (Pl. VIII., fig. 42.)

1896. *Brachiella merluccii*, Basset-Smith, op. cit. (6), vol. xviii., p. 14, Pl. VI., fig. 1.

From Dr. Basset-Smith's description of this species, which contains all that is of special note concerning it, I extract the following reference to the general appearance of the female:—"Cephalothorax of moderate length, about equal to that of the genital segment, tapering towards the head and bent forward in an obtuse angle. Head slightly widest in front, the arms (second maxillipedes) not quite so long as the cephalothorax, being united in the whole length by a thin membrane. Organ of attachment, a chitinous cup with a short pedicle."

"Genital segment fiddle-shaped, very thick, carrying posteriorly two pairs of elongated processes; a dorsal pair directed backwards and outwards and a vertical pair rising on either side of a filiform abdomen (post-abdomen, Gerst.), these being directed backwards, outwards, and upwards, encircling the ovisacs."

In a concluding note Dr. Basset-Smith directs attention to the peculiar position which this species occupies in the genus *Brachiella*. According to the present classification this species, he says, should be placed with *Anchorella*, for in the female the second maxillipedes are short and are also united in their whole length, but the peculiar *Brachiella*-form of the male causes it to be placed in this genus.

From the peculiar habit of the animal it is somewhat difficult to get a specimen into a good position for drawing. Figure 42 gives a side view of a specimen measuring about 8·5mm. in length. The antennal appendages and mouth-organs agree in general structure with other species of *Brachiella*.

A certain amount of variation is observable between different specimens, but the general configuration of the animal, its short arms, and the number and position of the posterior appendages, are all so characteristic of the species that there need be little difficulty in identifying it.

I have obtained specimens of this *Brachiella* on hake captured in the

Firth of Clyde by the "Garland," and also on large hake brought to the Fish Market at Aberdeen. *Brachiella merluccii* is usually found attached to the gill-rakers of the hake, and chiefly on the larger specimens of the fish.

Genus *Anchorella*, Cuvier (1817).

In this genus the arm-shaped appendages are very short, and they are united to each other from the base so as to resemble a single organ (Baird).

Anchorella emarginata, Kröyer. (Pl. VIII., figs. 49–51.)

1837. *Anchorella emarginata*, Kr., Naturh. Tidsskr., R. i., vol. i., p. 287, Pl. III., fig. 7.

A specimen of *Anchorella* which appears to belong to *Anchorella emarginata*, Kr., was obtained on the gills of a twaite shad (*Clupea finta*) captured near Dunbar, at the mouth of the Firth of Forth, in February 1897. This form, though small, readily attracted one's attention because of its extremely long and slender cephalothorax when compared with the robust form of the body and ovisacs (fig. 49).

The antennules in this species are of moderate length and apparently three-jointed. The mandibles are very small and armed with a few teeth (fig. 51). The maxillæ are rather larger than the mandibles, and are provided with three apical spines; the secondary branches of the maxillæ are very small (fig. 50). The first maxillipedes are small and moderately strong; the terminal claws are small. Dr. Basset-Smith states that in this species the second maxillipedes are not completely united at their bases; this is shown to be the case in our specimen also. In this particular, *Anchorella emarginata* does not altogether agree with the characters of the genus, and seems to form a connecting link between that genus and *Brachiella*. On the other hand, *Brachiella merluccii*, as has been shown, partakes also of the characters of the same two genera, though apparently more closely allied to the genus to which it has been ascribed. It will be observed, further, that in this specimen now under consideration the cephalothorax springs apparently from near the middle of the genital segment and becomes somewhat attenuated towards the end; also that the abdomen is so minute that it is not shown in my drawing (fig. 49). This drawing represents a side view of the specimen, and the projection of the posterio-lateral lobe on the side next the observer prevents the abdomen from being seen.

The specimen, of which the figure is a representation, measures, exclusive of the elongated cephalothorax and of the ovisacs, scarcely two and a half millimeters in length.

Anchorella (?) *rugosa*, Kröyer. (Pl. VIII., figs. 45–48.)

1837. *Anchorella rugosa*, Kr., Naturh. Tidsskr., R. i., vol. i., p. 294, Pl. III., fig. 6.

1850. *Anchorella rugosa*, Baird, op. cit., p. 338, Pl. XXXV., fig. 8.

The *Anchorella* which I ascribe to Kröyer's *A. rugosa* was obtained on the gills and gill-covers of the cat-fish, *Anarrhichas lupus*, Linn., where it is sometimes not very rare. I find also on the cod-fish what appears to be the same species of *Anchorella*. It is evident, however, that these organisms, so far as the British species are concerned, require a more careful study than they have yet received.

Anchorella rugosa differs very distinctly from the last, especially by the structure of the second maxillipedes. In this species these appendages are much more atrophied, being reduced to little more than a small button-like projection at the anterior end of the robust genital segment. The cephalothorax is not so elongated as in the form just described; it is also proportionally stouter and more rugose. The genital segment is considerably dilated, and, when looked at from above, or below, has a nearly square outline, the two sides being slightly emarginate or constricted. The ovisacs are stout and of moderate length.

The antennules and mandibles (fig. 47) are somewhat similar to those of *Anchorella emarginata* but larger. The maxillæ are distinctly larger, besides being somewhat different in structure; moreover, the anterior maxillipedes are considerably stouter than the same organs of that species.

The male is greatly dilated on the dorsal aspect (fig. 46), and measures only about a millimetre in length. The anterior and posterior foot-jaws are stout, and armed with short but strong terminal claws.

I have obtained *Anchorella rugosa* on *Anarrchichas lupus* in the Firth of Forth and the Firth of Clyde, and also on the same species of fish brought to the Aberdeen Fish Market.

It seems to me that *Anchorella rugosa*, Kr., is quite distinct from *Anchorella emarginata*, Kr., as shown by that author's descriptions of the two forms. As these descriptions are short, it may be of interest to give them in the author's own words, which are as follow :—

Abdomine nullo vel indistincto.
Anchorella emarginata, Kr.

"Caput mediocre vel parvum, a collo bene distinctum ; collum gracile, longissimum; brachia gracilia, brevissima, bulla simplice; annulus genitalis dilatatus (latior fere quam longior), obcordatus, postice medio sinum præbens rotundatum."

Anchorella rugosa, Kr.

"Caput latum complanatum, a collo bene distinctum; collum elongatum sed crassus, valde rugosum ; brachia fere rudimentaria, quasi in discum dilatata, bulla minuta, simplice ; annulus genitalis latior quam longior, sub-quadratus, postice late truncatus, supra infraque rugis sulcisque insignitus."

Dr. Baird's description of *Anchorella rugosa*, Kr., agrees with that of Kröyer, but the figure of the species seems to represent some other form. Kröyer in his remarks on the genus also refers to this difference in Dr. Baird's figure.* This want of agreement is probably due to some misunderstanding on the part of the artist.

Anchorella rugosa, var. (Pl. VIII., fig. 52.)

The specimen represented by figure 52, though it agrees very closely with that from the *Anarrchichas*, differs somewhat in the structure and armature of the mandibles and maxillæ ; the antennules also are slightly different, and will require further study. This form has been obtained on the haddock (*Gadus æglefinus*).

Anchorella uncinata, Müller. (Pl. VIII., figs. 43 and 44.)

1776. *Lernæa uncinata*, Muller, Zool. Dan., vol. i., Pl. XXXIII., fig. 2.

1850. *Anchorella uncinata*, Baird, op. cit., p. 337, Pl. XXXV., fig. 9.

Specimens of what I take to be this species are not uncommon on

* Naturh. Tidsskr., R. III., B. ii., p. 366 (1864).

species of *Gadus*, such, for example, as *Gadus merlangus*, captured in the Clyde and other parts of the Scottish coasts.

In this species (which belongs to Kröyer's division B) the abdomen is quite distinct, and is in the form of a prominent roundish knob. The cephalothorax, though nearly of the same length, is scarcely so stout as in *Anchorella rugosa*, but the second maxillipedes are more produced (fig. 43). The genital segment is moderately elongate and ovate. The female represented by the drawing measures about seven millimetres in length, exclusive of the cephalothorax and ovisacs.

The male, which is very small, has a general resemblance to the male of *Anchorella rugosa* (fig. 44).

The female antennules are moderately stout, and apparently three-jointed. The maxillæ are small, somewhat dilated towards the distal end, and provided with two terminal spines. The first maxillipedes are also small, they are each armed with a short terminal claw.

Anchorella stellata, Kröyer.

1838–39. *Anchorella stellata*, Kr., Naturh. Tidsskrift, R. i., vol. ii., p. 142, Pl. III., fig. 5.

1864. *Anchorella stellata*, Kr., op. cit., R. iii., vol. ii., p. 383.

This species of *Anchorella* was obtained on some specimens of hake, *Merluccius vulgaris*, forwarded from the Clyde to the Laboratory at Bay of Nigg. The fishes were captured by the "Garland" in Kilbrennan Sound on December 18th, 1899.

In *Anchorella stellata* the cephalothorax is moderately long and slender, and has the appearance of being continuous with, and but a prolongation of, the united second maxillipedes—the head being at one end of the prolongation and the chitinous plug, which terminates the maxillipedes, at the other; the length of this portion of the animal measures on an average about 6mm. The genital segment is ovoid in shape and measures about 4mm. in length by fully 2mm. in thickness. When the animal is alive or only recently dead this segment has the appearance of a pellucid and almost transparent bag, so that the creature is liable to be passed over under the belief that it is only a small roundish mass of mucus; in spirit the genital segment assumes a whitish appearance.

The membranous tissue surrounding the second pair of maxillipedes, and binding them together, is nearly transparent, and the maxillipedes could be easily seen side by side within their investment; it could also be observed that each maxilliped terminated in two or three minute roundish lobes, which together were arranged in a semi-circular manner round the inferior aspect of the apices of the maxillipedes, while from between the apices on the upper side proceeded the small chitinous process by which the creature attached itself to the fish. Moreover, in each of the specimens of this *Anchorella* that was examined, the chitinous process was observed to be adherent to the basal part of a scale, but the process did not penetrate through the scale, but spread out into a sucker-like disk between its outer and inner surfaces; and this sucker-like disk when closely examined exhibited a series of clear oval markings, which were arranged at regular intervals, and in a stellate manner, just within the circumference of the disk. The markings, which could be easily seen with a hand-lens, did not extend to the margin as shown in Kröyer's figure, but a small portion of the margin formed a continuous rim round the periphery of the disk; it is from this stellar arrangement of the pellucid markings that the specific name is derived.

The abdomen is scarcely developed in this species; it appears as a very slightly produced middle portion of the posterior end of the genital segment, while on each side of it is a minute tubercle representing the posterio-lateral processes so characteristic of species of *Chondracanthus* and *Brachiella.*

The specimens of *Anchorella stellata* which I have observed were found adhering to the scales near the bases of the pectoral and ventral fins, especially those of the pectorals, of the hake. It is interesting to note that Kröyer found his specimens of this *Anchorella* also on the same species of fish.

In concluding for the present these notes on the copepod parasites of fishes, I may mention one point which has been of some interest to me in the course of my study of the structural details of the various species I have had the privilege to examine. A cursory glance over the plates of figures which accompany these notes shows that almost all the species that have been recorded arrange themselves naturally into three distinct groups by the structure of their mandibles. In the group to which *Caligus* and *Lepeophtheirus* belong the mandibles are for the most part long and slender; their apex has usually a slight inward curve, and the inner edge of this curved portion is minutely serrated; the mandibles in this group are also usually composed of several more or less distinct joints.

In the second group represented by *Chondracanthus* the mandibles are large and falciform—somewhat like a broad-bladed scimitar—with one edge, and sometimes with both edges, fringed with setæ or teeth.

In the third group represented by *Brachiella* and *Lernæpoda* the mandibles assume a cleaver-like form, and the anterior third part, more or less, of the inner margin is nearly straight and armed with teeth usually coarse, and sometimes irregular in shape. Other peculiarities of structure—as for example, that of the antennules, characteristic of certain groups—may also be observed by anyone who cares to devote a little time to the study of these interesting organisms.

I will now proceed to notice briefly a few crustacean parasites of fishes belonging to some of the groups that have come under my observation, and my notes will, as in the preceding part of this paper, refer principally to Scottish species.

(1) Branchiura.

Argulus foliaceus, Linn.

A few years ago this curious little entomostracan was found to be very common on the greyling, *Thymallus vulgaris*, in the upper waters of the Clyde. So much were these fishes infested by the little parasites that they were blamed for being the cause of the unhealthy appearance which these fishes at this time had assumed. A friend secured a number of the parasites and sent them to me, and promised to try and obtain some more. It happened, however, that within the next few days a heavy rain set in and flooded the river, and he was thus prevented from securing other specimens; and when the weather moderated he found that the *Argulus* had all disappeared, and that the fish had assumed a more healthy appearance.

Argulus foliaceus has also been taken on the three-spined stickleback, *Gasterosteus aculeatus*, in the Union Canal near Edinburgh, by Miss Janet Carphin, who kindly presented me with a few specimens.

Several species of *Argulus* have been described by Continental writers on parasitic crustacea, but *A. foliaceus* is the only one I know of as occurring in Scottish waters.

(2) Isopoda Parasita.

Several species of the parasitic Isopods of fishes have been observed, of which the following may be referred to :—

Gnathia maxillaris (Mont.).

Specimens of *Gnathia*, which I consider to belong to this species, have been found adhering to the gills of the common gurnard, *Trigla gurnardus*, and of the lemon sole, *Pleuronectes microcephalus*, sent by the "Garland" from the Clyde to the Laboratory at Bay of Nigg. Females only of the *Gnathia* were observed, and in each case the Isopod was attached to the gills, under the gill-covers.

Æga strömii, Lütken.

A specimen of this Isopod was presented to me by one of the men on board a beam-trawl fishing boat belonging to Granton. The crustacean was found adhering to a large cod captured in the North Sea a considerable distance south-eastward of May Island.

Æga tridens, Leach.

A specimen of this species was brought to me by a Rothesay fisherman, who obtained it on a cod he had captured on his fishing lines in Rothesay Bay. One was obtained on a torsk in Aberdeen Fish Market on 15th September 1899.

Æga monophthalma (Johnston).

A fine specimen from a large cod captured by one of the Shetland fishing boats was handed to me for examination; it undoubtedly belonged to the species named, as described and figured in Prof. G. O. Sars' Crustacea of Norway, vol. ii.

I have had an opportunity of examining another fine species of *Æga*, viz., *Æga psora*. The species is included in the British fauna, but the specimens I saw were obtained on cod captured in Icelandic waters.

Cirolana borealis, Lilljeborg.

This Isopod is not very rare in the deeper parts of the Clyde, as, for example, to the east of Arran, in Kilbrennan Sound, and Loch Fyne, but I have never happened to find it there as a parasite. It has, however, been found adhering to several of the fishes brought to the Fish Market at Aberdeen, and on one or two occasions it was observed to be moderately frequent. I have notes of its occurrence on the following fishes:—The grey skate, *Raia batis*; the saithe, *Gadus virens*; the torsk, *Brosmius brosme*; and the conger, *Conger vulgaris*. The *Cirolana* were observed on the saithe in June, and on the conger in October, and on the other two species of fishes during the intervening months.

(3) Amphipoda Parasita.

There are only two Amphipods to which I wish to refer, viz. :—

Callisoma crenata, Spence Bate.

So far as I have been able to study the habits of this Amphipod, it seems to be a species whose energies are devoted for the most part to the removal of dead and decaying animal matter, rather than the destruction of living tissue. It would seem, however, that it does not confine its operations to decaying animal matter, but is ready to attack living organisms should there be a favourable opportunity for doing so. In October last, when examining some specimens of *Galeus canis* in the Fish Market at Aberdeen, which had just been landed from one of the trawlers, a large male was observed to be infested with small amphipods. These amphipods belonged to the species named above—*Callisoma crenata.* It was found, on the cioser examination of the fish, that the amphipods had penetrated the skin at the base of and immediately behind the claspers, and were burrowing in crowds in the hole they had formed. The skin and flesh of the fish appeared to be much injured by the parasites. Specimens of the same kind of fish were on one or two subsequent occasions observed to be similarly infested with the *Callisoma.*

Laphistius sturionis, Kröyer.

This Amphipod has been observed adhering to the cod, and also to the back of the angler, *Lophius piscatorius,* but only on the surface of the skin, and not, like *Callisoma,* burrowing in the flesh of the fish. *Laphistius* has been obtained as a parasite in the Firth of Forth and in the Firth of Clyde.

The following list contains the names of fishes on which the crustaceans, recorded in the preceding notes, were found :—

List of Fishes on which Copepod-Parasites have been Found.

Scientific names.	Common names.
Trigla lineata, Gmelin.	The Streaked Gurnard.
Trigla cuculus, Linn.	The Red Gurnard.
Trigla lucerna, Linn.	The Sapphirine Gurnard.
Trigla gurnardus, Linn.	The Grey Gurnard.
Agonns cataphractus, Linn.	The Pogge.
Zeus faber, Linn.	The John Dory.
Lophius piscatorius, Linn.	The Angler.
Gobius minutus, Gmelin.	The Spotted Goby.
Callionymus maculatus (Bonap.).	The Spotted Dragonet.
Cyclopterus lumpus, Linn.	The Lump-Sucker or Cockpaidle.
Anarrhichas lupus, Linn.	The Cat, or Wolf-fish.
Gasterosteus aculeatus, Linn.	The Three-spined Stickleback.
Gasterosteus spinachia, Linn.	The Fifteen-spined Stickleback.
Gadus callarius, Linn.	The Cod.
Gadus æglefinus, Linn.	The Haddock.
Gadus minutus, Linn.	The Poor or Power-cod.
Gadus merlangus, Linn.	The Whiting.
Gadus virens, Linn.	The Cod-fish or Saithe.
Gadus pollachius, Linn.	The Pollack or Lythe.
Merluccius vulgaris, Cuv.	The Hake.
Molua molva, Linn.	The Ling.
Onos (Motella) cimbrius, Linn.	The Four-bearded Rockling.
Brosmius brosme, Cuv.	The Torsk or Tusk.
Hippoglossus vulgaris (Flem.).	The Halibut.
Drepanopsetta platessoides.	The Long-Rough Dab.
Bothus (Rhombus) maximus, Linn.	The Turbot.
Bothus rhombus, Linn.	The Brill.
Pleuronectes platessa, Linn.	The Plaice.
Pleuronectes microcephalus, Don.	The Lemon Dab. Lemon Sole.
Pleuronectes cynoglossus, Linn.	The Pole Dab. Witch Sole.
Pleuronectes limanda, Linn.	The Common Dab.

List of Fishes on which Parasites have been Found—*continued.*

Scientific names.	Common names.
Pleuronectes flesus, Linn.	The Flounder.
Solea vulgaris, Quen.	The Sole. Black Sole.
Salmo salar, Linn.	The Salmon.
Salmo trutta (Flem.).	The Sea-trout.
Clupea sprattus, Linn.	The Sprat.
Clupea finta, Linn.	The Twaite Shad.
Conger vulgaris, Cuv.	The Conger.
Orthagoriscus mola, Linn.	The Short Sun-fish.
Galeus canis, Linn.	The Tope, or Toper.
Lamna cornubica, Cuv.	The Porbeagle Shark.
Scyllium canicula, Linn.	The Lesser-spotted Dog-fish.
Raia batis, Linn.	The Skate. Grey or Blue Skate.
Raia clavata, Linn.	The Thorny. Thornback Skate.
Raia oxyrhynchus, Linn.	The Long-nosed Skate.
Raia fullonica, Linn.	The Shagreen Ray, Fuller's Ray.
Raia circularis, Couch.	The Cuckoo Ray, Sandy Ray.

The number of fishes in this list is forty-seven. The majority of them have yielded one or two kinds of parasites only, while on a few as many as four and five different species have been obtained. The grey skate has yielded the largest number of parasites of any of the fishes examined, six different kinds having been found on specimens of this species. They comprise *Caligus curtus*, *Trebius caudatus*, *Chondracanthus annulatus*, *Charopinus dalmannii*, *Lernæopoda* sp., and *Cirolana borealis*. The saithe and the torsk come next with five species each. The hake and the toper have yielded four, while three each have been obtained on the common gurnard, the halibut, the turbot, the plaice, the conger, and the sun-fish. Eleven fishes have yielded two, and twenty-six only one species of parasite each.

Concluding Remarks.

The study of the distribution of these organisms is still being continued, and their habits and development will also form subjects of research as opportunities occur. It is probable that there is scarcely a fish within the Scottish seas, as there doubtless is in other seas, which does not at one time or other during its life harbour one or more crustacean parasites, and this itself furnishes a sufficient reason for the study of these creatures, and in this study more than one interesting problem is still awaiting solution. For example, we find, on the one hand, a species such as *Caligus curtus*, which seems to have no limit to the number of fishes from which to choose an associate for itself; on the other hand, we see a crustacean, such as *Lernæopoda bidiscalis*, which appears to be limited not only to a particular kind of fish, but also to a particular part of that fish. The interest in the difference between these two forms is increased when it is remembered that both in their early stages of life are free-swimming, and that they live in a medium which is favourable to their dispersal over a wide area; moreover, there are fishes of various kinds passing from time to time within easy reach of both during their free-swimming stages. How comes it, then, that in the one case the limit of existence in the adult is so greatly circumscribed, whilst there is almost unlimited scope in the other?

There is, of course, a possible explanation which might to a certain extent account for the difference I have alluded to, and that is that the difference is the product of the *habitat*; in other words, that the animals were practically the same species, and that the differences observed in their form and structure were simply the result of the difference in the mode of life they had happened to adopt. One might, in support of such an explanation, point to the close resemblance to each other of the young of the so-called different species—a resemblance so close that at this early stage it is difficult even for an expert to decide in some cases which belongs to one species and which to the other.

It must also be admitted that in the adult forms of certain species modifications are observed which have a provoking tendency to bridge over the space that intervenes between one species and another, and which are exceedingly troublesome to the systematist.

Notwithstanding all this, however, the explanation I have referred to can scarcely be considered tenable, except to a very small extent. There are too many difficulties in the way of accepting such an explanation; but it shows that even in a limited subject like that of the parasites of fishes there is still work for the theorist as well as for the student who simply deals with the practical aspect of the study.

DESCRIPTION OF THE PLATES.

PLATE V.

Thersites gasterostei, Pagen.

Fig. 1. Female, dorsal view . . . . × 40.
Fig. 2. Antennule . . . . × 380.
Fig. 3. Antenna . . . . × 253.
Fig. 4. Posterior foot-jaw . . . . × 833.
Fig. 5. Foot of first pair . . . . × 253.
Fig. 6. ,, fourth ,, ... × 253.
Fig. 7. Abdomen, dorsal view . . . . × 127.

Caligus curtus, Müll.

Fig. 8. Female, dorsal view . . . . × 48.
Fig. 9. Antenna . . . . × 53.
Fig. 10. Sternal fork . . . . × 53.
Fig. 11. Second foot-jaw . . . . × 40.
Fig. 12. Foot of fourth pair . . . . × 18.

Caligus rapax, M.-Edw.

Fig. 13. Female, dorsal view. . . . . . . × 7.
Fig. 14. Male ,, ... × 7.
Fig. 15. Mandible . . . . × 166.
Fig. 16. One of the *palpi*—male . . . . × 96.
Fig. 17. Sternal fork . . . . × 80.
Fig. 18. Posterior foot-jaw . . . . × 40.
Fig. 19. Foot of fourth pair . . . . × 40.

Caligus diaphanus, Nordm.

Fig. 20. Female, dorsal view . . . . × 11·4.
Fig. 21. Male ,, ... × 19.
Fig. 22. Mandible . . . . × 253.
Fig. 23. Sternal fork . . . . × 160.
Fig. 24. Posterior foot-jaw . . . . × 80.
Fig. 25. Foot of fourth pair . . . . × 80.

Lepeophtheirus pectoralis, Müll.

Fig. 26.	Female, dorsal view,	× 7·5.
Fig. 27.	Male ,,	× 16.
Fig. 28.	Mandible	× 253.
Fig. 29.	Sternal fork	× 80.
Fig. 30.	Posterior foot-jaw	× 53.
Fig. 31.	Foot of fourth pair	× 80.

Lepeophtheirus nordmanni (M.-Edw).

Fig. 32.	Female, dorsal view	× 33.
Fig. 33.	Antenna	× 20.
Fig. 34.	Mandible	× 20.
Fig. 35.	Sternal fork	× 20.
Fig. 36.	Posterior foot-jaw	× 20.
Fig. 37.	Foot of fourth pair	× 20.

Lepeophtheirus hippoglossi (Kr.).

Fig. 38.	Female, dorsal view	× 3·7.
Fig. 39.	Male ,,	× 5.
Fig. 40.	Mandible	× 88.
Fig. 41.	Foot of fourth pair	× 9.
Fig. 42.	Foot of fifth pair	× 190.

Lepeophtheirus thompsoni, Baird.

Fig. 43.	Female, dorsal view	× 6·5.
Fig. 44.	Sternal fork	× 80.
Fig. 45.	Antenna	× 53.

PLATE VI.

Lepeophtheirus hippoglossi (Kr.).

Fig. 1.	Posterior foot-jaw	× 26.
Fig. 2.	Sternal fork	× 40.

Lepeophtheirus stromi, Baird.

Fig. 3.	Female, dorsal view	× 4.
Fig. 4.	One of the *palpi*	× 80.
Fig. 5.	Sternal fork	× 53.
Fig. 6.	Foot of fourth pair	× 26.
Fig. 7.	Foot of fifth pair	× 190.
Fig. 8.	Newly-hatched specimen	× 53.

Lepeophtheirus pollachii, Basset-Smith.

Fig. 9.	Female, dorsal view	× 10.
Fig. 10.	Male, dorsal view	× 13.
Fig. 11.	Antenna	× 80.
Fig. 12.	Mandible	× 165.
Fig. 13.	Sternal fork	× 53.
Fig. 14.	Second foot-jaw, female	× 26.
Fig. 15.	Foot of fourth pair	× 26.

Lepeophtheirus (?) *obscurus*, Baird.

Fig. 16.	Female, dorsal view	× 10.
Fig. 17.	Antenna	× 80.
Fig. 18.	Sternal fork	Enlarged.
Fig. 19.	Foot of fourth pair	× 53.

Trebius caudatus, Kr.

Fig. 20.	Female, dorsal view	× 6·6.
Fig. 21.	Male ,,	× 11.
Fig. 22.	Antenna	× 40.
Fig. 23.	Sternal fork	× 80.
Fig. 24.	Mandible	× 103.
Fig. 25.	Posterior foot-jaw	× 40.
Fig. 26.	Foot of fourth pair	× 26.

Dinematura producta (Müll.).

Fig. 27.	Female, dorsal view	× 3·3.
Fig. 28.	Antenna	× 13.
Fig. 29.	Mandible	× 53.
Fig. 30.	Anterior foot-jaw	× 13.
Fig. 31.	Caudal furca	× 5.

Echthrogaleus coleoptratus, Guérin.

Fig. 32.	Female, dorsal view	× 6.

Pandarus bicolor, Leach.

Fig. 33.	Female, dorsal view	× 8.
Fig. 34.	Male (?) ,,	× 7·5.
Fig. 35.	Antenna, female	× 35.
Fig. 36.	,, male	× 35.
Fig. 37.	Foot of second pair, female	× 18.
Fig. 38.	,, ,, male	× 26.

Lemargus muricatus, Kr.

Fig. 39.	Female, dorsal view	× 3·3.
Fig. 40.	Mandible	× 53.
Fig. 41.	Anterior foot-jaw	× 13.
Fig. 42.	Posterior foot-jaw	× 12.

PLATE VII.

Clavella hippoglossi, Kr.

Fig. 1.	Female, dorsal view	× 10.
Fig. 2.	Antennule	× 95.
Fig. 3.	Antenna	× 40.
Fig. 4.	Mandible	× 500.
Fig. 5.	Posterior foot-jaw	× 84.
Fig. 6.	Foot of first pair	× 126.

Lernæenicus sprattæ (Sow.).

Fig. 7.	Parasite *in situ* on eye of sprat	Natural size.
Fig. 8.	Female, dorsal view	× $7\frac{1}{5}$.
Fig. 9.	Antennule	× 126.
Fig. 10.	Antenna	× 80.

Lernæa branchialis, Lin.

Fig. 11.	Female, dorsal view	× $1\frac{2}{5}$.
Fig. 12.	,, var.	× $1\frac{2}{5}$.

Lernæa minuta, n. sp.

Fig. 13.	Female, dorsal view	× 7.

Hæmobaphes cyclopterina (Fabr.)

Fig. 14.	Female, dorsal view	× 6.

Hæmobaphes ambiguus, n. sp.

Fig. 15.	Female, dorsal view	× 7.

Oralien asellinus (Linn.)

Fig. 16.	Female, dorsal view	× 4·8.
Fig. 17.	Antennule	× 152.
Fig. 18.	Mandible	× 152.

Chondracanthus cornutus (Müll.).

Fig. 19.	Female, dorsal view	× 4·8.
Fig. 20.	Antennule	× 27.
Fig. 21.	Antenna	× 40.
Fig. 22.	Mandible	× 84.
Fig. 23.	Anterior foot-jaw	× 126.
Fig. 24.	Male, dorsal view	× 53.
Fig. 25.	Foot of first pair	× 250.
Fig. 26.	Foot of second pair	× 250.
Fig. 27.	Female, dorsal view, var.	× 4·8.
Fig. 28.	Antennule	× 35.
Fig. 29.	Mandible	× 123.
Fig. 30.	Foot of second pair	× 760.
Fig. 31.	Foot of first pair	× 760.

Chondracanthus fluræ, Kr.

Fig. 32.	Female, dorsal view	× 6.
Fig. 33.	Antennule	× 35.
Fig. 34.	Mandible	× 84.

Chondracanthus clavatus, Basset-Smith.

Fig. 35.	Female, dorsal view	× 6·4.
Fig. 36.	Antennule	× 35.
Fig. 37.	Mandible	× 84.

Chondracanthus limandæ, Kr.

Fig. 38.	Female, dorsal view	× 12.
Fig. 39.	Antennule	× 80.
Fig. 40.	Mandible	× 250.

Chondracanthus soleæ, Kr.

Fig. 41.	Female, dorsal view	× 6·4.
Fig. 42.	Antennule	× 40.
Fig. 43.	Mandible	× 126.
Fig. 44.	Antennule, male	× 380.
Fig. 45.	Foot of second pair	× 380.

Chondracanthus annulatus, Olsson.

Fig. 46.	Female, dorsal view	× 4.
Fig. 47.	Male ,,	× 40.
Fig. 48.	Antennule, female	× 84.
Fig. 49.	Mandible ,,	× 126.
Fig. 50.	Antennule, male	× 380.
Fig. 51.	Antenna ,,	× 190.

PLATE VIII.

Chondracanthus zeus, De la Roche.

Fig. 1.	Female, dorsal view	× 3·7.

Thysanote impudica (Nordm.).

Fig. 2.	Female, dorsal view	× 9·6.
Fig. 3.	Mandible	× 250.
Fig. 4.	Maxilla	× 250.
Fig. 5.	Anterior foot-jaw	× 80.

Charopinus dalmanni (Retz.).

Fig. 6.	Female, dorsal view	× 1·3.
Fig. 7.	Male, side view	× 14.
Fig. 8.	Antenna	× 168.
Fig. 9.	Mandible	× 127.
Fig. 10.	Maxilla	× 127.

Lernæopoda elongata (Grant).

Fig. 11.	Female, dorsal view	× 4·7.
Fig. 12.	Antenna	× 53.
Fig. 13.	Mandible	× 80.
Fig. 14.	Maxilla	× 80.
Fig. 15.	Anterior foot-jaw	× 40.

Lernæopoda galei, Kr.

Fig. 16.	Female, side view	× 4.
Fig. 17.	Male, side view	× 16.
Fig. 18.	Antennule, female	× 126.
Fig. 19.	Antenna, ,,	× 20.
Fig. 20.	Mandible	× 126.
Fig. 21.	Maxilla	× 126.
Fig. 22.	Anterior foot-jaw, female	× 53.
Fig. 23.	Anterior foot-jaw, male	× 64.
Fig. 24.	Posterior foot-jaw, ,,	× 64.
Fig. 25.	Abdomen, ,,	× 26.

Lernæopoda salmonea (Gisler.).

Fig. 26.	Female, dorsal view	× 6.

Lernæopoda cluthæ, n. sp.

Fig. 27.	Female, side view	× 10.
Fig. 28.	,, dorsal view	× 7·5.
Fig. 29.	Male, side view	× 42.
Fig. 30.	Antennule, female	× 195.
Fig. 31.	Antenna	× 195.
Fig. 32.	Mandible	× 380.
Fig. 33.	Maxilla	× 380.
Fig. 34.	Anterior foot-jaw	× 80.
Fig. 35.	Anterior foot-jaw, male	× 95.
Fig. 36.	Posterior foot-jaw ,,	× 95.
Fig. 37.	Abdomen ,,	× 53.

Brachiella rostrata, Kr.

Fig. 38.	Female, dorsal view	× 4·7.
Fig. 39.	Male, side view	× 18.

Brachiella insidiosa, Heller.

Fig. 40.	Female, dorsal view	× 3·5.
Fig. 41.	Male, side view	× 9·6.

Brachiella merluccii, Bassett-Smith.

Fig. 42.	Female, side view	× 5·3.

Anchorella uncinata (Müll.).

Fig. 43. Female, side view . . . . . . × 3·8.
Fig. 44. Male, side view . . . . × 64.

Anchorella rugosa, Kr.

Fig. 45. Female, side view . . . . . . × 3·8.
Fig. 46. Male, side view. . . . . . . × 32.
Fig. 47. Mandible . . . . × 380.
Fig. 48. Maxilla . . . . × 190.

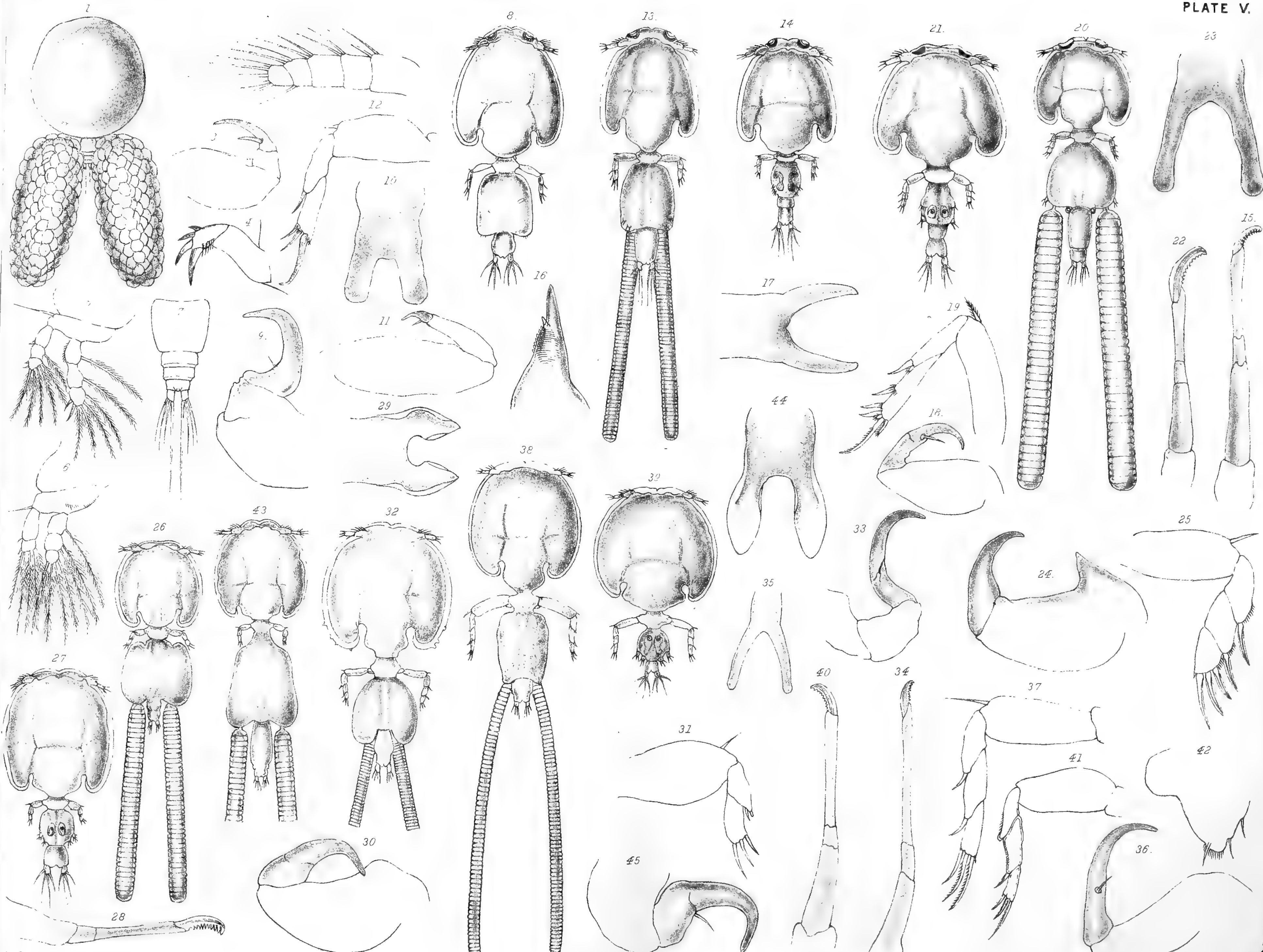
Anchorella emarginata, Kr.

Fig. 49. Female, side view . . . . . . × 11·4.
Fig. 50. Maxilla . . . . × 380.
Fig. 51. Mandible. . . . . × 380.

Anchorella (?) rugosa, var.

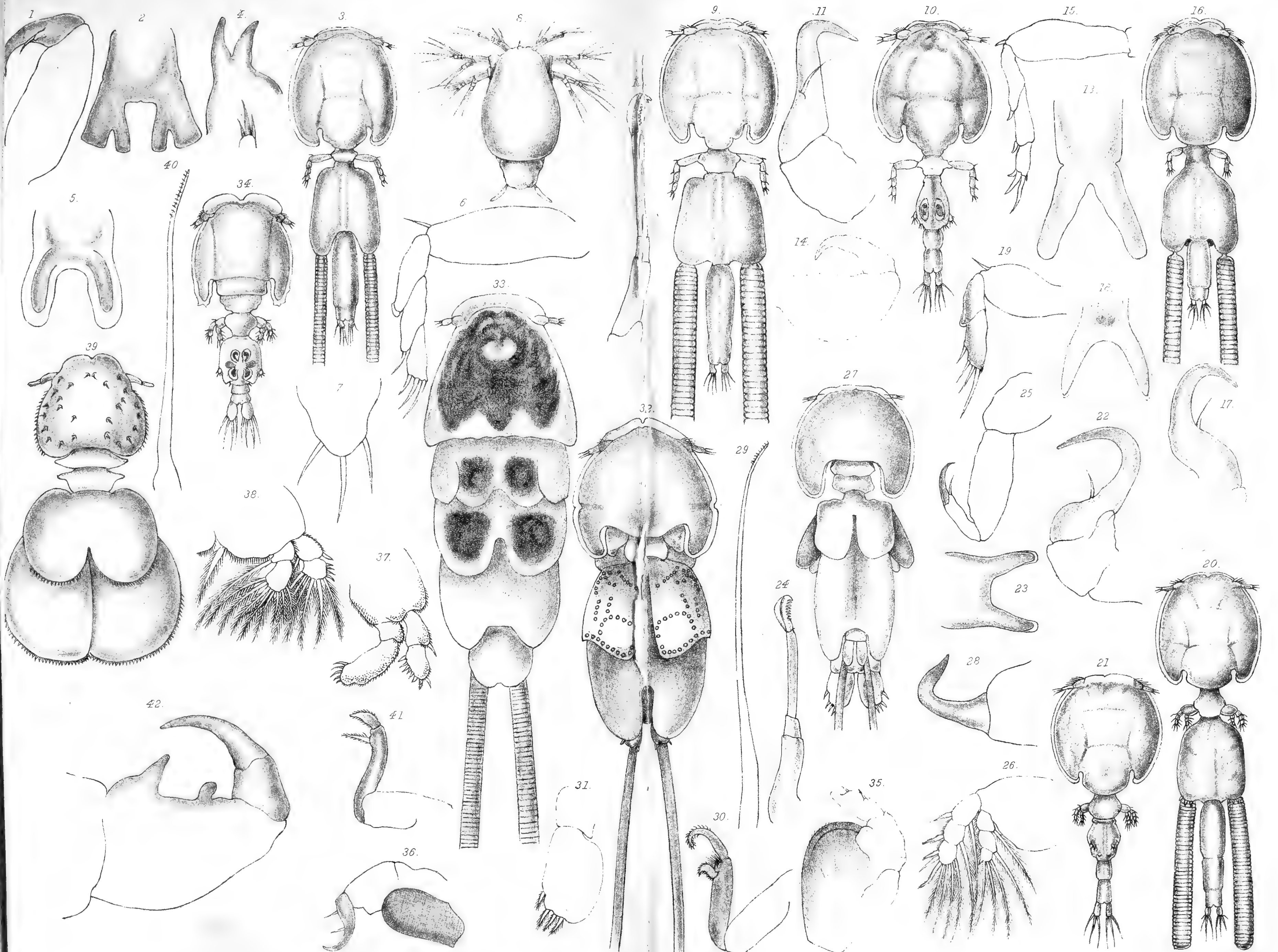
Fig. 52. Female, side view . . . . . . × 3·8.

PLATE V.



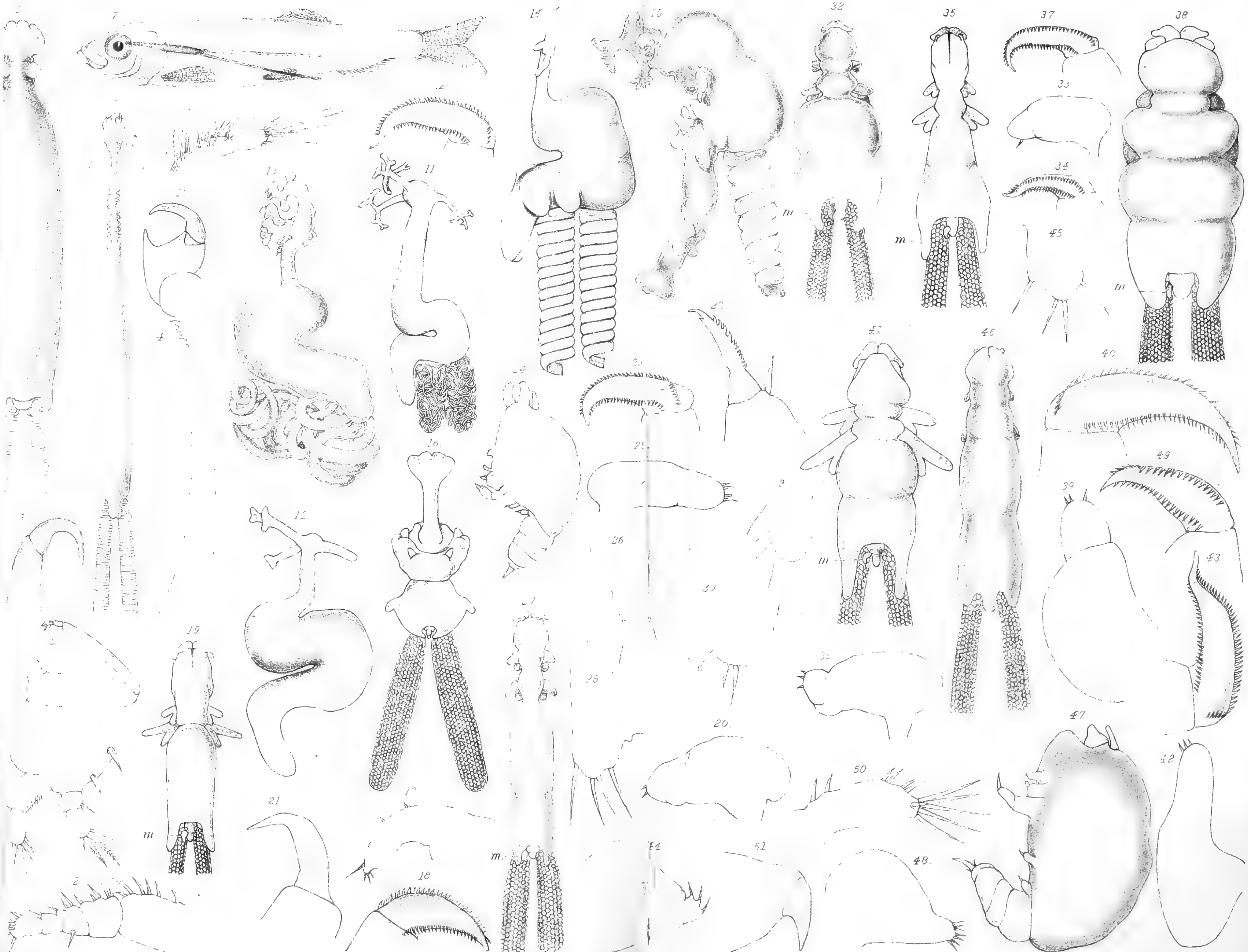
A. Scott, *del. ad nat.*

Parasites of Fishes.



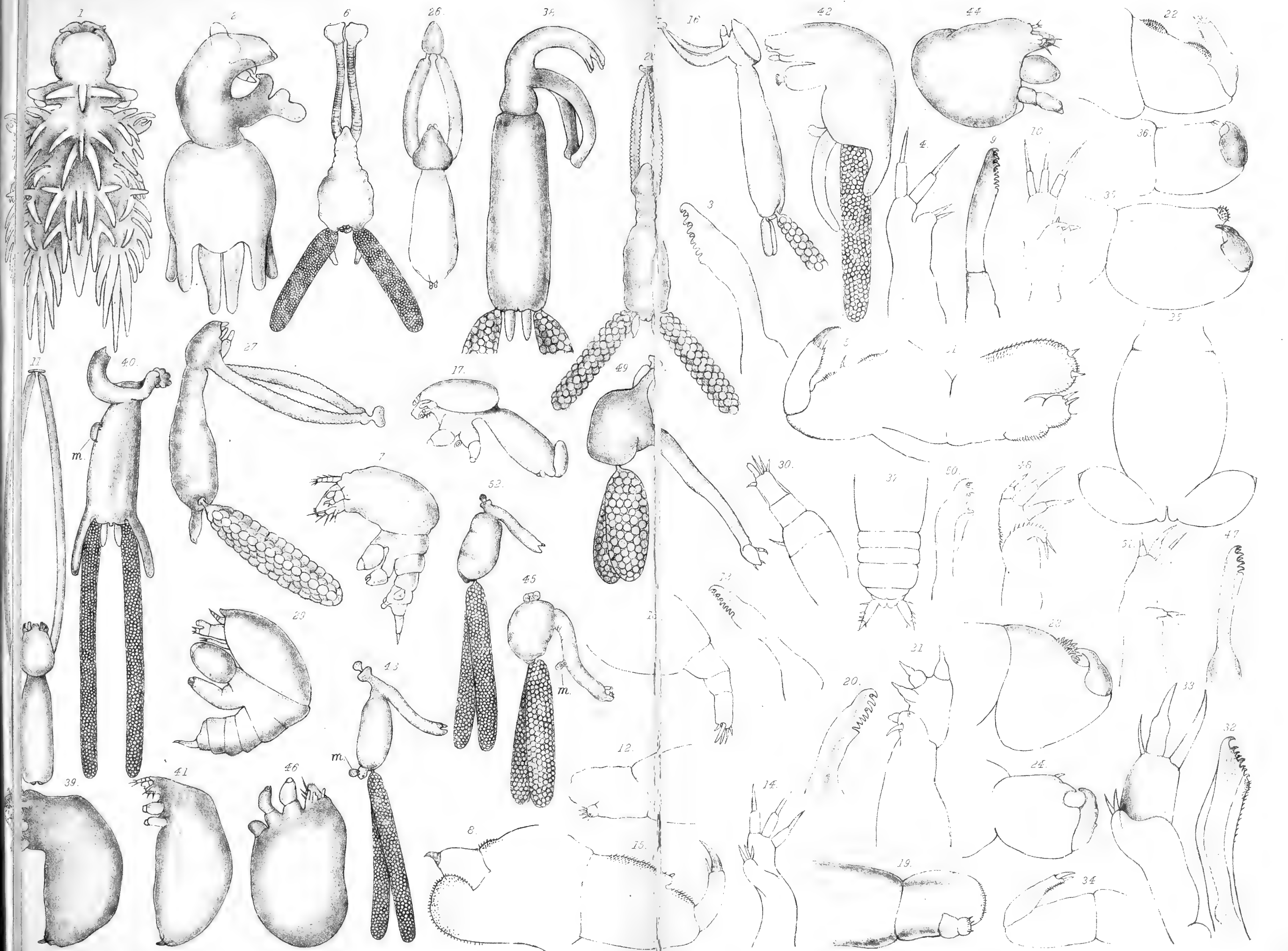
A. SCOTT, del. ad nat.

PARASITES OF FISHES.



[illegible]. Scott, *del. ad nat.*

Parasites of Fishes. *m* = Males.



Scott, *del. ad nat.*

Parasites of Fishes, *m* = Males.

IV.—CONTRIBUTIONS TOWARDS THE NATURAL HISTORY OF THE PLAICE *(P. PLATESSA L.).* By H. M. KYLE, M.A., B.Sc., Exhibition Science Scholar, St. Andrews. (Plates IX.-X.)

CONTENTS. PAGE.

INTRODUCTION.

The following pages contain the record of a portion of the work that has been going on for some time, and was concerned with the variations and variability of the plaice. It was at first proposed to collect and examine material from various places over the whole area inhabited by the plaice before publishing anything, but the work threatened to grow beyond all control, and it was thought advisable, for this as well as for other reasons of expediency, to work through a small portion thoroughly, so that the experience thereby gained might be of service to myself and others in the further development of the work.

The leading ideas contained in the present paper may be briefly stated. In the science of the fisheries the great bugbear to the naturalist, placing almost insuperable difficulties in the way of framing definite conclusions with regard to anything whatsoever, has been the great range of variations which everything—structure, size, rate of growth, spawning season, &c.—displays. This difficulty has not been confined, as is well known, to fisheries, but is common to every department of biology. The presence of this variability accounts for much of the indefiniteness and inconclusiveness of the work of the past. Within recent years, however, the prolonged endeavours of Galton and the stimulus given to the subject by the brilliant work of Bateson and Pearson, have been successful in establishing a method of treating variations and in founding thereby a new school of thought. In fisheries, Heincke has been the first to introduce the new method, and with it further original developments more particularly suited to the work on fishes. The present paper displays the working of this method so far as the material was suited to it. The various forms of variability and the problems in connection therewith are discussed. Race-variability is shown to be distinct from sex and growth variability ; their close relationship, however, is made evident, and the various and diverse causes of race-variations are displayed. Incidentally to the main body of the work, the material was found suitable to the discussion of a hitherto unsolved problem, and a method is shown by which this problem, the average size at which the plaice becomes ripe for the first time, may be solved.

With the exception of the herring, there is no species concerning which so much has been written as the plaice. A summary of this past literature has not been thought suited to the present instalment of the work, and reference has only been made to the literature directly bearing upon the subject.

The number of persons to whom I have been indebted during the progress of this work is large. To Dr. Hoek, the talented director of the Netherlands Zoological Station at Helder, and his assistant, Dr. Redeke, I am indebted for a very pleasant sojourn at Helder, as well as for many suggestive criticisms of my work. Dr. M'Intosh, my own Professor at St. Andrews University, has never failed me with his kindly advice and assistance. Dr. Fulton, the Scientific Superintendent of the Scottish Fishery Board, kindly granted me the use of the Marine Station at Nigg for a short period, and gave me a portion of my material. But, above all, am I indebted to the generous and friendly circle of Heligoland. Not only had I the pleasure of good company and the use of their Biological Station, including a considerable amount of material, but I had also the benefit of advice and counsel from Professor Heincke and Dr. Ehrenbaum over the initial, and perhaps the roughest, stages of the work. May beginners always find such friendly and capable advisers.

I have also to acknowledge the generous gift of £20 from the Worshipful Company of Fishmongers, London, which has aided me greatly in defraying the costs of material and transport.

Average Size at First-Maturity.

The combination of words, "first-maturity," does not seem very happy, but it is difficult to find any other short and compact expression which would explain the meaning intended. A fish is said to be mature once and for all when its reproductive organs have become ripe. There are some difficulties in the way of accepting this definition as perfectly general—*e.g.*, the young of the salmon—but such is the usage of the term, and this is the meaning employed here. "First-maturity" is then taken to mean, the first time that the reproductive organs become ripe.

A few years ago, when questions concerning the supposed decrease of fish in the sea were more in evidence than they are perhaps at present, attention was drawn to the great destruction of young immature fish that was going on. It was believed by many that this was one of the chief causes of the decrease, and it was therefore thought that if certain size-limits were fixed to prevent the fish below these limits from being brought to the market, then the young fish would have a better chance of becoming mature, and thence of maintaining the species.

The present investigations were not directly undertaken with the view of deciding what this size-limit should be, and it was only when the materials had been collected that they were seen to possess an importance previously unsuspected concerning this very question. The number of specimens is not so large as those of several naturalists who have previously investigated this subject, but large enough to illustrate a method of grouping the mature and immature fish which displays better than has previously been done the average-size at which the plaice spawn for the first time.

Before entering upon the discussion proper, it is advisable to distinguish between certain definite points—(1) The size-limit below which no plaice are allowed to be sold. This size-limit differs in the various countries where such limits exist, and has been fixed by the respective Governments solely from practical expediency, and not from any consideration of its biological aspect. (2) The size at which the plaice are on the average in the best condition for the market—*i.e.*, the best value-size. This size was first suggested and defined by Petersen* of Den-

* Petersen, C. G. J. *Report of the Danish Biol. Station*, IV., 1893.

mark, and from the economic point of view it is obviously of the greatest importance. (3) The lowest size at which the plaice is mature. This was laid stress on by Fulton* as being the most serviceable limit, from the practical point of view, for legislative purposes. (4) The average size of all the mature plaice. This was also defined by Fulton (*l.c.*), and is of interest, because it shows by contrast with the size at which the plaice become ripe for the first time that the great majority of mature plaice elude capture during their first spawning season, and survive to spawn several times. (5) The greatest size at which the plaice is immature—*i.e.*, the size at which all or nearly all have spawned. This was first proposed by Holt† in the course of his North Sea investigations, and was founded on the supposition that such a size-limit was necessary, because the numbers of plaice in the North Sea were on the decrease. (6) The average size at which the plaice become ripe for the first time—*i.e.*, the size at which as many plaice are immature as mature, below which more are immature than mature, and above which more are mature than immature. This size-limit has been spoken of by previous observers, but no endeavours have ever been made to fix it definitely.

From the biological point of view, the last is perhaps the most interesting and most important of the above size-limits. It is the size-limit that seems the most difficult to fix, and yet is in reality one of the easiest. It is the most representative size when two groups of the same species or two species have to be compared. The other size-limits refer to only a portion of the range of variations in the sizes of mature plaice, whereas the average-size when first-mature is the centre point of the range. And again, if regulations are to be framed upon such limits discovered by naturalists, then the average-size at which the plaice spawn for the first time is the most serviceable, from the biological point of view.

Referring now to the earlier work on this subject, and taking up, firstly, that done on the east coast of England, it is necessary to give a brief description of the observations and conclusions of Holt (*l.c.*). These observations, as already mentioned, were carried on with the object of obtaining the upper size-limit above which all or nearly all fish had spawned. Hence, a process of selection was carried on of the mature and immature, which unfortunately renders his tables of little use for the present purpose. Thus, the males were almost entirely disregarded, because it was well known previously that they spawned at a much smaller size than the females. Again, the females were also selected, those which were mature below a certain length the upper size-limit, being specially sought for, and likewise the immature above this limit, which was found to be 17 inches (43cm.). The smallest female that he found mature was 13 inches (33cm.), and very few mature specimens, comparatively speaking, were found between this size and 17 inches. On the other hand, ripe males were common as low as 9 inches (23cm.), and an exceptional one was ripe at 6 inches (15cm.).

In comparison with the numbers and sizes to be presently given, these show a greater range of variation, but as Holt included the whole North Sea—or rather the North Sea north from Grimsby—this greater range is easily accounted for. The plaice of the northerly North Sea are mature for the first time at a greater size than those from the English coast and southerly portions of the North Sea, and this difference would cause a greater range of variation. Otherwise there does not seem any pronounced difference between the sizes given by Holt and those found by myself.

* Fulton, T. W. *Eighth Rep., Fish. Board for Scotland*, 1890.

† Holt, E. W. L. *Jour. Mar. Biol. Ass.*, Vol. II., 1892.

This size-limit of 17 inches is, therefore, the upper limit, or nearly so, at which immature plaice—*i.e.*, those which have never spawned—are found in the North Sea. At 18 inches Holt considered that the proportion of immature to mature was "infinitesimal." One specimen with ovaries unripe was obtained at a greater size than 18 inches, but later in the season, and it was probably a "spent," not immature, fish.

The distinction between *spent* or *spawned* fish and *immature* fish may be referred to briefly before proceeding further. The *immature* fish are those which have never spawned and show no signs of going to spawn. If they show signs of going to spawn in the ensuing season, they may be taken as *ripe* for the purposes of this paper. The *spent* or *spawned* fish are those which have spawned at some time or other. Theoretically, the distinction is great, but in practice it is at times exceedingly difficult to discriminate between the two. According to Holt, the spent fish could always be distinguished from the immature, either by the presence of some remaining ripe ova, by the shrunken condition of the ovary, or when the ovary had contracted to its previous condition of unripeness by the groove that remains along the interspinous rays where the developed ovary had been. The two former characteristics always lead to a certain diagnosis of the spent condition, but the last has been called in question by Cunningham, and I have also found it unreliable. The groove or hollow along the interspinous rays is present (to a certain extent) in the young forms, which are evidently immature, and is, therefore, not diagnostic of the spawned condition. In short, so far as I have been able to determine up to the present, the ovary and the parts in connection with the ovary return to exactly the same condition in the spawned fish as they were previously in the immature.* It should be mentioned that Cunningham imagined at one time that he had discovered a sure sign of the spawned fish in small opaque bodies which he found intermixed with the undeveloped ova. These he thought were the degenerated remains of ova which had matured to a certain extent, but had not been spawned with the rest, and had then atrophied. He withdrew this distinction later, however, when he found that these opaque bodies were present in ovaries of small fish which were really immature. When the spawned fish is given time to return to its condition previous to spawning, there are, therefore, so far as known, no means of distinguishing the spent from the immature fish.

During the spawning season—from December to May for the whole North Sea—the difficulty of distinguishing between the spent and immature conditions is not great except at the very beginning and the end of the season. Doubtful cases certainly occurred in the course of my own investigations between these times in the case of large fish with unripe reproductive organs; but their number was comparatively small, and I have thought it better to consider them immature. At the beginning of the season and earlier—during October, November, and the first half of December—the difficulty was to tell whether a fish with reproductive organs a little larger than the normal unripe condition was really going to spawn that season or not. In consequence of this difficulty I have been obliged to form a third class, and consider a number of fish as "doubtfuls." These will be referred to later. At present it may be said that the difficulty of distinguishing between a spent and immature fish, and of telling whether a fish is going to spawn in the ensuing season or not, is greater for the males than for the females.

Cunningham† was the next naturalist who took up this matter in England. He found that for the plaice of the English Channel 15in.

* Petersen and Fulton (*l.c.*) were of the same opinion.

† *Jour. Mar. Biol. Ass.*, Vol. III., 1893, p. 70.

(381mm.) was the size at which all or nearly all were mature. This size was contrasted with that given by Holt (17in.), and was considered as indicating a racial difference in the plaice of the North Sea and of the English Channel. The borderland between the altogether immature and the altogether mature was found to be from 9–12in. (229–305mm.) for the males and from 9–14½in. (229–368mm.) for the females. The averages for these borderlands were considered to be about 10in. (254mm.) for the males and 12–13in. (305–330mm.) for the females.

At a later date the same naturalist continued the work of Holt on the east coast of England, but while Holt had studied for the most part the forms from the North Sea north of Grimsby, Cunningham investigated those from the southerly portions of the North Sea mostly, and more especially those from around Lowestoft. There is consequently a considerable difference in their results, the sizes given by the latter being much smaller than those given by Holt. Fortunately, the data recorded by Cunningham are sufficiently numerous and representative to be restated according to the method here proposed.

The following Table represents the totals of five different lots of plaice* collected from the same region—the southerly portion of the North Sea, and about the same time—from October to December. The specimens obtained by Cunningham from Geestemunde are omitted, as they came from another part of the North Sea, and do not seem representative.

TABLE I.

Proportions of Mature to Immature Plaice at Different Sizes.

Sex.	Condition of Reproductive Organs.	Size in Inches.									
		8	9	10	11	12	13	14	15	16	17
Males . .	Immature . .	1	10	27	20	12	11	2	1	—	—
	Mature . .	—	6	17	30	26	10	2	5	14	—
Do. *in percentage*	Immature . .	100	63	61	40	32	52	50	17	—	—
	Mature . .	—	37	39	60	68	48	50	83	100	—
Females . .	Immature . .	—	8	46	74	67	30	18	6	3	1
	Mature . .	—	1	2	18	24	21	7	9	13	9
Do. *in percentage*	Immature . .	—	89	96	80	74	59	72	40	19	10
	Mature . .	—	11	4	20	26	41	28	60	81	90

The proportions of immature and mature at each size are arranged in percentages, because by so doing the inequalities in the numbers of specimens at the different sizes are done away with. A comparison can then be drawn between the number of mature specimens at the different sizes, and similarly for the immature. In calculating the percentages the nearest whole numbers are always taken.

* "North Sea Investigations:" *Jour. Mar. Biol. Ass.*, Vol. IV., 1895, p. 106 *et seq.*

The advantage of this method lies in the clear and simple manner by which it shows the proportions of the mature to immature at the different sizes. Theoretically, if there is a true average at first maturity in nature —above which more are mature than immature, below which more immature than mature—this can only be where 50 per cent. of the one coincide with 50 per cent. of the other. Hence, if these percentages be plotted out as two curves, the point where the curve of immaturity crosses that of maturity is the point required at which the plaice are ripe on the average for the first time. In practice, however, this point is difficult to obtain. In theory, trustworthy curves and averages could only be obtained if a very large number of specimens at each size was examined, and it is further necessary that these should not be specially selected. Again, the specimens should be taken from the same region and at the same time—viz., the spawning season. If these conditions are not fulfilled then certain irregularities may appear in the curves, and it will be difficult to frame any conclusion. Such irregularities, however, do not destroy the efficacy of these curves; on the contrary, by means of the curves not only are the irregularities shown, but their causes and thence their explanation as well.

In the data given by Cunningham, for example, the percentages of the immature start from 100 and descend to almost nothing, whilst those of the mature start from 0 and mount up to 100. (*Vide* Plate IX.). This is the general trend of the curves, but it will be remarked that both for the males and females a fluctuation occurs so that the course of the curves is not quite uniform. This is partly due to the smaller number of specimens that have been examined at certain sizes than at others. Where the specimens are fairly numerous, as between 10–12in. for the males and 10–13in. for the females, the trend of both curves in each case is uniform. After these sizes the numbers decrease and irregularities appear. In such cases it is evident that the general trend of the curves has to be taken into consideration, otherwise no conclusions could be drawn. A further discussion of Cunningham's data and the curves that result therefrom will be entered into later, when the comparison is made between them and my own. It may be said at present, however, that, so far as numbers are concerned, Cunningham's data are better than mine, but the relative numbers at the different sizes are not so well proportioned.

In the following Tables the specimens from Heligoland, Helder, Lowestoft, and Grimsby are included together. The relatively small numbers from each place necessitated this; but the fact that the characters so far examined for the purpose of detecting races are almost identical in all four groups, as well as that the spawning season seems to be the same in all, makes this course a reasonable one. The inclusion of these four groups, on the other hand, will give a common average for the plaice of the southerly portion of the North Sea—south of the Dogger Bank—and this is an advantage if any common size-limit is wanted for legislative purposes.

These specimens are therefore considered as coming from one and the same biological region—*i.e.*, one in which the surrounding conditions are for the time being thought to be the same. On the other hand, the specimens from Aberdeen are separated from these because the characters differ, as will be shown later.

Something further may be said concerning the method. The range of variation within which the specimens fall lies between 240mm. and 380mm. (9·5 to 15in.), and it is divided into seven portions of 20mm. each. The specimens whose lengths fall within each division are considered to be half-way between the limits—*i.e.*, at 250, 270, and so on. By this method a more exact result is obtained than when the different lots are taken to the nearest inch. When the percentages of immature and mature in each division have been calculated, it will be noticed that whilst the proportions between the different divisions are made more equable, yet those within each division are magnified, because in each case a multiplier has to be used to bring each lot to a percentage. Hence, if there is any great disproportion between the numbers of the different divisions this disproportion will be displayed by the multiplier used. For example, if there are 50 in one division and only 5 in another, these two divisions will be brought to the same level in the percentages, and yet the value of the latter group is only $\frac{1}{10}$ of the former. In the case of the specimens from the southerly portion of the North Sea this disproportion is not great because the multipliers are small; in the case of the Aberdeen specimens it is much larger. Theoretically, this error would be done away with if a hundred specimens in each division were examined, and under such ideal conditions the only errors that could enter into the calculation would be errors of observation.

Table II.

Showing the Relative Proportions of the Immature and Mature Plaice at Different Sizes, from the Southerly Portion of the North Sea.

1. Males.

Region.	Condition of Reproductive Organs.	Size in Millimetres.						
		240-260	260-280	280-300	300-320	320-340	340-360	360-380
Helder	Immature	4	6	6	3	0	0	0
	Mature	4	7	10	4	1	3	5
Lowestoft	Immature	0	3	6	5	0	1	0
	Mature	2	5	16	10	14	15	10
Grimsby	Immature	3	1	2	2	0	1	0
	Mature	0	2	0	5	9	13	10
Total	Immature	7	10	14	10	0	2	0
(188)	Mature	6	14	26	19	24	31	25
Do. *in percentage*	Immature	54	42	35	35	0	6	0
	Mature	46	58	65	65	100	94	100

2. Females.

Region.	Condition of Reproductive Organs.	Size in Millimetres.						
		240-260	260-280	280-300	300-320	320-340	340-360	360-380
Heligoland	Immature	16	7	2	6	10	2	0
	Mature	1	0	0	4	19	13	10
Helder	Immature	14	21	17	10	0	0	0
	Mature	1	0	3	4	1	3	2
Lowestoft	Immature	1	8	16	14	5	1	0
	Mature	0	0	2	3	4	4	2
Grimsby	Immature	1	1	4	5	5	3	1
	Mature	0	0	0	3	6	6	8
Total	Immature	32	37	39	35	20	6	1
(269)	Mature	2	0	5	14	30	26	22
Do. *in percentage*	Immature	94	100	89	71	40	19	4
	Mature	6	0	11	29	60	81	96

From the first Table, which gives the proportions of the immature and mature male specimens, those from Heligoland are omitted, because there were very few specimens, and some doubtfully mature amongst them. It will be seen from the percentage columns that the relative numbers in the different divisions are more evenly distributed than they were in the case of the data given by Cunningham, and the resulting curves are therefore more uniform.

A certain allowance should be made for growth, because the specimens were not all collected at the same time. Those from Heligoland were obtained mostly during October, those from Helder towards the end of November, and those from Lowestoft and Grimsby during the spawning season in January, February, and March. No correction is required for the last, but those from Helder are at least two months from the height of the spawning season, and those from Heligoland four months. The average rate of growth yearly has been calculated for the earlier periods by Cunningham,* Petersen,† Masterman,‡ and more recently by Dannevig,§ and although there are considerable differences in their results, yet it is allowable to conclude that for the stage in question the plaice grow from 2–3in. (50–76mm.) in a year. The correction to be made

* Cunningham, J. C. *Jour. Mar. Biol. Ass.*, Vol. II., 1891-92.

† Petersen, C. G. J. *Fourth Rep. of the Danish Biol. Station*, 1893.

‡ Masterman, A. T. *Thirteenth Rep., Scot. Fish. Board*, 1895.

§ Dannevig, H. *Seventeenth Rep., Scot. Fish. Board*, pp. 232-246.

for the specimens from Heligoland is, therefore, about 20mm., and for those from Helder 10mm. A slight advantage is given to the immature, as they probably grow faster than the mature at this period.

The values are plotted out in the curves shown on Plate IX.—the light lines representing the observed percentages, the dark lines the corrected numbers. The first two curves (A) have been sketched from the data in Table I. given by Cunningham, and in these the abscissal axis is marked out in inches. In the following curves this axis is marked in centimetres. In all cases the ordinate axis represents the percentage values as given in Tables I. and II. An inspection of the first set of curves—those formed from the data given by Cunningham—shows that both for the males and the females the courses of the curves are irregular. The points which mark the percentages do not lie on one straight continuous curve, but on one which rises and falls irregularly, and the irregularity is more marked in the case of the males. The reasons for this irregularity may lie in the insufficient number of specimens at certain sizes or in their non-representative nature. The irregularity is restricted, however, to certain definite points, and the general trend of the curves seems sufficiently evident to permit free-hand outlines of the probably correct courses of the curves over the points of irregularity. This outline is represented by the dotted lines.

It will be remarked that in all the pairs of curves, the curve of the mature specimens begins between 8 and 10in. (20·3 and 25·4cm.) at or near 0 $^0/_{00}$, and mounts up gradually until between 14 and 17in. (35·0–43·2cm.) it approaches 100 $^0/_{00}$. The curve of the immature specimens, on the other hand, follows the reverse course, beginning about 100 $^0/_{00}$ and ending at 0 $^0/_{00}$. The two curves cross on the 50 $^0/_{00}$ line, and the point of crossing is taken to represent the average of the combined curves. The abscissa of this point is then considered to represent the average size at which plaice are ripe for the first time. In the case of the curves formed from the data given by Cunningham, this length is 13·7in. (34·8cm.) for the females and 10·5in. (26·6cm.) for the males. If a slight correction, similar to that already described, be made for growth, these averages become 14in. (35·6cm.) for the females and 10·8in. (27·4cm.) for the males. In the case of the curves formed from my own observations, the corrected averages are 33·2cm. (13·1in.) for the females and 26·6cm. (10·5in.) for the males.

It appears, therefore, that the average size at first-maturity for the plaice of the southerly North Sea lies between 13 and 14in. for the females and 10–11in. for the males. The close agreement between the two sets of observations is somewhat remarkable when the comparatively small number of specimens is considered, and shows that these averages must be close approximations to the real averages in nature. It has to be remarked also that the males are mature at a size 3 inches smaller on an average than the females. This difference may correspond to a year's growth—*i.e.*, the males may be mature a year earlier than the females.

If attention is again directed to the second set of curves (B), it will be noticed that the curves are open at both ends. This permits of the possibility that mature specimens may be found below the lowest limits recorded, and immature specimens above the highest limits. In accordance with this possibility, Cunningham has found mature female specimens at 9in. (22·9cm.) and mature males at 6in. (15·2cm.) There is, therefore, again a difference of 3in. between the earliest mature male and female, and this may correspond, as above stated, to a year's difference in age. The general slope of the curves for the female specimens probably represents better than any of the others what actually occurs.

A few "precocious" specimens become mature at a small size, from 9 to 11in. (22·9 to 27·7cm.); then the number of the mature increases rapidly, showing that the great majority become mature between 11 and 15in. (27·9 and 38·1cm.). This means that they become mature at the same average-age, which, if Dannevig's calculation be taken, is probably at five years old. According to Petersen's and Masterman's calculations, this average-age may be four years. The males become mature a year younger.

If the curves between 12 and 15in. (30–38cm.) be again considered, it will be noticed that they approximate, in the case of the females, very closely to two straight lines. This agrees with the notion that we have a single year's group between these sizes. The variation in the size of these mature specimens probably arises from the initial difference in age, to be referred to later in the section on "Variability," and this being so, the relative proportions of the mature and immature specimens should alter so rapidly and uniformly as to be represented best by two straight lines.

At the upper limits, on the other hand, we have to consider the presence of large immature specimens. From my own observations, the largest immature was 15in. (38cm.) for the females and 14in. (35·5 cm.) for the males; but the general trend of the curves admits the possibility of finding immature specimens at a larger size than this. And Cunningham's data shows that these may occur up to 17in. for the females and 15in. for the males. As with the earliest mature specimens, these are scattered examples, though probably of constant occurrence. If we suppose that they become mature in the following year, then we are perhaps justified in declariug that all the females are mature in their sixth year, and all males in their fifth at the latest. The exact upper limit in size is hard to fix, but may be taken as about 17in. for the females and 15in. for the males. The ranges of variation would, therefore, appear to be from 9 to 17in. for the females and 6 to 15in. for the males, and three years would be the range in time. Such seem to be the facts, although the reasons for these great ranges of variation are not yet evident.

We may turn now to the specimens from the northerly portion of the North Sea, which include those from Aberdeen and from St. Andrews. In Table III. they are arranged according to size, in the same manner as those of the southerly North Sea in Table II. The numbers of specimens are not so great as were those of the latter region, and more especially is this the case with the females. Consequently, when the numbers are divided into eight divisions, there are very few in certain of the divisions—from 320 to 420 mm.—and the value of the observed proportions of the immature and mature is therefore seriously affected. The multipliers that require to be employed in order to obtain the percentages lie between 3 and 8 in the case of the males, but between 3 and 20 for the females. No definite conclusions can be drawn in the latter case, and only the one set of curves, representing the male specimens, has been drawn. (Plate X.)

[Table.

TABLE III.

Showing the Relative Proportions of the Immature and Mature Plaice at Different Sizes, from the Northerly Portion of the North Sea.

Sex.	Condition of Reproductive Organs.	Size in Millimetres.							
		260-280	280-300	300-320	320-340	340-360	360-380	380-400	400-420
Males	Immature	12	25	23	7	1	0	0	—
	Mature	2	5	15	22	12	19	6	—
Do. *in percentage*	Immature	86	83	61	24	8	0	0	—
	Mature	14	17	39	76	92	100	100	—
Females	Immature	9	21	24	7	1	0	2	0
	Mature	0	0	3	3	4	12	5	7
Do. *in percentage*	Immature	100	100	89	70	20	0	29	0
	Mature	0	0	11	30	80	100	71	100

From these curves it is seen that the point of crossing lies very close to 320cm. (about 12·5in.). The lower limit of the mature specimens begins lower than 26·0cm. (10in. approximately), whilst the upper limit of the immature is about 37cm. (14·5in.). The range of variation does not seem to be so great therefore for the northerly specimens as for the southerly, but this may arise from the smaller number of specimens examined. If the distance between the average sizes of the males and females at maturity which was observed in the specimens from the southerly North Sea—viz., 7·0cm. (about 3in.)—be utilised for those from the northerly North Sea, then the average size, when the female plaice of the latter region become ripe for the first time, is about 39·6cm. or 15·5in.

The average size at first-maturity for the male plaice of the southerly North Sea was found to be about 26-0cm., a difference of 6cm., or more than 2in., from that of the northerly North Sea. Whether this difference means that the plaice of the latter region become mature at a later age—*i.e.*, a year later, than those of the former it is impossible at present to say. It may be that they grow much faster and spawn at the same average age; but this question can only be satisfactorily determined when the ages at different sizes can be ascertained.

On the east coast of Scotland, Fulton* has investigated the sizes at which the plaice becomes mature, the relative proportions of males to females, and their average as well as maximum sizes. The average size at first-maturity was not specially sought for, and it is consequently impossible to compare his results and my own with any definiteness. The limit between immaturity and maturity—*i.e.*, the commencement of maturity—is placed about 12–13in. This agrees exactly with what has been recorded here for the females, but it has been shown that the males may be mature at 11in. and even lower.

A comparison may be drawn between the average sizes at maturity of the North Sea plaice and those of the Kattegat and Baltic. Petersen states

* Fulton, T. W.: *Eighth Rep., Scot. Fish. Board.* pp. 161, 162; *Tenth Rep., Scot. Fish. Board*, pp. 239 *et seq.*; *Twelfth Rep., Scot. Fish. Board*, p. 307.

that these average sizes are 10in. in the Baltic, 11in. in the Lesser Belt, and 12–13in. in the Kattegat. These refer to both males and females although the males are said to be somewhat smaller. These sizes (p. 3) are said to represent the average size of the mature fish, but there seems to be some discrepancy between the stated sizes, and what one may gather from the Tables. In the Kattegat, for example, Table I.* shows that immature specimens were obtained at 15 to 16in., and even as high as 19in. (These are in Danish inches—in English inches the sizes would be a little less than half an inch larger.) It seems strange, therefore, that the average-size of the mature specimens of the Kattegat should be so low as 12–13in. From the Tables, indeed, one would infer that the average size at maturity was even greater than 12–13in. The data, unfortunately, do not lend themselves to the present mode of treating the subject, and I am therefore compelled to leave the matter in an indefinite state. From the resemblance that the plaice of the Kattegat have to the North Sea plaice, and from their actual geographical continuity with them—*i.e.*, with those of the Danish coasts of the North Sea—it seems more probable that 12–13in. is about the average size when they become ripe for the first time. The average for the females is perhaps higher than this, that for the males lower.

In conclusion, a brief reference may be made to the usefulness of the average-size when plaice become mature. Quite apart from the legislative and practical aspects of obtaining by its means a reasonable size-limit for the protection of the young immature fish, there is another aspect of far greater importance.

The average sizes at maturity and first-maturity might be put to effective use in order to tell whether the fish on any area are really decreasing. So far as known there are two effects of over-fishing—the larger fish grow scarce, and the average size of the mature fish consequently decreases. Whether the average size at first-maturity also decreases is not yet definitely known, but it may not do so. The averages found from Cunningham's data differed very little from those of my own, although several years intervened. In the Kattegat, again, the fishing is so severe that large specimens have entirely disappeared, and it is even doubtful whether any plaice survive to spawn twice. Yet the average size at first-maturity, on this supposition, is not much less than that for the North Sea specimens. The average size at first-maturity probably depends upon the surrounding conditions and not upon any change in the total number of fish. If it does vary, however, decreasing with the decreasing number of fish, its variations may be calculated in different years.

The greatest and most certain sign of a decrease in the number of fish on an area, apart from direct statistics, is to be found in the decrease of the average size at maturity. This represents the average size to which the plaice attain after they are mature, and if this size be compared with the average size at first-maturity we should know what proportion of plaice elude capture and spawn several times. By investigating these two averages in different years we should be able to tell whether the mature fish are decreasing or not. For example, it has been shown here that the average size at first-maturity for the female plaice of the northerly North Sea is about 15·5 in., and Fulton has shown that the average size of the mature specimens of the same region was about 20 in. some years ago. If this latter average still holds good, it is evident that more than half of the mature plaice in this region must escape capture and spawn several times, in spite of the refined methods of fishing now practised.

The method of finding out whether the number of fish on an area is

* *Rep. Dan. Biol, Station*, 1893.

really decreasing or not is therefore simple. It is necessary to calculate the average-size at first-maturity and that of the total mature, care being taken that the specimens are not specially selected and are yet representative for the area in question. The changes in the averages, and the changes in the relative distance between them, will show the change in the number of mature specimens, and thence in the total number of fish on that area. The investigations should be repeated for several years in succession in order to avoid the possible yearly fluctuation, and again some years later.

Variability and the Method of Treating Variations.

This complex subject has been dealt with recently by so many different writers and in so many different ways that it is impossible to give a complete digest of all the views concerning the method and its usefulness within the reasonable compass demanded by this paper. The mathematical aspect of the study has now assumed a definite form, with regard to its more elementary portions at any rate, and the introduction of shorter modes of working by Pearson and Duncker has greatly reduced the old labour and drudgery. This aspect of the method is described by Davenport,* and more fully by Duncker.†

So far as the biological aspect of the method is concerned, the study of variations is passing through a transitional period. For this aspect one must turn to Galton,‡ Weldon,§ and Heincke.‖

In the following pages the endeavour will be made to maintain the biological aspect constantly in the foreground, and to display the mathematical method as merely an instrument and aid, though a powerful one. The higher developments of the method, the determination of curves, and the correlation of different structures, are not shown here because the material is not very well suited for them. Attention is therefore directed to the simpler and more elementary portions, which in the present condition of the study are by far the most important.

The necessary foundations for the study are of course the facts of variation and the characters that vary. Here, at the very beginning of the study, we find that its use with regard to fishery research has diverged widely from that in other departments. In the latter one or two characters only have been taken, such as the number of fin-rays, of glands, the height or breadth of various parts, and so on ; their manner of varying has been displayed, and sometimes the correlation of one part with another. There are certain noteworthy exceptions, such as the works of Weldon on the Crustacea and of Bumpus on the Sparrow, and it is more than probable, now that the newness of the method has worn off, that more characters in each animal will be examined in future. Heincke has set the example for this in fishery research, and one can readily understand the reason. We do not wish to know how this or that character varies by itself ; we wish to know how many vary in relation to one another ; in short, how the organism varies. For this purpose a large number of characters has to be examined, and fewer specimens can be taken than was formerly the case.

In fishery research the method has been employed for the separation of groups of individuals from one another. Before entering upon the research it has been impossible hitherto to foretell how many individuals

*Davenport, C. B. : "Statistical Methods," 1899 ; Chapman & Hall, London.

†Duncker, G. : "Die Methode der Variationsstatistik, *Arch. für Entwick*, B. VIII., 1899.

‡Galton, F. : "Natural Inheritance," 1889 ; also *Proc. Roy. Soc.*, Vol. LXI., 1897.

§Weldon, W. F. R. : "Remarks on Variation in Animals and Plants, *Proc. Roy. Soc.*, Vol. LVII., 1895 ; also Presidential Address to the British Association, 1898.

‖Heincke, F. : "Naturgeschichte des Herings," *Abhandl. d. Deut. Seefisch*, V., 1898.

of each group would be required, and even now no definite rules can be given. Some characters are more valuable for the research than others, and fewer specimens are necessary for these than for other characters. It is necessary, further, to sub-divide each group according to size or sex, and if the differences between each group are small the number of specimens examined must be greatly increased. In the present work it has been found that two hundred specimens about the same size permit definite conclusions to be drawn. If the number in the sub-group falls below fifty the conclusions become uncertain.

The choice of characters is also a matter of moment. There is no doubt that numerical parts ("integral variates"), such as the vertebræ and fin-rays, are the easiest to manipulate and sometimes the most suitable, but this is not always the case. Even over a wide area, such as the North Sea, these characters may not show any appreciable change in their averages. This will be shown in the case of the plaice, and it probably occurs in many other forms. Differences do occur, however, in some forms, as in the herring and the plaice of the Baltic, and it is always advisable to choose these parts for study. Of more importance, however, are the "dimensional" and "substantive" variations. These arise from linear parts, length, breadth, form, &c., and from the mass or weight of structures. These have been disregarded hitherto by most workers on variation, chiefly on account of the difficulty of obtaining exact measurements. The reason is quite valid, and great care has to be exercised in the choice of the dimensions, and of the conditions under which the measurements are taken. If possible, fresh specimens should be examined, but if preserving agents are used then the contraction or expansion of each measured part has to be determined. This gives rise to a great amount of labour, and it is better to examine only fresh specimens. Soft or flexible parts should also be avoided, because the errors arising from faulty observation may be considerable. Matthews and Heincke have shown, however, that certain characters in the round fishes are valuable, although they involve the measurement of soft and flexible parts. Such characters are the relative distances of the fins from the snout and tail. The changes that take place in these during growth are well known in the cases of the sand-eel and young herring, and they are therefore of importance for investigation. It is preferable, however, to choose the dimensions on the skeleton—*e.g.*, the skull and vertebræ—of which the measurements can be made accurate to within half a millimetre.

In the present work the large majority of the measurements consisted of these dimensions on the skeleton. Exceptions were the height of the body and length of tail, and in these cases the error of observation would be within 1.5–2mm. only. It is on account of these possible errors that such dimensions are unsatisfactory. In a large number of specimens the errors will be distributed almost equally about the mean, and hence will not affect the average of the character, but they will affect the standard deviation, and hence the fluctuations of the averages. These will be presently defined; at present it is sufficient to say that the conclusions that might be drawn from the averages are thereby rendered uncertain.

The number of characters that should be chosen depends upon the object desired. If it is desired to ascertain whether groups or races exist, or to investigate the variations due to sex or age, it is advisable to examine a large number. This part of the study is still somewhat unsettled, but a few general considerations may be stated. The changes that arise during growth, or from differences in the environment, are, apart from the "integral variates," changes in the relative proportions of the structures of the body, and these are concerned with the movements of the animal, its balance or equilibrium. It is necessary, therefore, to choose such parts as will best express this balance. The skull, for example, is in proportion to the caudal region, the height of the body is correlated with the height of the skull, the position of the fins is connected with the movements of the body, and so on. The various dimensions which express these relations should be chosen, and not one only of a structure but several. By choosing several dimensions of one structure the conclusions in the end are more certain and satisfactory, even though something is added to the labour.

The measurement of the mass or weight of the various parts and structures has not yet been attempted on account of the great practical difficulties in the way. When these have been overcome and accuracy in measurement attained a new and valuable field for the study of variations will be opened up. In connection with the taking of the measurements, further, it may be said that each species presents different possibilities. In addition to the general considerations, it is therefore necessary to take note of the characters which differentiate a species from its nearest allies. Systematists have hitherto chosen the superficial characters for the most part in order to distinguish between species, but it is becoming more and more apparent that if we are ever to gain a definite notion of the "species" and its mode of origin in any one case, we must penetrate to the internal morphological differences, and from these limit off the species from one another. The distances between various species (as between herring and sprat, plaice and flounder) may differ in the various genera; we do not yet know. And here again, as Heincke points out, the study of variations methodically carried on is part of the work of the present-day morphologist and systematist.

The methods by which the measurements are taken are various, and depend a great deal on the ingenuity of the observer. Davenport (*l.c.*) explains the various methods now in use, but there is still scope and need for more accurate ways of taking measurements. This is a separate study in itself demanding special attention, and in a short time it is probable that the laboratory of the biologist will be supplied with instruments as delicate and accurate as those of the physicist and chemist. For the present work the ordinary instruments only have been used, but it is hoped to make some improvements in the future stages of the study.

When the characters have been measured and their values tabulated it is necessary to reduce them to their percentage-values with respect to some common standard, otherwise they would not be directly comparable. The common standard chosen by different observers is not always the same. The total length of the fish, or this length minus the length of tail, are usually taken. In the present work, the total length minus tail-length and skull-length has been chosen as standard, and is called "body-length" throughout, although the small distance between the tip of the snout and the anterior end of the vomer is included therein. The choice of this standard is not merely a matter of convenience. It has to be chosen so that the differences in the values of the various dimensions are fairly represented in the averages. If the standard dimension is itself under or near 100 of the units employed (millimetres, say), this condition is always fulfilled. But if the standard is large, over 200 and more, then it will be necessary, in order to bring this down to 100, to divide it always by a larger number than 2. Each dimension must be so divided, consequently, and the differences between the original values will be reduced according to the value of the divisor. Thus, if the divisor is 3 or 10, then a difference of 3 or 10 in the observed values becomes only 1 in the percentages. This difficulty is certainly obviated if the standard is taken as 1000, and the secondary dimensions expressed in thousandths, but this increases the labour of calculation enormously. It is advisable, therefore, to use percentages, and in order to do so, and avoid at the same time the above-mentioned difficulty, the standard dimension should be chosen as near 100 as possible.

Certain parts of the body, again, may be grouped together if they are related to one another. Thus, the height or breadth of the tail is usually expressed—when it is taken—in terms of the tail-length, and the breadth and height of the skull are expressed in percentages of the skull-length. For the present work forty characters in all have been taken, but only a few of these have been chosen for the present paper, as it was thought better to direct more attention to the thorough working out of the method in a few cases than to the superficial display of the variations of many characters. The characters chosen are probably the most valuable for the purposes required, but the value of the others has yet to be decided.

When the percentage-values of a character are arranged in order it is found that a varying number of individuals come under each percentage. Each percentage-value is called a "variate" or "variant," and the number of individuals under each variant is the "frequency" of the variant. The variant having the largest frequency is called the "mode." When the average or mean has been calculated these variants are commonly spoken of as "deviations." More strictly used, the term "deviation" applies to the distances that the variants are from the mean or average. When these distances have been calculated their average may be obtained, and this is called the "average deviation" of the variants. Within recent years, however, biologists, following the advice and example of Pearson, do not employ the average deviation, but the "error of mean square" of the deviations. This is obtained from the formula

$$\sigma = \sqrt{\frac{\Sigma (x^2 \cdot f)}{n}},$$

where x is any deviation, f its frequency, and n the total number of individuals. σ, the so-called "error of mean square" of the physicists, is called the "standard deviation" or "index of variability" by biologists. It is employed to represent the range of variations or the "variability" of a character, and is useful in comparing the variability of different organs n the same species or the same organ in different species.

A short method of obtaining σ, given by Pearson and described by Duncker, consists in taking the "mode" as the approximate average, calling it 0 and the deviations from it + 1, + 2, + 3, etc., on the one side, and—1—2—3, etc., on the other. Calculating the "average deviation" of these (having regard for the signs) we obtain the distance of the true average of the variants from the mode. The sum of the squares of these deviations is then calculated, according to the formula $\Sigma (n^2 f)$, and σ is then obtained from the formula—

$$\sigma = \frac{1}{n} \sqrt{n \Sigma (x^2 f) - [\Sigma (x f)]^2},$$

where x is any one of the integral deviations, and f its frequency as before. Since this mode of working involves only whole numbers, it is obviously much simpler than the older method of employing the actual deviations from the true average, which meant using numbers of two and three figures where now 0, 1, 2, etc., are used.

The further processes in the development of the mathematical method are borrowed from the mathematical theory of probabilities. Without entering into the reasoning of their mathematical aspect, which may be found in the writings of Galton, Weldon, and Heincke (*l.c.*), it is necessary to show their biological meaning. The individuals examined represent only a very small fraction of the total number of individuals in the group. Hence the average found for the observed individuals is only probably the true average of the total number. The amount of probability can be calculated from the following formula. The probably true value of the standard deviation or

$$P.\sigma. = 0{\cdot}6745\ \sigma,$$

and dividing this by the square root of the number of individuals observed, or $\sqrt{n}$, we obtain the probable error (r) of the observed average. The true average for the total number of individuals in the group will then probably lie between $M \pm r$, where M is the observed average. According to Davenport, if we take three times r, then the probability is 19 to 1 that the true average will lie between $M \pm 3r$. If we take five times r, then, according to Heincke, the probability is 1000 to 1 that the true average lies between $M \pm 5r$.* Through this method, therefore, we are given the means of testing and telling the amount of probability or certainty in our results.

The further developments of the mathematical theory—the plotting-out and determination of the variations-curves, the correlation of variations and of averages—are not employed in the present paper, and may be left for future discussion.

A few words should be said as to the meaning of the words "variation" and "variability." According to the common usage in Biology, "variation" is a general and vague term, which might be applied to either "variants" or "deviations" as defined above. For common usage this does not much matter, and in the present paper the term is employed in its general sense. But a good deal of confusion would arise in the mathematical method if its meaning were not made more precise. In the more restricted sense now employed, "variations" mean the observed deviations expressed in terms of the standard deviation.

The definition of the term "variability" is extremely difficult. It is one of those words which imply potentiality or possibility, and is best described by showing what it is not. Any character whatsoever presents a series and range of variations, but variability is not the variations nor the range of variations. These are the outward expressions or indications of the variability, which is something potential and innate. In one and the same individual, again, the characters do not all remain constant and unchanging throughout life, but alter with growth, and here, again, variability is not the actually observed change, but the possibility of that or any other change. Variability is, however, not indefinite, so far as we know, but gives rise to variations which are limited within a certain range. Variability is thus a general term which indicates the power that an organism possesses of giving rise to variations. These variations are particular observed objects more correctly spoken of by reference to a particular observed average, and their standard deviation about that average is a measure of the variability, and is thence called the "index of variability."

The various forms of "variability" will be presently dealt with; meanwhile it is of importance to show more closely the underlying meaning and inter-relation of these conceptions. This subject has recently been discussed by Professor Sedgwick,† who endeavours to make a generic division of variations into two kinds—genetic and acquired. Genetic variations are inherent in the constitution of the individual. They arise in the germ in consequence of conjugation, and manifest themselves in "habit, constitution, form, and structure." They have nothing to do with the environmental conditions. On the other hand, acquired

* The "fluctuations of the averages" in the Tables are based upon the formula $M \pm 5r$.

† Address to the Zoological Section of the British Association, Dover, 1899.

characters or variations are "those which are caused by the direct action of external conditions." Theoretically, the difference seems obvious, yet, when it comes to the working out in details, Sedgwick's own words show that the distinction breaks down. In one place (p. 8) he says "it would appear, then, that every feature which successively appears in an organism in the march from the uninucleated zygote to death is an acquired character." If so, how should we be able to tell that any observed change in habit, constitution, form, or structure was genetic?

This point is of the utmost importance in many ways, and the crux of Sedgwick's position is found when we take the environment into consideration. If we could conceive of a zygote developing into an adult or passing through any stage whatsoever independent of the environment—*i.e.*, "outside of" an environment—then we should unhesitatingly call its features "genetic." But do any features arise independent of external stimuli? So long as we are forced to believe that an organism is in touch with the environment from beginning to end, then, according to his own definition, we are obliged to call every feature or variation "acquired." The difficulty arises from the new meaning which Sedgwick has given to the words "acquired characters." Formerly these meant simply such changes as were directly traceable to some impression of the environment, such as mutilations, and to such as were caused by the activity of the organism, such as the increase of muscular tissue. The old meaning was, however, too indefinite and vague, and Sedgwick's definition undoubtedly clears the air. If we accept his definition of "acquired character" as given above, it is evident that we now require a new classification of acquired characters.

On this view therefore we may call the observed particular features of any organ or structure an "acquired character," and the advantage of this is that our attention is directed to the environmental conditions—*i.e.*, the stimuli which have led to the appearance of this particular feature. Behind these characters is the formative protoplasm which tends to take definite shape in diverse ways—*i.e.*, possesses "variability"—and is finally led into one particular line by particular stimuli of the environment.

We may briefly refer also to the complex question of heredity. If all the particular features of structure and form of an organism are acquired in its own individual life-time, what does it receive by inheritance? Obviously, as Sedgwick points out, we may conclude from the above reasoning that the offspring does not receive through the germ any particular feature whatsoever—*i.e.*, acquired characters are not inherited. If the same features recur in successive generations we should look for the reason in the continuation or successive reappearance of similar environmental stimuli. The importance of this conclusion is widespread, for we account for the appearance and reappearance of particular features in parent and offspring, not merely by the continuity of the germplasms, but also by the continuity of the environmental conditions. In other words, the so-called inheritance that parents bestow upon their offspring is the inheritance of better, worse, or similar living conditions to those they themselves possessed.

It follows from these conceptions that when we talk of particular characters being "preserved by inheritance" we mean that the environmental conditions must remain the same. Thus, if we should find that a particular species of fish, say, the herring or the plaice, was divisible into groups, and we should say that the essential condition for the permanence of each group was the continual inheritance of the parental characteristics, we mean that the environmental conditions must remain similar or nearly so throughout. If we had reason to believe that these conditions altered, or that the parents, through migration or otherwise, did not return continually to similar spawning places under similar conditions, we should be forced to admit the uselessness of searching for groups or "races." It will be shown, however, on the contrary, that we have good evidence to believe that through habit or instinct the animals of a group return constantly to approximately the same places and conditions where they were born in order to spawn. Thus, we have the essential "inherited" conditions for the maintenance of a group or race.

What would happen, however, if the conditions changed in the meanwhile? Obviously we could not expect the "acquired characters" to remain constant. If the change was so extreme that the variability possessed by the organism could not respond to the impressed stimuli we should expect that none of the offspring would survive. As an example of this wholesale destruction of a group or species may be mentioned the remarkable case of the tile-fish in American waters. If the variability possessed by the organism was, however, equal to the emergency, then we should expect that the new "acquired characters" would differ greatly from the old, and would be similar to the characters of any other group of the same species which had formerly lived under these new conditions. If the new conditions had come to stay, might we not believe that "through the nature of the organism and of surrounding conditions, but not through natural selection,"* a new group or race had been formed, and if a new group, why not a "new" species?

This conceivable mode of the differentiation or formation of species, is not to be confounded with "evolution" or the process by which one form has developed from another so that the distinction of higher and lower may be made—which is a related yet quite separate problem.

The Various Forms of Variability.

The questions in connection with variability resolve themselves into at least three distinct main problems, which are so closely related to one another that it is necessary to treat of them together, and yet so complex and large that they demand separate attention and study. These problems arise from the different ways that the variability of the organism shows itself. There are (1) *sex-variability*; (2) *growth-variability*; (3) *race- or family-variability.* Another form of variability has been suggested by Heincke, namely, *asexual variability,* which is meant to include the differences that would be found between two groups of animals after the other forms of variability have been eliminated. It is doubtful, however, whether these differences would not come under the heading (3) race-variability in the end.

I. *Sex-variability.*—Sex-differences are divided into two classes—primary, those directly concerned with the reproductive organs; secondly, those not so connected, but in some way related to sexuality. Only the latter group come into the present research. In the class of fishes, as a whole, secondary sexual differences are not so well marked as in other vertebrates, but where they do occur they manifest themselves in a similar way, in colouration, structure of the jaw, for example. The question is whether they occur in the plaice.

No very definite external differences have been found except in the case of "ciliated scales," and even this is doubtful. Both Duncker† and Cunningham‡ found that the mature males possessed these scales, but

* Darwin, C.: "Origin of Species," ed. 6, p. 176; cited by Professor Sedgwick, *l.c.*, p. 12.

† Duncker, G.: "Variation u. Verwandtschaft v. *P. flesus* L. u. *P. platessa* L.," *Wisen Meeresunter.*, B.T.H. 2, 1896.

‡ Cunningham, J. C.: "Peculiarities of Plaice from different Fishing Grounds," *Jour. Mar. Biol. Ass.*, Vol. IV., 1897, pp. 315–357.

Cunningham shows that they are to be also found, though much less frequently, in the females. It is given by Duncker and Cunningham, however, as a secondary sexual character, although it may be associated rather with some peculiarity in the environment, because it seems to occur more frequently in the Baltic plaice than in those of the North Sea.

Other secondary sexual differences found by Duncker and Cunningham lay in the height of the body, length of the head, and number of vertebræ and fin-rays. The conclusions of Duncker were, however, inconclusive,* because of the small number of specimens that he worked with, and because the majority were immature. The differences due to growth, therefore, are not clearly separated from those of sex. Cunningham's conclusions labour under the latter difficulty also, and they are even more unsatisfactory, because he did not calculate the averages.

The various characters examined by these observers may be gone over in detail.

Vertebræ and Fin-rays.—These have been examined for sexual differences without result. One example only need be taken. In the adjoining Table IV. the frequencies of the dorsal fin-rays in both sexes and in different regions are given in full, the averages of each are given in the fourth column, and the fluctuations of the total averages are stated at the foot.

A glance at the averages will show that they are on the whole slightly larger for the males than the females—a result in contradiction to Cunningham's conclusion, but that the fluctuations of the total averages overlap and agree more than they disagree. The conclusion is, therefore, forced upon us that we cannot find any secondary sexual differences in the dorsal fin-rays. In a short preliminary note of his work on the variability of the flounder, Duncker† shows the same result for all the fins.

The vertebræ and other fins examined by myself lead to the like conclusion, and in their work on the herring both Matthews‡ and Heincke§ found the same thing. It is allowable, therefore, to take the males and females together so far as regards the numbers of vertebræ and fin-rays.

* See criticism of Duncker's work by F. B. Stead, *Jour. Mar. Biol. Ass.*, Vol. IV., p. 293.

† *Jour. Mar. Biol. Ass.*, Vol. V., 1898, pp. 172–175.

‡ Matthews J. D.: *S.F.B. Rep.*, IV., p. 61; V., p. 295.

§ Heincke, F., *l.c.*

[TABLE.

Table IV.—Dorsal Fin.

Region.	Sex.	No. of Specimens.	Average of Frequencies.	Frequencies of Rays in Dorsal Fin.																		
				64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82
Aberdeen,	♂	154	72·91	1	–	1	6	–	5	15	15	29	15	20	17	15	8	6	1	–	–	–
	♀	100	72·38	–	–	–	1	5	8	16	11	19	6	11	10	3	4	4	1	–	1	–
Grimsby,	♂	60	72·85	–	1	1	–	3	1	8	4	6	6	14	6	6	2	1	1	–	–	–
	♀	60	72·17	–	–	–	1	3	3	8	10	7	11	6	7	3	–	1	–	–	–	–
Lowestoft,	♂	94	72·70	–	–	–	3	2	2	16	14	7	11	14	7	14	2	1	–	–	–	1
	♀	76	72·74	–	1	–	2	1	3	6	13	13	10	9	6	2	5	3	2	–	–	–
Helder,	♂	68	72·15	–	–	1	–	2	4	13	9	13	10	6	1	1	6	2	–	–	–	–
	♀	82	71·83	2	2	–	1	4	9	9	11	11	10	6	8	3	3	2	–	1	–	–
Heligoland,	♂	37	71·60	1	–	1	1	1	3	5	6	8	5	1	1	1	–	2	1	–	–	–
	♀	108	72·61	–	–	1	1	2	7	6	20	17	21	12	7	4	6	2	2	–	–	–
Total,	♂	413	72·64	2	1	3	10	8	15	57	58	63	48	55	32	37	18	2	3	–	–	1
	♀	426	72·37	2	3	1	6	15	30	45	65	67	58	44	38	15	18	12	5	1	1	–

Probable Error or Fluctuation of Average, ... ♂ 72·19—73·09
♀ 71·92—72·82

Body-height.—By this is meant the greatest distance between the dorsal and anal fins measured from their bases. As already mentioned, this dimension is taken in percentage of the total length of the fish minus the length of tail and length of skull. Both by Duncker and Cunningham it has been stated that this dimension was slightly greater in the females than the males. So far as their data is concerned, however, this conclusion is not very evident, and it will be seen from Table XI., p. 230, that such a conclusion can only be drawn with great caution.

In five groups—the males and females of each group being directly comparable as regards size and condition of reproductive organs—only one group shows a clear difference between the males and females in the fluctuations of the averages. This is the group of mature plaice from Aberdeen, which are over 350mm. in length. The fluctuations are 62·50–64·30 per cent. for the males and 65·48–67·88 per cent. for the females. The difference is certainly considerable, being on the average for a fish of 400mm. length about 8mm., or one-third of an inch in favour of the females. The number of specimens in both cases is, however, small, and it may be that this character is not well represented by them. In the other four groups, where the specimens are more numerous, the fluctuations of the averages overlap in each case, although the averages for the males are slightly smaller in all cases than those for the females. From the latter fact there is a certain amount of probability that a slight sexual difference in this character does exist.

In endeavouring to state the amount of this probability it must be remembered that the individuals, the averages of whose characters are here given, represent only a small fraction of the total in the sea, and yet that the probability can only be based on the actually observed values. On account of the former fact some might say that the averages given may not even approximate to the averages that would be obtained from an infinite number. Unless there is collateral evidence to show that the specimens examined are not sufficient in number and are not representative, however, the latter fact—that this is the only kind of evidence we can have—forces us to trust in the amount of probability there is in the results.

As they stand in the Tables the fluctuations of the averages are calculated from five times the probable errors of the averages. This means that if the averages did not overlap, then the probability is a thousand to one that the differences observed correspond to true differences in nature. The four groups in question will not give this amount of probability. If the probable errors are only multiplied by 3, however, then, according to Davenport (*l.c.*), the probability is only 19 to 1. Not one of the four groups in question will give the amount of probability. Again, if the probable errors are multiplied by 2 only, the probability is then 4 to 1 that there are real differences in nature corresponding to the observed differences. But none of the four groups give even this amount of probability. Lastly, if the probable error alone is used the probability is simply 1 to 1. This amount of probability is given by the three groups from the southerly North Sea, but not from the group of immature specimens from Aberdeen. In conclusion, therefore, if the group of mature specimens from Aberdeen be omitted, as being by comparison with the other groups not true representatives of the values of this character, then the probability of there being secondary sexual differences in this character is only 1 to 1—*i.e.*, it is just as probable that there are no such differences.

Length of Skull.—This corresponds to a certain extent with the dimension taken by Duncker and Cunningham, called the "length of the head." This latter was measured externally from "the apex of the lower jaw to the end of the opercular bone, on the upper side." Owing to the indefiniteness of the latter point, and to the consequent difficulty of taking this measurement accurately, this dimension is not so good or reliable as that taken on the hard skull. This dimension was measured along the ventral aspect from the extreme anterior edge of vomer to the extreme posterior edge of the basioccipital. As with the body-height, it is expressed in percentage of the total length minus the tail and length of skull—*i.e.*, of the "body-length."

Secondary sexual differences are somewhat more evident in this dimension than in the case of the body-height. In all five groups, Table XIII., p. 232, shows that the averages for the males are smaller by ·73 on an average than those for the females, although in only two groups—viz., the mature specimens from the southerly North Sea—are the fluctuations of the averages free from overlapping. If the same process of calculating the probability of the results be gone through here as with the body-height, it is found that the fluctuations of two more groups do not overlap when three times the probable error is employed. Hence, for these two groups the probability of differences existing is 19 to 1. For the fifth group—the mature specimens from Aberdeen—the fluctuations of the average cease to overlap when twice the probable error is employed, and the probability is then 4 to 1. In conclusion, therefore, the probability is, on the whole, in favour of there being secondary sexual differences in this character—being 1000 to 1 for two groups, 19 to 1 for two other groups, and 4 to 1 for the fifth. If an average be struck between these probabilities it may be said that the probability is about 100 to 1 in favour of there being secondary sexual differences.

Two fine points in connection with the working of the method may be mentioned here. It has been shown that the group of mature specimens from Aberdeen were not very representative with regard to the body-height, and this conclusion might be held to vitiate the value of this group in all other characters. This, however, is not so, because the body-height is an extremely variable character, having a wide range of deviations, and is, further, not so true and easily measured a character as the length of skull. Hence, the conclusions formed with regard to the body-height of this group do not apply to other characters.

Again, this group was at variance with the other groups in regard to the body-height, but in regard to the length of skull it is in entire agreement with the others—the greater size of the probable errors and thence of the fluctuations of the averages being really due to the smaller number of specimens. This example shows well how the probability or certainty of our conclusions varies with the number of specimens examined.

It may be mentioned that the only dimension which Heincke found to vary with the sex was the side length of the head, and the difference, in favour of the females as above, was very small, only $\cdot 5^{0}/_{00}$ (*l.c.*, p. 94).

In the other dimensions of the skull, *skull-breadth* and *skull-depth*, Tables XIV. and XV., pp. 233, 234, show that relative to the skull-length there is no sex-variability. The differences in the averages for the males and females are very slight, and sometimes the average for the male is the higher, sometimes that for the female.

It has just been seen, however, that the skull-length is slightly greater in the female than in the male. Hence, the measurements of the skull-breadth and skull-depth partake of this difference when referred to the body-length. The calculation of the exact amount of difference is somewhat complicated, but if approximate values are given to the breadth and depth of skull a very close approximation to the true values can readily be obtained. From the Tables it will be seen that the skull-breadth is very little less than $\frac{1}{2}$ of the skull-length, and the skull-depth a little more than $\frac{1}{3}$ of the same dimension. The difference between the males and females—viz., ·73—for the skull-length has to be multiplied by these fractions in order to give the approximate amount of differenee in the breadth and depth relative to the body-length. The skull-breadth is therefore relatively greater in the females by $\cdot 36^{0}/_{00}$ than in the males, and the skull-depth is similarly greater by $\cdot 25^{0}/_{00}$.

The reason for this difference in the dimensions of the skull between the males and females does not seem difficult to perceive. It is probably connected with the position and mass of the reproductive organs. These are larger in the female and are placed further back than in the male. The centre of gravity in the plaice seems to lie close to the first caudal vertebra, and the male reproductive organs are placed along the hæmal and interhæmal spines of this vertebra, and anteriorly to it, whilst the female organs lie along the interhæmal spines posteriorly. The greater size and therefore mass of the skull in the female would counterbalance anteriorly the greater mass of the reproductive organs posteriorly.

Tail.—Table XII., p. 231, shows that there is very little sex-variability in the length of tail. In the females it is longer in four groups, but in the fifth group the males have a slightly greater length of tail than the females. It is therefore difficult to decide from the observed specimens whether this variability is present in the tail or not. A slight probability tells in favour of the females having the longer tails, and this may be correlated with the differences in the body and skull already described.

It should be mentioned that the length of tail was measured along the longest fin-ray, the median one. The proximal end of the fin-ray is found by bending the fin to the side, and then the point of junction of the fin-ray with the ring of cartilage that terminates the hypural elements is obtained with little difficulty. This dimension is perhaps of little value on account of the variation in size caused by fraying of the distal extremity. This affords another good reason for deducting the tail-length from the total-length of the fish in choosing the standard dimension—in percentage-values of which the other dimensions are expressed.

II. *Growth-variability.*—This form of variability is a much more important factor in giving rise to differences between groups of individuals than is sex-variability, and must be carefully eliminated before conclusions can be made with respect to race-variability. It is, further, a much more complex factor and gives rise to problems extremely difficult to unravel.

Some of these may be briefly referred to. There is, first, the possible difference of age in specimens about the same size, and in the case of some organs, as, for example, the skull, it might be thought that the hardening process or ossification would depend upon age and not upon growth. There seems no clue to the solution of this difficulty for the present, but if it be considered that, so far as known, there is no definite limit to the growth of such parts in fishes—unless we imagine such a limit to be like the limit of a convergent series in mathemathics—and that time or age is therefore of minor consideration, then attention may be directed to the question of change in growth only. Treating the matter more definitely, if we suppose that of two fish about the same size one may be seven years old and the other only five, then our conception of a convergent series in mathematics permits us to disregard the difference in age—because the difference in the size of a part considered as due to this difference of age would be of the third or fourth order of infinitesimals in comparison with the sizes of the parts dealt with—and thence to consider the two specimens as of the same age. In actual observation, also, we are obliged to follow this course, because we cannot as yet fix the age of a fish by its size beyond the first year or two.

In connection with this question an interesting paper by Reibisch* which has recently been published may be referred to. He endeavours to show how it is possible to tell the age of a plaice by an examination of the otoliths. These, according to his view, grow by successive depositions of calcareous matter, and hence the rings formed at the successive stages may be utilised to tell the age of the fish, just as the successive rings in wood tell the age of a tree. This interesting suggestion came too late for use in the observations recorded in the present paper, but it will not be difficult to act upon it in future.

A further problem arises when the rate of variation in fishes of presumably the same age is considered. If a group of individuals be taken which are alike in the condition of their reproductive organs—*e.g.*, immature males, and which are nearly alike in size—*e.g.*, between 250 and 350mm.—it is found that they differ greatly from one another in every character, and these differences when arranged according to the method of variations give a certain average condition and a certain range of variation round this average. The average condition may be compared directly with the average of other similar chosen groups, but the question at present is to account for the range of variations. With respect to certain characters—*e.g.*, numbers of vertebræ and fin-rays—which, as will be shown, do not vary with growth, the range of variations must arise from influences which are operative on the organism when these parts are in process of formation. These parts are fixed at the earliest stages, when the fish is in the larval and post-larval condition, and the influences that affect their formation are for the most part the surrounding physical and chemical conditions. It might be thought, and it has been stated, that the differences in the amount of food—*i.e.*, of nutrition—may affect the formation of these parts, but it seems to me that such a factor is probably of secondary importance. These parts are not formed in a few minutes, so that the momentary condition of the animal has to be taken into account, but in the course of some days and even weeks. Considering, therefore, that the chances of obtaining food are the same for individuals hatched about the same time, it is possible that the differences in the physical and chemical conditions are of the first importance, and the differences in nutrition only secondary, in causing the variations of these parts.

This question may be left open, however, until further observation and experiment provide more satisfactory data. Under artificial conditions it is probable that the differences in nutrition are the sole cause of differences in growth,† but whether, under natural conditions, such differences in the amount of food obtained by each fish can arise may be doubted.

On the other hand, the differences in the physical and chemical conditions when these parts are in process of formation are well marked. The spawning-period for the plaice extends over three months, from January to March, for the most part, and the average change of the external conditions during those months is considerable, though not yet known very definitely. Hence these differences in the external conditions are perhaps of chief importance in causing the variation in the parts mentioned. It will be said, however, that the organisms which provide food for the young fish are the more abundant the further the season advances, and hence that the difference in nutrition may play an

* Reibisch, T.: "Ueber die Eizahl bei Pleuronectes platessa und die Altersbestimmung dieser Form aus den Otolithen," *Wissen. Meeresunter. Abtheilung*, Kiel, B. IV., 1899.

† *Vide* Cunningham, J. C.: "The Rate of Growth of some Sea-fishes, etc.," *Jour. M.B.A.*, v. II., 1891-92.

important part in causing differences in structure. It is possible, but at the earlier portion of the spawning period, when there is little nutrition to be had, there are also relatively few young fish, and at the later portions of the spawning period, when food is abundant, so also are the young fish. For such parts as the vertebræ and fin-rays, therefore, it is probable that the range of variation which is observed is mostly, if not entirely, due to the physical and chemical conditions.

In the case of other characters, length of fish, length of skull, and so on, the range of variations observed is probably due not so much to the physical and chemical conditions, nor to the differences in nutrition, but to the known difference of age. If the spawning period extends over three months and more, all dimensional parts will show in the range of their variations the effect of this range of variation in the time at which the individuals were born. If two individuals start out on life from the same place and about the same time, then the chances are that they will differ much less from one another than two other individuals which start out on life from the same place but at different times. Hence, the range of variation of any organ at any particular period of life may be considered as corresponding to the initial difference of age. Each period of life, however, has a certain average-condition for each character, and in order to obtain a measure of the growth-variability attention has to be directed to the change in this average-condition and not to the ranges of variation.

The converse problem of variations due to differences in place may be stated here for the sake of contrast. If two individuals start out on life about the same time but at different places, then the chances are that they will differ more from one another than two individuals which begin life at the same place, and the differences between them will be the greater the greater the distances between the two regions. Similarly for time, and if the two individuals in either case which have begun life at some distance from one another are the representatives of many others—of groups, in short—they may possibly represent two distinct races. The further condition necessary is that the offspring of the individuals should arise constantly at similar distances apart from one another as the two individuals mentioned. The external physical and chemical conditions will thus be constantly different, and the differences in the characters which depend upon these conditions will likewise be constant.

It follows from this that racial differences only differ in degree from the differences due, on the one hand, to age or time, and, on the other hand, to place, if it be understood that differences in time and place mean differences in the external conditions. Races may be recognised by other signs, such as differences in the average size at maturity, distinct differences in the times of spawning, distinct regions within which the migrations of the different groups are restricted; but from the examination of characters alone it is evident that certain limits must be ascribed to the ranges of variations due to age and place. The simplest method of picturing how these limits are obtained is that of arranging the different ranges of variations in the form of curves along the same axis. These curves will almost certainly overlap, but the centres of the curves will be at some distance from one another. The question then becomes—What must be the least difference between the centres so that we may say that these centres respectively represent distinct races? According to the method of treating variations already explained, these curves may be taken to represent distinct races if the probable fluctuations of the averages of each group do not overlap.

Before going further it has to be noted that the difference of "age" here spoken of is distinct from the difference of "age" referred to in the first few paragraphs of this section. A reference to the following Tables will make this distinction clear. In these, the specimens from two different regions are arranged into three groups—immature specimens between 250–350mm. in length, mature specimens of the same length, and mature specimens over 350mm., mostly between 350–450mm. If we consider any one of these groups, say, the immature, then the age of the specimens is uncertain. The individuals between 250–350mm., which are grouped together, may be three, four, or five years old, so far as our present knowledge goes. But this difference for the reasons given may be disregarded. All the groups are alike in this respect and thus directly comparable. On the other hand, the average in each group is the average of a range of variations which, even if we suppose the individuals in each group to be of the same year, have arisen from the initial differences due to age. Hence, in comparing the groups from the two different regions—southerly North Sea and Aberdeen—it is necessary that the probable fluctuations of the averages of the variations due to the latter cause should not overlap if we are to find racial distinctions.

The use of the words "differences due to age" in this sense may appear at first sight a little confusing, but when understood the distinction is of importance and the usage allowable.

If, now, two groups of different sizes, but from the same region—*e.g.*, the mature specimens from the southerly North Sea—between 250–350mm. and 350mm. and above, are compared, it is evident that the differences in the averages are not due to any of the causes yet mentioned. Such differences are usually ascribed to "growth-variability." In the length of the skull, for example, the average size—*i.e.*, the average ratio of the skull-length to body-length—diminishes with growth. This means that at whatever rate the body grows the head does not grow so fast. It follows from this example that it might lead to quite erroneous conclusions if a group of mature specimens between 350 and 450mm. coming from one region was compared with a similar group, but between 250 and 350mm., coming from another region. The differences found might really be due to this growth-variability, although ascribed to race-variability.

It is difficult to say what this growth-variability may mean. Separate explanations have to be given for each character that presents this variability, but in general it may be connected with the balancing of the different organs and structures. The weight of the head, for example, will increase in a greater ratio than will the length of the skull, and it may be, therefore, that the greater rate of increase of the body-length relative to the skull-length is correlated with the rate of increase of the head-weight.

In the discussion of the growth-variability of the various dimensions the influence of maturity will also be mentioned.

Vertebræ and Fin-rays.—In the following Table a collection of 341 plaice from Heligoland is divided up into three lots according to the differences in size:—

[Table.

TABLE V.

Growth Variability in Vertebræ and Fin-rays.

M—Average ; P.F.—Probable fluctuation of average ; No.—Number of specimens.

Length in Mm.	No.	Vertebræ.		Dorsal Fin.		Anal Fin.	
		M.	P.F.	M.	P.F.	M.	P.F.
16- 25	134	43·05	42·95 -43·15	72·45	71·69–73·21	54·31	53·70–54·92
67–300	113	43·03	42·93 -43·13	71·83	71·05–72·61	53·30	52·68–53·92
300-464	94	43·01	42·895–43·125	72·53	71·75–73·31	53·99	53·37–54·61

It is evident that the vertebræ remain the same throughout, because, even when the simple probable error of the average is employed, the fluctuations still overlap. The fin-rays, however, seem to show a decrease and then an increase. In the case of the dorsal fin there is no difference between the smallest and the largest lots, but the fluctuations of the averages between the intermediate lot, from 67–300mm. and those on either side, cease to overlap when twice the probable errors of the averages are taken instead of five times. In the case of the anal fin, the smallest and largest lots are again almost the same, but the averages of the intermediate lot do not overlap with those of the first when four times the probable error of the averages are used, and do not overlap with those of the third lot when twice the probable errors are employed. There would thus seem to be some evidence of a decrease in the numbers of fin-rays during the intermediate stages of growth, but this is counter-balanced by a subsequent increase. This process seems improbable, and it is safer to conclude either that the intermediate lot is not representative or that a difference in the external conditions in the different years has given rise to these observed differences.

Duncker (*l.c.*, p. 174), in his work on the flounder at Plymouth, similarly divided up the specimens into different lots according to size, but although there are slight differences in the averages at the different sizes both for the dorsal and anal fins, they are too small and too irregular to be recognised as differences due to growth-variability. Heincke found also for the herring that there were no such differences, and this seems to be the most reasonable conclusion for the plaice. This point will be referred to again.

Body-height.—A reference to Table XI., p. 230, will show that there is very little growth-variability in this character. The difference that there is tends to show that a slight increase takes place, but it is very slight, and the amount of probability is small. It will be noticed, further, from this Table that maturity has little or no effect on the body-height, the averages for the southerly portion of the North Sea being practically identical, whilst in the case where a difference is shown—viz., in the male specimens from Aberdeen—the probability is very small in favour of a decrease.

Similar conclusions hold for the *Tail* (Table XII., p. 231); the changes in the averages are irregular, and the differences too small to admit of any probability in favour of a decrease or an increase in length. Maturity also has no effect on this character. Hence, we may conclude that the body-height and the length of the tail do not alter relative to the body-length during growth.

Skull-length.—This dimension, as Table XIII., p. 232, demonstrates, shows a decrease due to growth-variability in all the groups. If the groups of mature specimens alone be considered, then a comparison of three groups between 250–350mm. with other three between 350mm. and upwards is possible. In the first two groups—those from the southerly North Sea—the probability is about 1000 to 1 in favour of a decrease in the relative length of the skull. In the case of the third—the male specimens from Aberdeen—the probability in favour of this decrease is only about 4 to 1, but it will be noticed that the number of specimens is small in comparison with those of the former groups, and this, as already mentioned, lowers considerably the amount of probability.

The decrease is for the three cases ·88, 1·01, and ·36. The average of these is ·75, so that there is a decrease of ·75 per cent. in the length of the skull relative to the length of the body in mature specimens. The difference in the total length of the fish is approximately 100mm., because the average for the specimens between 250–350mm. is 300mm. in both cases, whilst that for those over 350mm. is just a little under 400mm. This decrease in the skull-length, it will be noticed, applies both to males and females.

If the first two columns be now considered, those containing the immature and mature specimens of the same size between 250–350mm., it will at once be noticed that the differences in the averages between the two groups are smaller than were those between the mature specimens at different sizes. The average difference, indeed, only amounts to ·42 per cent., where above it was ·75. Again, if the probability of the observed decrease be calculated, it is found to be 19 to 1 in the first two cases—*i.e.*, those from the southerly North Sea, but only 1 to 1 in the third case—*i.e.*, the male specimens from Aberdeen. Hence, the probability that maturity, or the ripening of the reproductive organs, affects the length of the skull is comparatively small, and the actual decrease observed is small in comparison with that observed as due to growth-variability.

Both Matthews and Heincke found that the length of the skull relative to the length of the body decreased in the herring during growth, but do not give the amount of decrease. The comparison between the herring and the plaice—a free-swimming round fish with a semi-sedentary flat fish—would, on this point, as on many others, be of considerable interest. Such a comparison will be possible later when the promised second portion of Heincke's work appears.

Skull-breadth.—This dimension was measured from the pterotic of the one side to the pterotic of the other, near the posterior extremity. In the plaice the posterior end of the pterotic slopes backwards and inwards to form an articulating surface for the second head of the post-temporal bone of the pectoral arch, and thus presents no definite end-points for measurement. Immediately in front of this articulating surface is the last tubercle on the pterotic, and as this tubercle offers a definite end-point the dimension was measured from tubercle to tubercle. The variations in height of these tubercles are thus included under the variations of the skull-breadth.

As with the skull-length, Table XIV., p. 233, shows that there is a decrease in the breadth of skull relative to the increasing length of body. The proportions given in the Table are relative to the skull-length, but as this decreases with increase of body-length, the observed decrease in skull-breadth relative to skull-length must be all the greater when considered relative to the body-length. If the groups of mature specimens alone be considered, it is seen that the probability of the observed decrease being real is much less than it was in the case of the skull-length. In the first two cases—those from the southerly North Sea—the probability is about 19 to 1 in the first case and about 4 to 1 in the second in favour of the decrease. In the third case—the group of male specimens from Aberdeen—the probability is again about 4 to 1. The amounts of this decrease for the mature specimens are respectively ·73, ·42, and ·60 in the three cases, which gives ·58 of a decrease on the average. If this amount of decrease, which is relative to skull-length, be added to the decrease of skull-length relative to the body-length, ·75 per cent., and divided by 2 as before, then we find that an approximate decrease of ·66 per cent. takes place in the skull-breadth relative to the body-length as the total length of the fish increases by 100mm.

If the total length of the fish, including tail and skull-length, had been used as the standard and not the body-length, this result, along with that showing the relative decrease in skull-length, would then perhaps have been easier to grasp. A short and simple calculation from the values given will show approximately this decrease relative to the total length of the fish. The length of the tail relative to the body length has been shown to be constant during growth, and practically $30^0/_{00}$. The relative length of the skull at 300mm. is—for the southerly North Sea specimen—practically $25^0/_{00}$. Hence, since the body-length has been taken as 100, the total length of the fish is 155. This gives the skull-length as $16{\cdot}1^0/_{00}$ of the total length of the fish at 300mm. At 400mm., again, the relative tail-length has not altered, but the relative skull-length, for the same groups, has become approximately $24^0/_{00}$. Hence, the total length of the fish is now represented by 154, and the skull-length relative to this is $15{\cdot}6^0/_{00}$. The decrease in skull-length, therefore, is $\cdot5^0/_{00}$ where the increase of total length is 100mm., or, in other words, at 400mm. the skull is 2mm., on an average, shorter than it would have been if there had been no growth-variability. If a similar calculation is gone through for the skull-breadth, it is seen that $\cdot45^0/_{00}$ of a decrease occurs, and hence that the skull-breadth is narrower at 400mm. by 1·8mm. than it would have been if there had been no growth-variability.

To return again to the Table, a comparison may be drawn between the immature and mature specimens at the same size. It will be remarked that there is a decrease in each case, but the probability that this observed decrease is real is only 4 to 1. The amount of the decrease is, on the average, $\cdot42^0/_{00}$. As was remarked in the case of the former dimensions, maturity, or the ripening of the reproductive organs, seems to have little effect during the first period on the structures observed. It might have been thought that the maturity of the reproductive organs would lead to the withdrawal of nourishment from other parts. This is probably the case, but from what has just been shown its effect seems to be less during the first than during the second period. The difference between the immature specimens with average at 300mm. and the mature specimens with average at 400mm. is, on the average, $1{\cdot}00^0/_{00}$, whilst between the former and the mature specimens of the same size it is only $\cdot42^0/_{00}$.

Further remarks on the relation of "maturity" to "growth-variability" will be made at the end of next section.

Skull-depth.—This dimension was measured from the commencement of the supraoccipital spine to the middle of the base of the basioccipital region of the skull. This dimension is not always satisfactory, because the supraoccipital spine is liable to injury. The second point on the base of the skull is fairly well-defined by the markings on the parasphenoid bone, which are left when the pharyngeal teeth are removed. These are attached to the expanded part of the parasphenoid under the basioccipital by strong ligaments, and when the latter are taken away a rough patch on the parasphenoid forms a good end-point. The line joining this to the commencement of the supraoccipital spine passes at right angles to the longitudinal axis of the skull.

Table XV., p. 234, shows that this dimension does not alter either with maturity or with growth. The averages remain practically stationary throughout, and the slight differences there indicate neither increase nor decrease. The depth of the skull, therefore, grows at the same rate throughout relative to the skull-length, but the latter, as has been shown, decreases relative to the body-length by $\cdot 75\,{}^0/_{00}$, when the total length of the body increases by 100mm. Hence, relative to the body-length the depth of the skull decreases by $\cdot 26\,{}^0/_{00}$ approximately.

It has been shown, therefore, that for the three dimensions of the skull whose variability is recorded here a decrease in the rate of growth takes place relative to the body-length between 300 and 400mm. If the rates of decrease of the three dimensions considered be taken relative to the total length of the fish, the amounts become ·5, ·45, and $\cdot 18\,{}^0/_{00}$ for an increase in total length of 100mm. The rates of decrease, therefore, for 1mm. of increase of total length are $\frac{\cdot 5}{100}$, $\frac{\cdot 45}{100}$, and $\frac{\cdot 18}{100}$ or $\frac{50}{10^4}$, $\frac{45}{10^4}$, $\frac{18}{10^4}$. If the skull were a regular six-sided figure, with length, breadth, and depth corresponding to the actual dimensions of the skull, this would mean—neglecting the products of the above fractions—that a relative decrease in volume of $\frac{113}{10^4}$, or about $1\,{}^0/_{00}$, took place. For such a box this relative decrease would be very small, but in the case of a skull whose volume is only a fraction of that of the box the relative decrease is considerable. It is not simply the volume that is affected, but the weight or mass also, and this must be of some moment. As already mentioned in connection with the relative decrease in skull-length, the reason of the decrease in the skull probably lies in the necessity for a certain constant balance between the weights of head and body always being preserved. On account of the greater mass of the skull relative to the mass of the body, if the dimensions of the head and body increased uniformly together, the head would become relatively much heavier than the body. This would disturb the balance and form of the animal—the qualities most fixed in the species, if anything can be regarded as fixed. In the section on sex-variability it has been shown that the weight of the skull is probably greater in the females than in the males, and this was also explained by the necessity of preserving the balance between head and body. In the herring, again, Heincke has shown that the relative positions of the fins, as well as the length of the bases of the fins, vary during growth, and he has correlated these changes with the movements of the animal, and consequently with the interbalancing of the separate structures and organs.

If we take up now the question of maturity, or the ripening of the reproductive organs, in the light of this conception of the balancing of organs, we see that we have at one and the same time a physiological cause of the changes in the relative positions and sizes of organs during growth, and, on the other hand, a reason for the changes. It has been shown that the maturing of the reproductive organs hardly affects the relative proportions of structures during the first year, but that later—if 400mm. be considered for the time being as the average-size of a group in the second or later years of maturity—its effect is more clearly marked. Hence, the withdrawal of a portion of their ordinary nourishment from other parts of the body for the sake of the reproductive organs is the direct physiological cause of the relative decrease in size of those parts. And, on the other hand, we see that this relative decrease has a place in the general fitness of things, because the balance of the organism is thereby preserved.

III. *Race-variability.*—After what has been said at the beginning of the section on growth-variability, little further mention need be made of the relationship of racial to the other forms of variability. It has been shown that race-variability differs only in degree from the variability that is present in a single group, and that the relationship between them may be pictured by the aid of curves. If the variations of a large number of specimens be plotted out in the form of a curve—the course of the curve representing the "frequencies" accompanying each "variant," the "variants" being marked off along an axis (abscissal axis)—then three eventualities may arise. The curve may be quite continuous and have only one maximal frequency (*unimaximal curve*), or, again, continuous but with two or more maximal frequencies (*multimaximal curve*). This latter form—if a certain distance, undefined by the author, lie between the maxima—has been taken to represent "discontinuous variation" by Bateson,* but it is clear that the word "discontinuous" is here misused. The different forms of variability give rise to ranges of variation, which grade into one another just as those of the external conditions in the environment are supposed to do, and the continuity of the curve represents this continuous gradation. "Discontinuous variation" is present when the two curves—*i.e.*, the two ranges of variation—do not overlap at all. Such would arise when the variabilities of two widely-separated species—*e.g.*, plaice and herring—were compared.

To return to the consideration of the multimaximal continuous curve, this may arise in the observed variations of a character of a group of specimens in four different ways. Firstly, through *sex-variability.* It has been shown in the section dealing with that subject how a group of specimens, alike as regards age and region from which they came, may show two distinct averages for the variations of a character by reason of a difference between the sexes. If the sexes be taken together, therefore, and the frequencies of the variants plotted along a curve, this curve may present two maxima. Hence, when two different groups are to be composed, it is necessary either to compare similar sexes only, or to calculate, according to Galton's method, a sex-factor for each group so as to eliminate the difference between the sexes.

When sex-variability has been eliminated a multimaximal curve may arise, secondly, through *growth-variability.* This appears in the changes of the relative proportions of parts and organs during growth and maturity. When two groups of specimens otherwise alike, but one about 300mm. in length on the average, the other about 400mm., are compared, it has been shown that the averages of the variations in certain characters are not the same, and we may thus have a multimaximal curve when these variations are arranged in this form. Hence, if two groups of specimens are examined for racial differences, it is necessary either to compare the specimens of the same size in the two groups, or, as above, to calculate the growth-correction or factor so as to bring all the specimens to the same size.

* Bateson, W.: "Materials for the Study of Variation," Introduction; 1894.

When these two forms of variability have been eliminated a multimaximal curve may still arise from two causes—variability in time or age and variability in space. Both of these are included under the term *race-variability*, and it has already been shown that the difference between them and the latter is in each case only a matter of degree. Age or time-variability arises from the prolonged spawning period of a fish. An individual born at the beginning of this period cannot be exactly the same as an individual born at the end of the period. This is probably the chief cause of the range of variations in a character. If the spawning period has only one maximum, as is believed to be the case for each group of plaice, then it is improbable that a multimaximal curve of variations will arise from this cause. In the case of the herring, however, Heincke has shown that a large group of individuals inhabiting the same, or nearly the same, region may be divided up into two separate groups on account of this age-variability. Although connected by intermediate stages, there are, for example, two maximal spawning-periods for the herring of the east coast of Scotland, and in correspondence with this it is found that the averages of the variations in certain characters of these two groups are distinct from one another, although the ranges of variations overlap. Hence, we see how age-variability grades into race-variability and how a unimaximal may become a multimaximal curve. The degree at which the one passes into the other can be determined from the inspection of characters only by the method of probability already illustrated.

Again, multimaximal curves of variation and race-distinctions may arise from differences in geographical distribution, or space-variability. Individuals born at the same time but in different regions will differ more in their characters from those born at the same time and in the same region, and the wider apart the regions are the more likely are they to give rise to race-differences. The latter, therefore, arise from the former by differences of degree only.

It is this latter form of variability that has been found in the plaice, so far as observation has gone. It should be remembered, however, that race-variability does not necessarily arise from the time and space differences. Accompanying these must be other factors whose exact importance in any one case is not yet known. It is not difficult to see that the environmental conditions must differ just as much as the characters before race-differences can be said to be present, but this is not all. The characters of one generation in one local form may differ from those of the same generation in another local form; yet if these differences do not remain from generation to generation we are hardly justified in talking about "races."

Avoiding the question of heredity, this problem may be stated in another way. We may believe, in opposition to Bateson (*l.c.*), that the environmental conditions may be discontinuous as the "species" may be continuous—in the sense that he uses these words—because the environmental conditions of the whole life-cycle of the species must be considered, and yet the question will still arise, how do the "species" or "races" remain distinct and separate? Are the races "isolated" from one another either in time or space or physiologically by definite barriers? Most biologists who have written on the subject of isolation within recent years have considered that some such barriers were necessary, and Darwin himself, in the later editions of the "Origin of Species," after the effects of inter-crossing were pointed out to him, was inclined to agree with these views. Yet his original conception seems most suited to what we find amongst fishes at any rate. On a widely extended area, such as that occupied by the herring or plaice as species, for example, there need be no definite geographical or other barriers, and yet we can conceive how distinct races and thence species might arise. The individuals at the extreme ends of such an area may and do differ greatly from one another—in some characters as much as two separate "species" do—and there may be all intermediate stages. On such an area the individuals would probably aggregate into groups, and inter-crossing would be rare, except between contiguous groups. The older notions of extensive migrations amongst fishes are not now maintained, and hence races would spring up simply because the various groups always remained in nearly the same region, or because the spawning-period became extended over a great part of the year, and broke up into two or more maximal periods. It is evident that, so far as the environment is concerned, different races and even species might arise, because the external conditions would not be the same in the different regions or periods, and, again, if the external conditions in any one region remained always about the same average so would the group inhabiting that region.

On the other hand, it might be held that since there are no real and definite barriers in the sea the individuals of one group might pass by some means or another into a neighbouring region at an early stage and there assume the characters of the "race" of that region. This conception has been put forward by Petersen in order to explain the differences in the characters of the Baltic and Kattegat plaice. These differences, as will be shown, are considerable, but even if this interchange does really take place we should only have another example of the great variability of the organism, which would not refute the evidence for "races" in other regions.

The matter is still very obscure, however, and more facts are wanted. There has been a tendency—more especially in England*—to found "races" upon little or no evidence, and without in any way showing what was meant by "races." A few characters were taken, a little difference was found, and "races" were discovered!

In the following pages it will be shown how, after the elimination of the differences due to sex- and growth-variability, a difference determined by probability as before, remains between certain groups which seems due to race-variability as above defined. Whether such differences persist from generation to generation it is of course impossible to tell from the present facts, but other evidence will be shown which inclines one to believe that such is really the case.

The four groups of specimens from the southerly North Sea—*i.e.*, from Heligoland, Helder, Lowestoft, and Grimsby—are all taken together as one. No satisfactory reasons could be found for regarding them as separate. The evidence for this will be given in a later paper. Of course, there may be two or more definite groups or races in this region; it is only that the evidence is insufficient to justify the declaration of such. These four groups, considered as one, are compared with the specimens from Aberdeen, the Solway Firth, the Baltic, and a few from the Kattegat.

Vertebræ.—In the two following Tables the averages and their fluctuations are given for all the regions separately, except the Kattegat. In the first Table the total number of vertebræ is considered; in the second, the abdominal and caudal. That these two do not vary together can be seen at once from the figures for the Baltic. Whilst the average for the abdominal vertebræ in the Baltic specimens is as high as in those from Aberdeen, yet the average for the caudal vertebræ is considerably lower. Indeed, the abdominal vertebræ differ little in the whole region concerned,

* *Vide* Cunningham, T. C.: "On the Peculiarities of Plaice from different Fishing Grounds,' *Jour. Mar. Biol. Ass.*, Vol. IV., 1895–97, p. 315. Garstang, W.: "The Variations, Races, and Migrations of the Mackerel," *Jour. Mar. Biol. Ass.*, 1898.

the lowest average in the Solway Firth specimens being only ·06 less than the highest in the Aberdeen and Baltic specimens. This means that the size of the abdominal cavity is probably the same in all.

The case is different with the caudal vertebræ, and these may be considered before proceeding to the total number of vertebræ. The Table shows that the averages of the caudal vertebræ for the whole of the North Sea differ very little between themselves, the lowest, in the Helder specimens, being only ·125 less than the highest in the Heligoland specimens. The fluctuations of the averages, again, greatly overlap in these, and the only conclusion is that they are all identical in regard to this character. The specimens from the Solway Firth also have an average but little smaller than those from the North Sea, and the fluctuations of the averages overlap as before. On the other hand, the specimens from the Baltic differ greatly from the above. The average differs from the lowest of the others by ·48, and the fluctuations barely overlap. If it be considered that the number of specimens from the Baltic is comparatively small, and that this has the effect of increasing the size of the fluctuations, it may be admitted that a similar number of specimens from the Baltic, as from the other regions, would have reduced the fluctuations of the average so much that they would not overlap those of the other regions.

If we turn to the total number of vertebræ the same conclusions are forced upon us. The average for the whole North Sea is practically 43·00, and very little difference exists between the different regions. Helder has the lowest value, its average being ·1 less than those of the others. The standard deviation is, however, the greatest here, and this causes a bigger fluctuation of the average. Whether, if a much larger number of specimens from Helder was examined, this difference in the averages would remain constant, and thus tend to show that the plaice from Helder were really a distinct group from those of the other regions, it is difficult to say. There is a certain amount of probability, but it is at present small.

TABLE VI.—*Vertebræ.*

Average, M.; probable fluctuation, P.F.; standard deviation, σ.

Region.	No. of Specimens.	M.	P.F.	σ
Heligoland, ...	341	43·032	42·932—43·132	·56
Helder, ...	200	42·90	42·74 —43·06	·675
Lowestoft, ...	170	43·05	42·91 —43·19	·54
Grimsby, ...	120	43·02	42·84 —43·20	·59
Total, Southerly North Sea, .	831	43·002	...	...
Aberdeen, ...	254	42·996	42·882—43·110	·54
Solway Firth, ...	197	42·85	42·71 —42·99	·62
Baltic, ...	47	42·42	41·97 —42·87	1·02

[TABLE.

TABLE VII.

Averages for abdominal (M_1) and caudal (M_2) vertebræ; M_2.P.F., probable fluctuation of M_2.

Region.	No. of Specimens.	M_1.	M_2.	M_2. P.F.
Heligoland, ...	308	12·91	30·12	29·95 —30·29
Helder, ...	200	12·91	29.995	29·845—30·145
Lowestoft, ...	170	12·94	30·106	29·936—30·276
Grimsby, ...	120	12·94	30·07	29·87 —30·27
Aberdeen, ...	254	12·96	30·03	29·905—30·155
Solway Firth, ...	197	12·90	29·95	29·81 —30·09
Baltic, ...	47	12·96	29·47	29·07 —29·87

What has been said concerning the specimens from Helder applies with slightly greater force to those from the Solway Firth. The average is certainly smaller than that of the North Sea, and in such an important character as the vertebræ such a difference has considerable importance. It will be necessary to wait, however, until other characters have been examined before drawing definite conclusions.

For the specimens from the Baltic there can be little doubt of the great difference in the average. Although the fluctuations overlap with some of the other groups, the small number of specimens, as well as the large standard deviation, tend to show their distinctness from the North Sea groups. If the number of specimens were increased with a consequent diminution of the standard deviation the fluctuations would cease to overlap. As it is, the total fluctuation is ·9, whilst the greatest in the other groups is ·36. Again, Duncker (*l.c.*) found that the average for the Baltic was 42·3, which, if allowance be made for the comparatively small number of specimens in both cases, shows that the average is practically constant. He also gives the averages for the Kattegat as 43·0 and for Heligoland as 42·9, which shows that these groups are also fairly constant.

It is fair to conclude, therefore, that the average number of vertebræ remains the same for the whole North Sea and the Kattegat, that the Solway Firth group is perhaps different in this respect, and that the Baltic group is certainly different.

These differences lead to the consideration of what is known concerning the changes in vertebræ. Heincke shows that for the herring there is a difference between the groups of summer- and winter-spawners in regard to this character, the former having a smaller number of vertebræ on the average than the latter. Again, the American writers have shown in detail what Günther and others had previously remarked, that in each of the chief groups of flat-fishes the numbers of vertebræ decrease as we pass from the northerly to the southerly species. These remarkable facts would seem to show that temperature has something to do with the number of vertebræ. In the plaice it has been mentioned that there is no such extended spawning-period in the North Sea as there is for the herring. Further, it is probable that the spawning-period in the northerly North Sea is at its maximum a little later than that of the southerly North Sea. Hence, the difference in the temperature between these two regions at the spawning-periods may be very small, and thus we can understand the uniformity of the average number of vertebræ over the North Sea. And not only the vertebrae but the fin-rays, whose numbers are correlated with those of the vertebræ, are uniform over the whole North Sea, as will presently be shown.

The temperature is not the only influence, however, that seems to affect the vertebræ. The Baltic herring, like the plaice of that region, have a smaller average-number of vertebræ than the North Sea herring. Similarly, the herring from the Zuyder See resemble those of the Baltic in this character, and it has been remarked that the plaice from this region (Helder) are perhaps distinct from the North Sea. The average number of vertebræ and fin-rays in dorsel and anal fins is somewhat smaller than in those of the North Sea plaice. The difference between these regions and the North Sea is probably more one of salinity than of temperature. On the other hand, again, with the possible exception of the lemon-sole, the flounder is the nearest ally to the plaice in North Sea waters and has probably been derived from it. The essential difference between them lies in the vertebræ and fin-rays, which are, on the average, less numerous in the flounder than in the plaice. The young of the flounder, as is well known,* enter the brackish waters at the stage when the vertebræ and fin-rays are forming, and proceed thence into the fresh-water streams. On the other side we have the lemon-sole, which has apparently been derived from the plaice also, and differs from it mainly in the greater number of vertebræ and fin-rays. The young of this form are not found with those of the plaice and flounder, but seem to seek the deeper waters, where the salinity is greater and the temperature probably lower. The pole-dab (*P. cynoglossus*) shows a further advance in the same direction.

It appears, therefore, that salinity as well as temperature has been one of the factors leading to the differentiation of these races and species. Another factor has also to be taken into account, but the subject is too large and complex to be discussed here, and a consideration of the facts is postponed to a future period.

Fin-rays.—In the two following Tables, IX. and X., are set forth the averages of all the fins, the standard-deviations, and the fluctuations of the averages. As the full discussion of all that is contained in these Tables, as well as in those of the vertebræ, would lead to the consideration of many fine points interesting by themselves but not connected with the scope and object of the present paper, attention will be directed only to the general and obvious differences and resemblances.

Considering, in the first place, the dorsal and anal fins, reference must be made to the supposed differences which Cunningham found in these characters in plaice from Plymouth and the North Sea. As already mentioned, this observer did not calculate the averages of the observed frequencies, much less the probability of truth in his results, but trusted himself to general reasoning. The following Table gives the averages for the number of fin-rays found by Cunningham in the plaice for the different regions. The males and females are included together for the reasons stated in the section on sex-variability.

* *Vide* Kyle, H. M., *Sixteenth Rep., Scot. Fish. Board*, pp. 225–246.

[Table.

*Table VIII.

Region.	Plymouth.	Brown Ridges.	Norfolk Coast.	N.E. of Dogger Bank.
No. of specimens . .	36	109	140	43
Dorsal fin .	72·94	72·98	73·028	72·95
Anal fin . .	54·50	54·05	54·27	54·44

It will be seen that the averages for the dorsal fin are practically indentical in all—the greatest difference being ·088. In the anal fin the difference is larger, being ·45 between Plymouth and Brown Ridges. But these two regions are taken together by Cunningham to represent the southern samples, and Norfolk Coast and N.E. of the Doggar Bank are combined to represent a northern group. The averages for these two groups are 54·16 for the southern group and 54·31 for the northern. If one could form any conclusion, therefore, from the small difference between these averages it would be that the southern group had a smaller average-number of anal fin-rays than the northern, which is exactly the reverse conclusion to that reached by Cunningham by general reasoning.

Turning to the Tables IX. and X., it will be seen that the conclusions reached with regard to the vertebræ hold good also for the dorsal and anal fin-rays. The North Sea groups cannot very well be separated from one another, although the group from Helder shows signs that it may be separate. The differences, however, are too fine, as the fluctuations of the averages show, to admit of a definite probability being stated from the characters as to the actual existence of these differences. It can only be said that the plaice from the northerly parts of the North Sea—*i.e.*, Aberdeen—show a tendency to have more fin-rays than those from the southerly parts. The plaice from the Kattegat† come under the same category as those from Aberdeen.

The plaice from the Solway Firth, again, show slightly smaller averages than those from the North Sea, but the differences are again too small to admit of any great probability that they would constantly be found were more specimens examined. For the Baltic specimens, however, the case is very different. The fluctuations of the averages show no tendency to overlap, and the probability that these differences are really permanent becomes a certainty when the figures given by Duncker are considered. He found the average for the dorsal fin to be 67·6 and for the anal 50·4, both of which lie within the fluctuations of the averages given here.

* Made up from numbers given in *Jour. Mar. Biol. Ass.*, Vol., IV., 1897, pp. 356-357.

† I am obliged to Dr. Duncker of Hamburg for being able to give these values of the Kattegat and a number of the Baltic plaice here. In his paper (*l.c.*) the values were given as symbols, but he has very kindly permitted me to bring them into line with the system used in this paper.

[Table.

TABLE IX.

Average Number of Fin-rays in the Various Fins (M.), *with Standard Deviation* (σ).

Region.	No. of Specimens.	Dorsal.		Anal.		Left Pectoral.		Right Pectoral.		Left Ventral.		Right Ventral.		Caudal.	
		M.	σ	M.	σ	M.	σ	M.	σ	M.	σ	M.	σ	M.	σ
Heligoland, - -	341	72·27	2·57	53·89	2·10	*10·71	·80	‡11·14	·74	‡5·99	·226	‡5·980	·25	‡20·04	·46
Helder, - - -	200	72·01	2·61	53·65	2·05	10·80	1·22	11·135	1·14	5·980	·222	6·00	·00	20·05	·41
Lowestoft, - -	170	72·73	2·77	53·98	1·91	10·93	·65	11·26	·68	5·994	·077	6·00	·00	20·00	·33
Grimsby, - - -	120	72·51	2·66	53·98	1·88	10·91	·64	11·30	·76	5·984	·124	6·00	·00	20·07	·43
So. North Sea, - -	831	72·34	2·63	53·87	1·98	†10·83	·72	§11·20	·73	§5·989	·150	§5·995	·123	§20·04	·39
Aberdeen, - - -	254	72·69	2·70	54·28	2·09	10·98	·69	11·53	·64	5·985	·121	6·00	·100	20·045	·29
Solway Firth, - -	197	71·91	2·76	54·21	1·78	10·84	·74	11·30	·64	–	–	–	–	–	–
Baltic, - - -	143	67·23	2·71	49·98	2·16	‖ 10·23	·75	‖ 10·59	·73	‖ 6·00	·00	‖ 5·96	·204	‖ 19·73	·58
Kattegat, - - -	51	72·84	3·25	55·06	2·41	–	–	–	–	–	–	–	–	–	-

* 193, † 683, ‡ 194, § 684, ‖ 47 specimens.

TABLE X.

Fluctuation of the Averages of the Fin-rays.

Region.	Dorsal.	Anal.	Left Pectoral.	Right Pectoral.	Caudal.
So. North Sea,	72·03 —72·65	53·64—54·10	10·74 —10·92	11·11 —11·29	19·99—20·09
Aberdeen,	72·12 —73·26	53·84—54·72	10·835—11·125	11·39 —11·67	19·98—20·11
Solway Firth, -	71·245—72·575	53·78—54·64	10·66 —11·02	11·145—11·455	–
Baltic, - -	66·465—67·995	49·37—50·59	9·86 —10·60	10·23 —10·95	19·45—20·01
Kattegat, -	71·31 —74·37	53·92—56·20	–	–	–

The number of fin-rays in the pectorals leads to the same conclusions. The groups from the North Sea and Solway Firth cannot reasonably be separated from one another, but the Baltic group is again quite distinct. For neither of the fins do the fluctuations of the averages of the last group overlap with those of the other groups.

The ventral fins show very little variation, but the left ventral fin—*i.e.*, that of the under side—shows a greater tendency towards a reduction than the right. There is no difference in the different groups. In the caudal fin, again, there is more variation than one would expect, and the average for the Baltic group is somewhat under that for the North Sea groups. The fluctuations of the averages show also that the probability is almost 1000 to 1 in favour of the difference being real.

Considering the fin-rays as a whole, therefore, it is clear that the only distinct difference that is demonstrably permanent lies between the Baltic plaice and the plaice from the North Sea; the plaice of the latter region cannot be separated into races by these characters, nor can they be separated from the Solway Firth group.

In comparison with the flounder, the plaice possesses a greater variability in regard to its fin-rays. According to Duncker*, the standard deviation ("index of variability") is for the dorsal fin in the flounder between 2·3118 and 2·4445; in the plaice it is 2·63. Similarly for the anal fin; but the pectorals possess an equal variability in both. This large variability in the dorsal and anal fins shows how precarious any attempt to found "races" on the numbers of fin-rays must be. Even though the averages of two groups differed by one fin-ray the large possibility of variation would show itself in the overlapping fluctuations of the averages. There requires to be a difference of almost 2 in the averages of a large number of specimens of both groups before conclusions can be safely drawn. Further, this great variability probably means that these characters are very sensitive to slight changes in the environment when in process of formation, and if the average of these changes is not the same from year to year, the average number of fin-rays will likewise vary. This has been already referred to in the section on growth-variability, and it probably accounts for the slight difference in the averages given for the dorsal and anal fin by Duncker, Cunningham, and myself.

Those who are sceptical as to the existence of "races" and the possibility of detecting them may perhaps think that this probable change from year to year would explain the differences observed in other characters, and would thence destroy the validity of any conclusions

* *Jour. Mar. Biol. Ass.*, Vol. V., 1898, p. 173.

This is not, however, the case, and the example given tends rather to confirm our faith in the method than to destroy it. By means of the method we are able at once to see where conclusions cannot be drawn, and to give good reasons for not doing so. In the other characters, however, where the variability is not so great, there will not be such changes in the averages from year to year. Again, the fluctuations of the averages, which are calculated from the index of variability, leave room for the possible change in the average.

This objection which might be raised simply lays stress on the necessity of comparing, first of all, the individuals of the same generation—*i.e.*, of eliminating the growth-variability, and then of comparing successive generations in order to see if the differences are permanent—before stating definitely that groups or races exist.

Body-height.—It has been shown that no sex- or growth-variability can be ascribed to this character, and the specimens from the southerly North Sea might all be grouped together and similarly all those from the northerly North Sea. In Table XI., however, the sexes and the different sizes are retained separate, because what applies to any one set is applicable to the other.

Cunningham stated that the body-height was distinctly greater in the northern samples than in the southern, and the adjoined Table shows that such is really the case. Whichever groups we compare, male or female, mature or immature, we find the same conclusion. The average of the differences between five groups is $3 \cdot 91 \, ^0/_{00}$, and between none of the groups do the fluctuations of the averages overlap. The average body-height for the southerly North Sea is a little over $61 \, ^0/_{00}$ of the body-length, whilst that of the northerly North Sea is a little over $65 \, ^0/_{00}$ of the same length. Reducing the observed difference between the two groups to the percentage of the total length of the fish, we find that the northerly North Sea specimens are higher (or broader) by $2 \cdot 6 \, ^0/_{00}$ than the southerly North Sea specimens. This means that a plaice from the former region at 300mm. is greater by 7·8mm., or more than a third of an inch, than one from the latter region of the same size, and a plaice at 400mm. greater by 10·4mm., or nearly half an inch.

The average body-height of a small number of specimens from the Baltic is included in the Table for the sake of a comparison. Although there is no great certainty in the conclusion, the body-height of these is less than that of the northerly North Sea specimens, and approaches more nearly the average body-height for the southerly North Sea. This conclusion was also arrived at by Duncker. He found that the specimens from Heligoland were slightly smaller than those from the Baltic in this respect, and the latter, again, were considerably smaller than those from the Kattegat. And his conclusions, although he did not make allowances for growth-variability, are perfectly valid, because, as has been shown here, there is no alteration in this character during growth.

[TABLE.

TABLE XI.

Height of Body in Percentage of Body-length.

Region.	Sex.	Immature (250–350mm.)			Mature (250–350mm.)			Mature (350—mm.)		
		No.	M.	P.F.	No.	M.	P.F.	No.	M.	P.F.
So. North Sea .	♀	146	61·46	60·71–62·21	61	61·42	60·52–62·32	84	62·00	61·15–62·85
	♂	48	60·75	59·40–62·10	115	60·76	59·91–61·61	76	61·42	60·47–62·37
Aberdeen . .	♀	61	65·64	64·44–66·84	–	–	–	28	66·18	65·48–67·88
	♂	65	65·48	64·28–66·68	51	64·77	63·37–66·17	36	63·90	62·50–64·30
Baltic . . .	♀	–	–	–	30	62·27	–	–	–	–

There seems to be no other conclusion but that this difference arises from the presence of distinct races in the North Sea. Age-, maturity-, sex- and growth-differences are all excluded, and a probability, which amounts to a certainty, declares that the observed differences represent real differences in nature. We should expect, however, that this character would not be the only one to differ, because this difference in height means a difference in mass, and such a difference must be correlated with other differences in structure if the notion of the balance of organs already stated is correct. It will be shown later whether this is the case or not.

Tail.—It will be seen from the accompanying Table that the length of tail relative to body-length is practically identical in both the northerly and southerly North Sea specimens. Relative to the body-length, therefore, there seems to be no change in this character from any cause. The Baltic specimens seem a little longer in this respect, although the small number of specimens renders this conclusion uncertain. Duncker did not notice any difference, but he expressed this dimension apparently in percentage of the total length of the fish, and such fine differences would not be shown as when the dimensions were taken to the length of body only. An examination of more specimens from the Baltic would therefore require to be made.

[TABLE.

TABLE XII.

Length of Tail in Percentage of Body-length.

Region.	Sex.	Immature (250–350mm.)			Mature (250–350mm.)			Mature (350—mm.)		
		No.	M.	P.F.	No.	M.	P.F.	No.	M.	P.F.
So. North Sea .	♀	162	30·51	30·06–30·96	63	29·93	29·18–30·68	84	29·38	28·73–30·03
	♂	49	29·94	28·99–30·89	117	30·02	29·51–30·53	78	28·94	28·29–29·59
Aberdeen . .	♀	64	29·53	28·93–30·13	–	–	–	36	29·89	29·04–30·74
	♂	66	29·21	28·36–30·06	51	29·77	28·92–30·62	36	29·75	28·60–30·70
Baltic	♀	–	–	–	30	31·00	29·95–32·05	–	–	–

Average for North Sea, 29·77.

Skull-length.—It has been shown that this character possesses both sex- and growth-variability, but more especially the latter. It is therefore necessary to compare groups of the same sex and size, and this can readily be done from the Table adjoining.

Considering first the immature specimens, the Table shows that both for males and females there is a considerable difference between the southerly and the northerly North Sea. The latter have a shorter skull-length than the former. The average difference is $1{\cdot}335\,^0/_{00}$ of the body-length. The fluctuations of the averages, further, do not overlap in either case, so that the probability of the observed difference corresponding to a real difference in nature is at least 1000 to 1.

A comparison of the male mature specimens between 250 and 350mm. leads to the same conclusion. The difference between the two groups is, however, not so great, being ·82, and the fluctuations of the averages, although they do not overlap, are not so distinct from one another as in the former cases. Yet, from the fact of the fluctuations not overlapping, the probability of the observed difference being real is almost as great as in the above cases. There seems to be a further reduction in the difference between the two groups in the mature specimens above 350mm. The averages of the Aberdeen specimens are certainly smaller than those of the southerly North Sea for both sexes, but the average-difference is only ·37, and the fluctuations of the averages overlap in both cases. In the case of the females, the probability that the observed difference is real is 19 to 1, but in the case of the males it is only 1 to 1. As partial, if not the whole, cause of the overlapping of the fluctuations may be considered the comparatively small number of specimens in the Aberdeen groups.

Regarding the groups as a whole, the southerly North Sea specimens have a longer skull-length than those from Aberdeen, the average-difference for all five groups being ·846, and the probability is greatly in favour of this difference being real. For a plaice of 300mm. this means a difference of 1·7mm. between the two groups, and for one of 400mm. a difference of 2·2mm.

TABLE XIII.

Length of Skull in Percentage of Body-length.

Region.	Sex.	Immature (250–350mm.)			Mature (250–350mm.)			Mature (350—mm.)		
		No.	M.	P.F.	No.	M.	P.F.	No.	M.	P.F.
So. North Sea .	♀	162	25·93	25·68–26·18	63	25·48	25·03–25·93	83	24·60	24·15–25·05
	♂	49	25·24	24·69–25·79	117	24·62	24·22–25·02	79	23·61	23·21–24·01
Aberdeen . .	♀	64	24·50	24·05–24·99	–	–	–	36	24·03	23·38–24·68
	♂	66	24·00	23·60–24·40	51	23·80	23·40–24·20	36	23·44	22·89–23·99
Baltic . . .	♀	–	–	–	30	24·83	23·98–25·68	–	–	–

Again, it is seen that in this character also the Baltic specimens lie between the two other groups, but are somewhat nearer the southerly North Sea group than that of Aberdeen.

Skull-breadth.—The following Table, XIV., shows that in all the groups, both immature and mature, a considerable difference exists between the southerly North Sea specimens and those from Aberdeen with regard to this dimension The average-difference over all the groups amounts to 1·84 $^0/_{00}$ of the skull-length, the Aberdeen being larger than those from the southerly North Sea. The fluctuations of the averages, again, do not overlap in any of the groups, so that the probability amounts to a certainty in favour of this difference observed being real.

If this difference in skull-breadth be taken relative to the length of body instead of the length of skull, it becomes—taking skull-length as equal to one-fourth of the body-length—·46 $^0/_{00}$ on the average. Hence, independent of any difference in the skull-length, which has been shown to be less in the northern than in the southern groups, we find that there is an increase in skull-breadth in passing from south to north. For a plaice of 300mm. this difference amounts to ·9mm., and for one at 400mm. to 1·2mm.

We may briefly contrast the difference in skull-length with that in skull-breadth. For plaice of 300mm. the Aberdeen group is less by 1·7mm. in the former character, but greater by ·9mm. in the latter, than the southerly North Sea group. As they stand, however, these two differences are not comparable. The skull-length is more than twice the skull-breadth, so that any change in the former is of the same relative value as less than half that change in the latter. It would therefore appear that the one difference is counterbalanced by the other, or that what has been taken away from the Aberdeen group in skull-length is exactly made up for by an increase in skull-breadth.

A further reference to these correlated changes will be made in discussing the depth of skull. Meanwhile, it may be remarked that the Baltic plaice group is again intermediate between the two other groups, but that its average approaches more nearly to the southerly group than to the northerly.

TABLE XIV.

Breadth of Skull in Percentage of Skull-length.

Region.	Sex.	Immature (250 350mm.)			Mature (250–350mm.)			Mature (350—mm.)		
		No.	M.	P.F.	No.	M.	P.F.	No.	M.	P.F.
So. North Sea, .	♀	154	47·49	47·19–47·79	63	47·05	46·40–47·70	82	46·32	45·72–46·92
	♂	49	47·41	46·76–48·06	106	47·00	46·45–47·55	73	46·58	45·88–47·28
Aberdeen, . .	♀	62	49·05	48·30–49·80	–	–	–	36	48·14	47·34–48·94
	♂	66	49·41	48·71–50·11	51	49·00	48·00–50·00	36	48·40	47·70–49·10
Baltic, . . .	♀	–	–	–	30	47·80	46·65–48·95	–	–	–

Skull-depth.—As in the case of the skull-breadth, the sex- and growth-variability of this dimension does not affect the conclusions that may be drawn from the Tables as they are arranged. The same sizes and the same sexes may be compared directly.

It is seen that in all the groups the averages for the southerly North Sea are much smaller than those for Aberdeen. The difference between the various groups is very much the same in all, varying only from 1·21 to 1·55, and the average amounts to 1·35 °/₀₀ of the head-length. The amount of probability for the actual existence of these differences is very great, being 1000 to 1 in the first three groups, and but little less than that in the last two in spite of the large fluctuations of the averages in the groups of mature specimens from Aberdeen. These large fluctuations, as already pointed out, come from the relatively small number of specimens in those groups.

When this difference in the skull-depth relative to the skull-length is taken relative to the body-length it becomes ·34. There is thus an increase in the skull-depth of ·34 °/₀₀ of the body-length as we pass from south to north. For a plaice of 300mm. this difference means an increase of ·68mm., and for one at 400mm. an increase of ·88mm.

We may again compare this increase of skull-depth with decrease of skull-length in the northern plaice. For a plaice of 300mm. the northern group is greater by ·68mm. in skull-depth, but less by 1·7mm. in skull-length than the southern group. But as they stand these two proportions are not directly comparable. The skull-depth is on an average about 38 °/₀₀ of the skull-length, or a little more than a third, and hence, if a change of 1·7mm. occurs in the skull-length, the proportionate change in the skull-depth should only be ·64mm.

[TABLE.

TABLE XV.

Depth of Skull in Percentage of Skull-length.

Region.	Sex.	Immature (250–350mm.)			Mature (250–350mm.)			Mature (350—mm.)		
		No.	M.	P.F.	No.	M.	P.F.	No.	M.	P.F.
So. North Sea,	♀	147	37·58	37·13–38·03	60	37·10	36·35–37·85	80	37·70	37·05–38·35
	♂	47	37·64	36·99–38·29	115	37·88	37·48–38·28	77	37·48	37·03–37·93
Aberdeen, . .	♀	62	39·13	38·38–39·88	–	–	–	36	39·00	37·60–40·40
	♂	66	39·03	38·33–39·73	50	39·20	38·60–39·80	36	38·69	37·89–39·49
Baltic, . . .	♀	–	–	–	30	37·67	36·82–38·52	–	–	–

As in the case of the skull-breadth, therefore, the change in the skull-length is counterbalanced by the change in skull-depth, and the slight difference that occurs is in favour of a relatively greater increase in breadth and depth than in length.

As with the other dimensions which have been considered previously, so with the skull-depth it is seen that the Baltic plaice are intermediate between the southerly and northerly groups of the North Sea, but approaches more nearly the southerly group.

Skull.—We may now endeavour to compare the two North Sea groups with regard to the skull as a whole. It has been shown that as we proceed from north to south we meet with an increasing length of skull, but a decreasing breadth and depth. The skull becomes more elongated, but compressed posteriorly. It is, unfortunately, impossible to say exactly what alteration in mass and volume this change in dimensions brings about, but this should not be difficult to determine later. If we consider the form of the skull, however, how by far the greater proportion of the mass and volume is concentrated posteriorly, and how the elongated parasphenoid, vomer, and ethmoid anteriorly show but comparatively little bulk, it seems reasonable to conclude that the equal "dimensional" variation from north to south is not accompanied by an equal variation in mass and volume. It is more probable that the latter diminishes with the diminution of the breadth and depth of the skull as we proceed from north to south.

If now, along with these results, we consider the changes in the skull arising from growth-variability, we find that the two changes cannot be confused with one another. It has been shown that the relative length of skull decreases during growth, hence it might be thought that the reason for the northerly plaice having a lesser skull-length than the southerly was that they were older, or larger. Even apart from the fact that the same average-sizes, and presumably, therefore, the same average-ages have been compared throughout, this reasoning would at once be refuted on turning to the changes in the breadth and depth of skull. These dimensions, it has been shown, also decrease with age, and should on this line of reasoning follow the change in skull-length and decrease as we go from south to north. On the contrary, however, they increase.

The changes that have arisen from race-variability, therefore, are just the reverse of what have occurred through growth-variability.

The differences that arise in the skull from sex-variability, again, have been shown to be very slight, and tend to demonstrate that the skull is relatively a little larger and heavier in the female than in the male. These differences, however, do not in any way affect the evidence for race-variability, because the differences arising from the latter cause appear both in males and females.

It appears, therefore, that changes arise in the skull from all three forms of variability, and it has been sought to find the reason for these changes in the inferred alterations in volume and mass or weight, and thence in the maintenance of a continual balance between the head and body. Under sex-variability it has been inferred that the greater mass and weight of skull in the female is correlated to the greater mass and weight of the reproductive organs. Under growth-variability it has been inferred that the dimensional relative decrease in the skull accompanying the relatively stationary condition of the body means that the mass and weight of the skull has remained throughout in exact proportion to the mass and weight of the body. Lastly, under race-variability, it has been inferred that although the dimensional changes from north to south balance one another, yet that the mass and weight of the head as a whole in reality decreases. This may be correlated with the changes that occur in the body.

Body.—The changes that occur in this dimension arise solely from race-variability. Nor was it to be expected that changes would arise here from sex and growth variability. If any difference arose in the body from these causes it would be between the dorsal and ventral halves and not in the body-height as a whole. It may be inferred also that the differences lie not only in the greatest body-height, but along the whole length of the body from head to tail. Any great increase in weight, therefore, in the region of the body posterior to the first caudal vertebræ would be partially counterbalanced by the greater weight of the abdominal region.

If we now consider the body-height and skull together we may conclude that the changes in the latter arising from sex and growth-variability are correlated with the ripening of the reproductive organs, but that the changes in it arising from race-variability are correlated mostly with the changes in body-height. It has been shown that the northerly plaice have broader and deeper skulls than the southerly, and this is associated with a greater body-height. In the northerly plaice the skull is larger posteriorly than in the southerly, and this is probably related to a greater development of the opercular and pectoral arches, and of the muscular system round the skull. And it is probable, again, that this greater development anteriorly aids to counterbalance in mass and weight the greater mass and weight of the posterior caudal region in spite of the lesser length of the skull. If, therefore, we regard the balance of organs in the northerly and southerly groups to be still the same, we may picture the difference as one of form. The northerly plaice are rounder fish than the southerly. The body of the plaice has very approximately the form of an ellipse, and the change that has occurred in passing from north to south shows itself in the relative decrease of the minor axis (body-height) and relative increase of the major axis (total length of fish).

If we consider, as is generally believed, that the plaice is descended from a northerly sub-arctic stock, then the change above described has probably been the change that has actually occurred. And this alteration has been the only one—no change, so far as can yet be detected, taking place in the vertebræ and fin-rays. The manner by which the change has actually occurred can only be conjectured. It may be that the earlier or younger condition has become the older condition in the southerly plaice, and that the decrease in the skull and body is accompanied by a less great development of the reproductive organs than in the northerly plaice.

Again, it has to be noticed that a similar alteration in form has taken place in the Baltic group. This, so far as Duncker's results and those given here allow us to conclude, is more nearly allied in form and proportions to the southerly North Sea group. Yet, on the other hand, accompanying the alteration in form, the Baltic plaice also show a great reduction in the number of vertebræ and fin-rays, and this reduction is probably associated with the decrease in salinity of the waters in which the adults live and the young develop.

We may turn now to the evidence from other sources for the existence of groups or races of plaice in the North Sea. Fulton*, as one of the results of his great work on the migration of fishes and the directions of the currents in the North Sea, has shown that even for the slow-moving plaice there is a definite cycle of changes on the east coast of Scotland. Beginning with the spawning of the plaice off the coasts of Aberdeenshire and Kincardineshire, he has shown that the eggs are drifted along by the surface currents—which are not simply superficial—until the young are found on the southern shores of Scotland. There they pass the early stages of life, probably during two and three years, according to the results of Dannevig (*l.c.*), and then begin a northward migration along the shores until at the end of their third, or perhaps fourth, year they reach as far north as where they were spawned, and thence at the period of maturity they go out into deeper waters to spawn. These facts show how definite is the life-cycle, and in a former paper† it has been shown how the young immature plaice of St. Andrews Bay could be detected as a portion of the Aberdeen group by an inspection of their characters.

The facts displayed in this present paper, along with this life-cycle demonstrated by Fulton, show how the northern plaice of the North Sea are distinct from the southern, and show also that the separation is a consequence of this life-cycle, and requires no barriers of any sort in the sea. It is possible, again, that the plaice off the English, German, and Dutch coasts are similarly divided into groups or races, but there is no satisfactory evidence as yet from either side—that of the life-cycle or that of the characters. It may be that as we pass from north to south the differences in characters between the northerly and southerly plaice of the North Sea shown here gradually diminish, so that the differences in the averages are too small to be detected and spoken of with any certainty. Perhaps with a very large number of specimens these finer differences will show themselves, but for the present we can only say that the groups may be present, and that the life-cycle of the one group may be passed under very nearly the same conditions as the life-cycles of the other groups, so that the characters which vary under the stimulus of those conditions are similarly closely related.

The evidence of a definite life-cycle may likewise be brought to bear upon the problem of the plaice in the Baltic. So far as direct evidence is concerned, Petersen's view that they may spring continually from the plaice of the Kattegat, just as those of the Limfjord do from the plaice of the North Sea, is just as correct as Heincke's that the plaice in the Baltic form a distinct race. But the probability seems to me in favour of Heincke, because we have no evidence that the characters of the plaice can change so quickly, and because the evidence of a race remaining distinct and separate off the east coast of Scotland appears conclusive. The plaice of the Baltic may do so likewise, and the eggs and larvæ that

* Fulton, T. W.: *Eleventh Report, Scottish Fishery Board*, pp. 176-186.

† "Extension of the Method of Treating Variations, etc.," *Natural Science*, Dec. 1899.

are found drifting down the Belts into the Baltic may return later as young to the Kattegat, as Heincke supposes, in a similar fashion as those off the southern shores of Scotland return northwards.

In drawing this section to a conclusion, it may be pointed out how, starting from the characteristics of the groups into which a "species" may be naturally divided, we attain by examples a clear conception of the underlying theoretical meaning of the term "race." This has been shown by Heincke with reference to the herring, and his definition adequately displays this inner meaning—"A race is a collection of individuals which live within like surroundings, and which through the intermingling of the sexes stand in close blood relationship." This definition gives a picture of the "race," and the observations recorded here show that such collections of individuals may and do exist.

Conclusion.

At the end of the section on the "average age at first-maturity," the usefulness of the results therein obtained was discussed, and it is now advisable to give a brief review of the contents of the succeeding sections on variability. In such an abstruse subject it is somewhat difficult to explain the theoretical and practical bearing of the work, although the underlying current of thought and relation of part with part may be comprehensible. The chief endeavour throughout has been to utilise and display those portions of the mathematical method of treating variations which are most essential in fisheries research. The work of past observers in Scotland, England, and the Continent has shown that many problems in connection with the fisheries can never be satisfactorily solved until large quantities of material from different places and different times have been examined. The reason for this lies in the great variation displayed by everything. One cannot rely upon a few scattered observations here and there, but must be prepared to amass the facts, not only by the hundreds, but by the thousands.

When the facts have been collected they have to be sorted into groups, and the average value of each group must be calculated. Even this is not sufficient. It is necessary to remember that a thousand facts represent only a fraction of the possible millions in nature, and the amount of probability that the averages of the observed facts represent the true averages must be calculated. As with all new subjects and methods, the work is at first extremely laborious. The calculation of the averages and of their true worth is comparatively easy; the labour arises from the need of carefully selecting and arranging the groups so that no confusion may arise later, and that the conclusions may be justified and self-evident.

In the preceding pages only a few of the total number of characters examined have been described because of the time taken to find the best manner of grouping the facts. As arranged at present each Table serves three purposes. Sex-, growth-, and race-variability can be read directly from any of them without confusion, and this has seemed the shortest and simplest method of arranging the groups. With greater quantities of material it would be possible to sub-divide certain of the groups still further, as, for example, those displaying growth- and race-variability, and finer conclusions might then be drawn. With the material in hand, however, the groups could not be further sub-divided. The characters chosen are perhaps the best for all purposes, but some of the others may be of importance. The latter will be considered at a future date, it is hoped, along with various other points of importance which have only been lightly referred to in the present paper.

It has been shown in these pages how the relative dimensions of various parts of the body—*e.g.*, the skull—may vary with sex, age, and in different regions. The exact amount of the changes observed have been stated, but the conclusions have not been pressed too far. It is believed that the changes in the dimensions are only the superficial evidences of what remains constant throughout. The various structures and organs are so bound up with one another that any change in the one may be accompanied by changes in others, but these relative changes mean that a certain balance of the organs is constantly maintained.

How this balance of the various organs and structures is to be expressed according to the mathematical method of treating variations is still an unsolved problem. The correlation of two, and even three, structures can be displayed by Pearson's and Duncker's methods of treating correlation, but this only shows the amount that one part varies in company with another; or the correlation of the averages may be worked out by Heincke's method, and this is perhaps the nearest approximation to a solution of the problem that has yet been made. This shows how an extreme variation in one part of an individual may be counterbalanced by variations in other directions of other parts. But, apart from the inherent difficulties in connection with the method, this leaves us in the end with facts illustrative of the simple statement that there is a balance of organs. In the present paper it has been shown that the balance is most probably one of mass or weight about a certain point in the body, which may be called the centre of mass or gravity. The changes in the relative dimensions have been referred to the need of preserving constantly this balance It therefore follows that in order to express the balance of organs they must all be reduced to the same common denominator—that of mass or weight. The practical, as well as the mathematical, difficulties in the way of expressing this balance are very great, and all that can be done at present is to show that the solution lies in this direction.

Under the section on race-variability it has been demonstrated that a "species" may be naturally divided into groups, which under normal conditions may have no connection with one another. The practical bearing of this lies in the possibility of telling where any given specimens have come from. The fisherman with long experience is often able to do this almost at a glance, and there is no reason why the naturalist should not be able to do the same in his laboratory. The necessary requirement is that the relative values of the characters at different ages and sizes should be tabulated for the various groups. This should be done for all the common species of food-fishes. The actual need of this has not yet been felt in the case of the marine forms, but cases have arisen amongst the fresh-water forms, such as the trout, where knowledge acquired by the present method would have been invaluable. We cannot tell either when such knowledge of the marine forms, especially of the herring, cod, and plaice, may be required. It simply means that we should be able to distinguish between the different groups of a species just as we are at present able to distinguish the species, although the latter is not at all easy in many cases in the present condition of our knowledge.

A further important aspect of the practical bearing of this study lies in the ability that arises from it to track a certain group through the sea. If the characters of a certain race—say those of the plaice of the northerly North Sea—have been carefully tabulated and differentiated from those of neighbouring races, we should be able to follow these plaice wherever they went. This has already been illustrated in a previous paper. Heincke has shown it also in the case of the Bohuslän herring, and there seems little doubt that it is only lack of definite knowledge that prevents our doing so in other cases as well.

We may turn now to the theoretical consideration of the conclusions that the plaice as a species is divided naturally into several groups, and we may endeavour to answer the question how these groups have arisen. We may believe that they have sprung from a more primitive form which inhabited the sub-arctic regions. Migrating southwards, they have gradually spread out over the comparatively shallow areas of the temperate zone, penetrating to wherever the conditions were suitable to their habits of life, and as they reached the successive regions their characters slowly altered.

Such seems to have been the progress of events, but we do not know how the changes have been wrought. In the case of the Baltic groups the evidence seems almost conclusive that the direct action of the changed environment has effected the changes in vertebræ and fin-rays. These are formed in the early post-larval stages, and in some way that we do not yet understand the decrease in salinity and the increase of temperature in the surrounding waters have brought about a decrease in the number of vertebræ and fin-rays. Correlated with this decrease the average size of the adults has also decreased, and the relative proportions of the various organs and structures have altered in the same directions as those of the southerly North Sea plaice.

In the case of the North Sea plaice we find that there is no appreciable change in the number of vertebræ and fin-rays, and we may thence conclude that the range of variations and the averages of the salinity and temperatures over the whole North Sea are approximately the same during the periods that these organs are developing. This belief is strengthened when we find that the plaice of the south-west coasts of Scotland* possess the same average number of vertebræ and fin-rays as those of the North Sea. These probably come under very similar conditions of salinity, and possibly also of temperature.

It is evident that careful records of temperatures and salinities over these different areas are much needed for such a work as this, where fine differences in characters are sought for.

On the other hand, it has been shown that the North Sea plaice are divided into at least two groups by definite and distinct differences in structure. These differences show themselves in alteration of proportions, such that the plaice of the southerly North Sea are relatively more elongated and narrower, where those of the northerly North Sea are shorter but broader. The plaice of the latter region are more massive, where those of the former are more slender. It has been shown that in all probability this change has taken place without any alteration of the balance of the various organs—*i.e.*, the centre of mass or balance of the animal remains the same. This has been shown to be the case also with the relative changes in parts which arise from sex- and growth-variability. If we suppose that this balance is constant for the species, then the alterations in the relative proportions of structures due to sex, growth, or race are evidences of the various possible combinations of structures and organs which may arise from the specific variability of the organism.

* Dr. Fulton informs me that the salinity of the Solway Firth is certainly lower than that of the North Sea, though actual statistics are not to hand. The plaice from the Solway are therefore comparable rather with those from the Helder than with those of the North Sea, because those from Helder are reared most probably in the brackish waters of the Zuyder See. The values of the averages for these two regions (*vide* Tables VI., VII., and IX.), with the exception of those for the anal and right pectoral fins, are also more akin than with those for the North Sea. It may be, as already suggested (p. 77 and elsewhere), that plaice from both these regions are distinct races, *i.e.*, distinct from those of the North Sea, but other characters than the fin-rays must be more closely examined. The evidence given in this paper shows that for the plaice the averages of the vertebræ and of the fin-rays do not materially alter except under very marked differences in salinity, as, for example, in the case of the plaice in the Baltic.

The question then appears—How have these alterations in the relative proportions of the North Sea plaice arisen? Why should the specific variability of the organism not give rise to the same relative proportions over the whole area? Two formal answers are ready to hand, both of which take for granted that certain differences must exist in the surrounding conditions. On the one hand, natural selectionists would have it that these relative proportions of structures and organs are "adaptive"—*i.e.*, that each combination has been selected by its environment as the best fitted for the conditions around. On the other hand, we might say that the differences in the environment have directly caused the differences in the proportions. The various combinations of the proportions are all adapted, it might be said, to the environment, and natural selectionists can suggest no reason why the one combination should appear in one place and another combination in another.

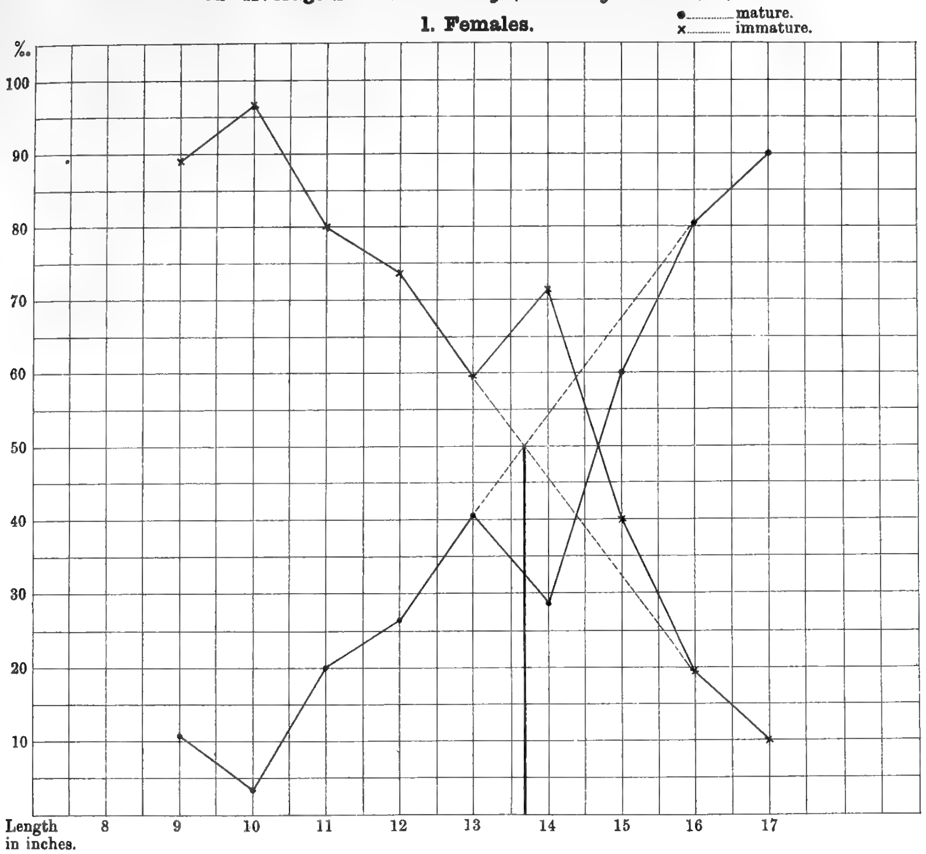
Many arguments might be brought forward in favour of both of these formal explanations, but as they are based only on circumstantial evidence* any discussion is premature. It is profitable, however, to consider whether these alterations in the proportions of the North Sea plaice may not have arisen under exactly similar external conditions. We have accounted for the changes in the Baltic plaice. The environment is different there from that of the North Sea. But in the plaice of the latter region we have not the same evidence for differences in the environment. In the former case the average numbers of vertebræ and fin-rays were greatly reduced, and these were connected with a decrease of salinity and an increase of temperature. In the latter case the average numbers of vertebræ and fin-rays remain the same over the whole region, and we might thence conclude that the average salinity and temperature remained also the same. We have no reason, further, to conclude that the remaining external conditions—pressure, physical and chemical constitution of the water, food supply—are in any way different in the regions referred to. They may be, but we lack evidence.

If the conditions are the same, how may we account for the alteration in the proportions of the northerly and southerly North Sea plaice? A possible explanation may be found in the action of man. The southerly regions of the North Sea have been more rigorously fished for centuries than the northerly regions. Various effects of this rigorous fishing have been already mentioned. The number of large specimens decreases, the average size of the mature specimens is therefore lowered, and possibly also the average-size when they become ripe for the first time. The effect of this would probably be that the specimens which survived would be of a younger type than formerly. Now, it has been shown that in certain respects the plaice of the southerly North Sea might be taken for younger specimens of those of the northerly North Sea. The differences which contradict this are shown in the smaller relative body-height and correlated dimensions of the skull in the plaice of the southerly North Sea. It has been demonstrated also that these dimensions are correlated with the development of the reproductive organs, and if the above reasoning holds good we should expect that the smaller body-height and correlated parts are accompanied by less developed reproductive organs. In other words, the selection practised by man, "natural" in a sense, would have the effect of reducing the size of the reproductive organs, and in order that the balance of the organism may be maintained, the other organs vary concomitantly.

* We might take the work of Bumpus on the sparrow (Biol. Lectures, Woods Holl, Boston, 1898) as direct evidence in favour of natural selection. Weldon's conclusions with regard to *Carcinus mænas* are not so evident. On the other hand, although we find many definite examples in favour of the direct action of the environment in botany, there seems to be only one in zoology—viz., the change of *Artemia salina* to *Artemia milhausenii*.

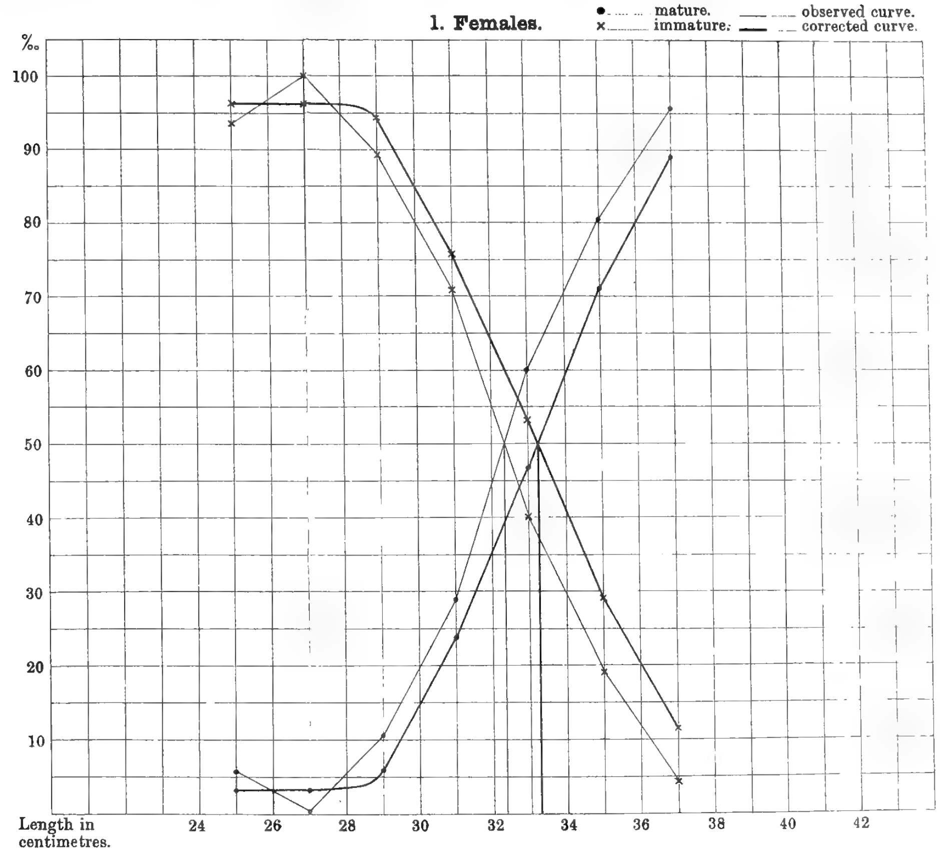
A.—Average-Size at Maturity (southerly North Sea).

1. Females.

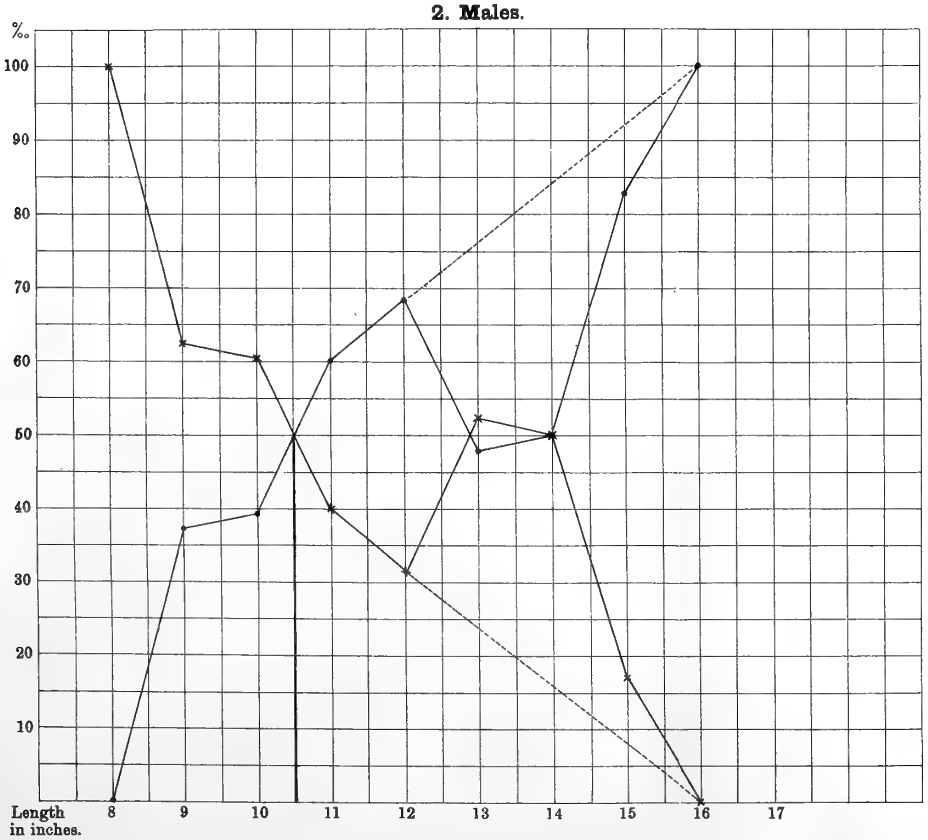


B.—Average-Size at Maturity (southerly North Sea)

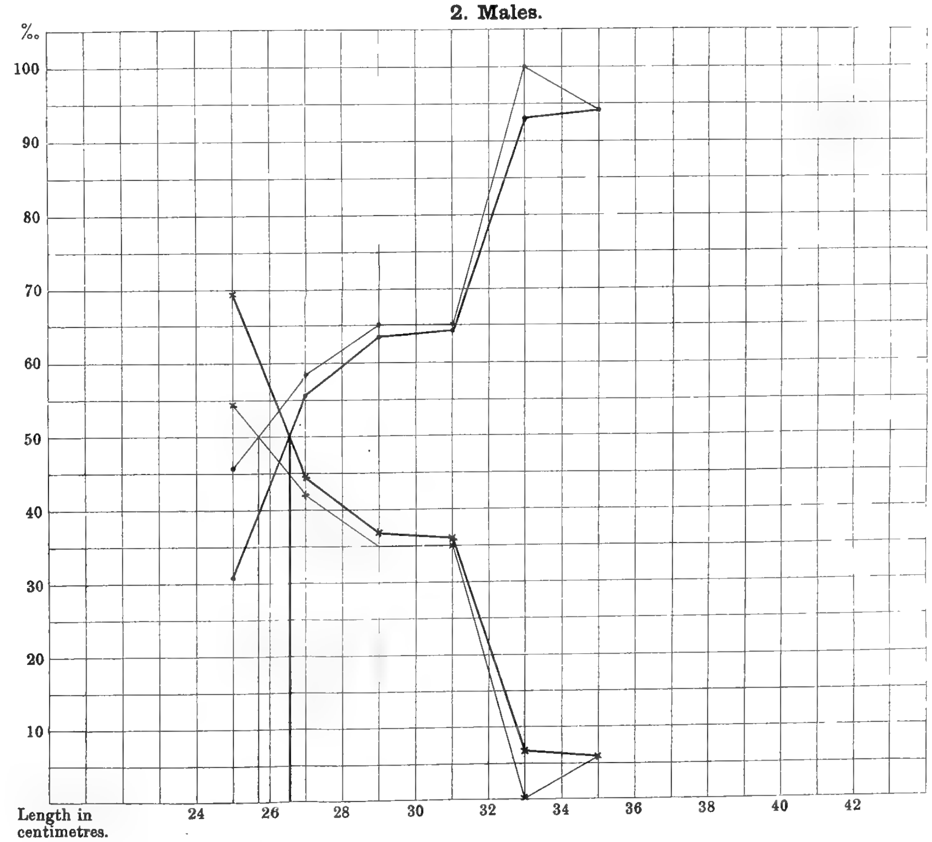
1. Females.



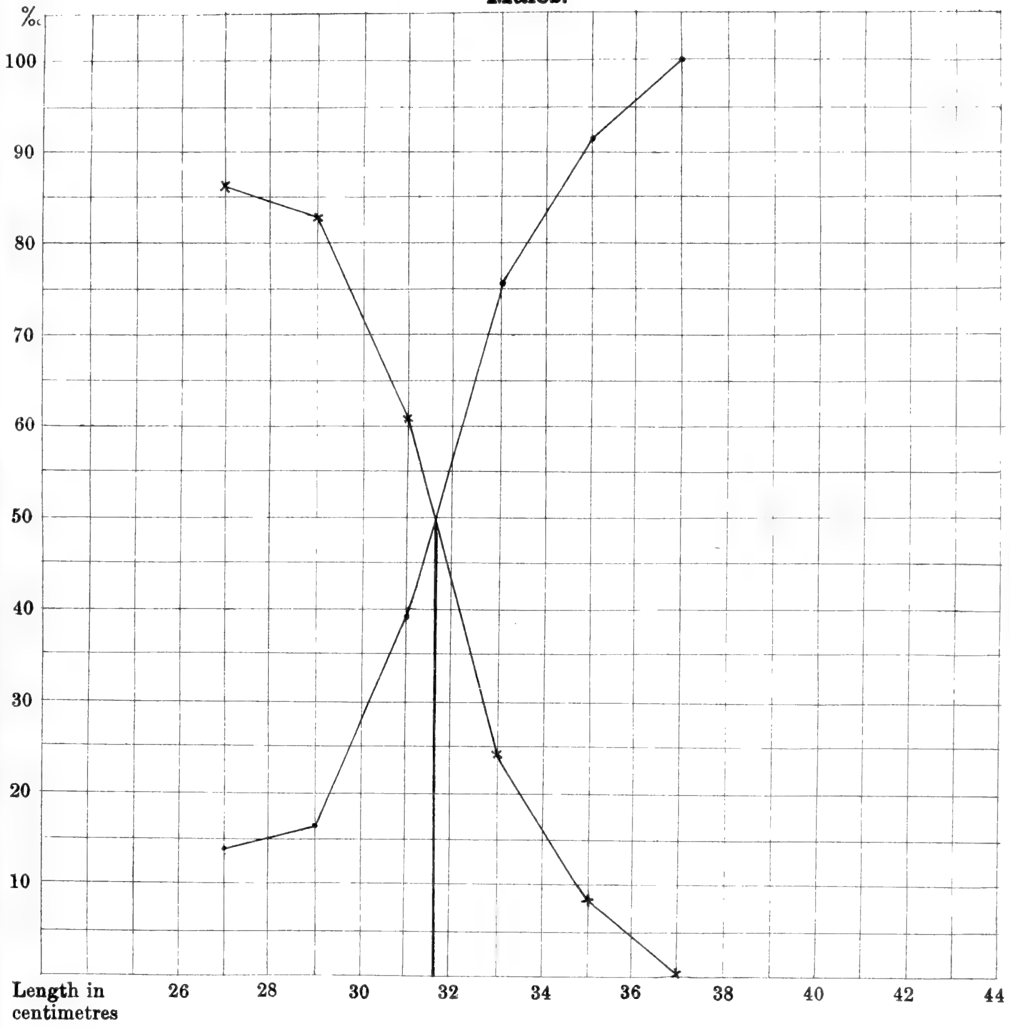
2. Males.



2. Males.



Average-Size at Maturity (northerly North Sea).
Males.



We thus have three possible and plausible explanations of the alteration in the combination of characters in the plaice. The evidence required to bring us nearer to a more exact explanation will come from two directions. We require a more exact measure of the reproductive fertility—mass of reproductive organs, or number of eggs—in the different regions, and thence some notion of the so-called "reproductive selection"* within those regions, and at different ages or sizes. Secondly, we require some knowledge of the meteorological, physical, and chemical conditions over the North Sea area, together with a more exact determination of the seasonal fluctuations and their averages in the life-cycle of the plaice, especially of the southerly regions.

* *Vide* Pearson, K.: "Chances of Death," 1897.

V.—REPORT OF AN ENQUIRY ON THE ACTION OF THE HERRING SEINE-NET.

By T. Wemyss Fulton, M.D., F.R.S.E., Scientific Superintendent.

Introduction.

In recent years complaints have been made respecting the alleged injurious action of the seine net used for the capture of herrings in Loch Fyne and off the coast of Ayrshire, and the results of an enquiry on this subject are contained in the following report, especially as concerns the capture of immature herrings and the destruction of herring spawn deposited on the bottom. The investigation was begun some years ago at Ballantrae Bank, but owing to the failure of the fishing there in successive seasons, its progress was delayed until the present year, when the herrings returned in considerable numbers. This method of fishing for herrings has formed the subject of legislation and of several previous enquiries which must be here alluded to.

The seine net appears to have been first introduced into the Scottish herring fishery about the year 1838, when it was employed in Loch Fyne. Its use gradually extended, and it became known locally as the "herring trawl," the system of fishing being called "trawling for herrings"; but these terms are improper, since the net is in reality a seine, without a distinct "cod" or pocket, and not a trawl. By the year 1846 or thereabouts the seine had come into pretty common use in Loch Fyne, and disputes and conflicts soon arose between the "trawlers" or seiners, and those pursuing the ordinary and time-honoured system of fishing for herrings with the drift net. The drift-net fishermen alleged that the seine or "trawl" was injurious for many reasons; and this opinion being supported by the leading fish curers and merchants, an Act of Parliament was passed in 1851, with the concurrence of the Board of British White Herring Fishery, by which the employment of the seine for catching herrings was made illegal, the only net recognised as legal and proper being the drift net with the standard meshes of one inch from knot to knot.*

Under this statute the Board of Fisheries took prompt measures to suppress the use of the herring seine net in Loch Fyne and also in the Firth of Forth, where, being used for the capture of sprats, it also took occasion-

* 14 and 15 Vict., c. 26. An Act to Amend the Acts relating to the British White Herring Fishery. Section 6 was as follows:—"That whenever the herring fishery is commenced or carried on it shall not be lawful for any person to use for the purpose of taking herrings any drag net, or sea net mounted for trawling, or any sweep, circle, ring net, or scringe net, or any net prohibited by the said recited Acts or any of them, or any net of any kind or description whatsoever other than the usual drift net, or to use any drift net by dragging the same through the water in the manner of trawling; nor shall it be lawful to take or have on board of any fishing vessel or boat, during the time of the herring fishery, any net of any description other than drift nets; and every such net other than drift nets, used as aforesaid, or found on board of any fishing vessel or boat during the herring fishery, or found on shore, or in the possession of any person for the purpose of being so used, shall be liable to be seized by any superintendent of the herring fishery, or person acting under his order, or by any officer of the fishery; and any person using or having on board any fishing vessel or boat, or having on shore for the purpose of being used as aforesaid, any net contrary to the provisions of the said recited Acts or any of them, or this Act, shall be subject and liable to the penalties imposed in that behalf by the said recited Acts or any of them, and any net so seized shall be liable to forfeiture in terms of the said Acts."

ally considerable quantities of young herrings. The difficulties in enforcing the Act were, however, very great. The trawlers or seiners resorted to all sorts of shifts and expedients to carry on their operations while avoiding detection. When pursued they usually cut the net adrift, or threw it overboard, and the mere seizure of the nets found in the water had little effect in repressing the practice. The naval superintendent in command of H.M.S. "Porcupine," with a crew of 60 men, reported that "although he had unlimited authority under the Act to put down trawling, he had not been able to do so, and that more force was required even to suppress it in the confined area of Loch Fyne," which, however, it was impossible to grant him.* In 1852 the Act was carried out, as far as possible, with great vigour, and 1853 was also "a year of repression," but it was less effective, partly in consequence of an unfortunate accident which occurred from firearms having been used on board one of the boats of the "Porcupine," engaged in enforcing the Act, whereby a fisherman was wounded. The gunner and one of the marines were tried at Inveraray for this offence, and were sentenced to three months' imprisonment, afterwards commuted. In 1854 the outbreak of the Russian war caused the gunboat to be withdrawn; the Act fell largely into abeyance, and the use of the seine revived in 1855 and 1856.†

The Board of Fisheries declared that the Act "had not been found to work satisfactorily," owing to certain defects in it which were specified,‡ and a Commission of Inquiry on the duties of the Board of Fisheries, which was appointed by the Lords of the Treasury in 1856, also examined into the working of the Act and reported against it. "The Act," they said, "has failed to accomplish its object, and has been unfortunate in its consequences. The difficulty of obtaining the legal evidence necessary for conviction has given complete immunity to offenders, whilst the successful continuance of unlawful conduct has tended to familiarise men with law-breaking, and to demoralise them. The evidence of all parties concurs in declaring that trawling is as openly and extensively practised as if it were legal; but the fact is also established that the amount of herrings actually caught in Loch Fyne has largely increased. . . . We earnestly recommend the repeal of a Statute which has no other result than to keep a considerable population in the habitual and successful violation of the law." § In consequence of this report the subject was brought before the notice of the Government with the view of dealing with it by legislation, the Act meantime remaining only nominally in force.|| Then an event occurred which hastened action. In the autumn of 1858 the shoals of herrings, which had for a long period been absent from upper Loch Fyne, made their way up as far as Inveraray (the headquarters of the drifters), and they were followed thither by the seine boats which brought on a collision between the two classes of fishermen. In 1859 the same thing happened, and the drift-net fishermen then combined to put down seining; they took arms into their boats and threatened to enforce the Act for themselves.¶ The authorities thereupon circulated notices that trawling for herrings was illegal, and they stationed a gunboat and fishery officers in Loch Fyne so as to preclude any trawlers from passing up beyond Otter Spit into the upper loch.

* Report by the Commissioners for the British Fisheries for 1859, p. 5.

† *Ibid.* for 1853, p. 6; for 1859, p. 5. Report on the Herring Fisheries of Scotland by Buckland and Walpole (1878), p. 2.

‡ Report by the Commissioners (1859), p. 4.

§ Report by Messrs. Bonamy Price and St. John and Admiral Sullivan (1857).

|| Report of Commissioners for the British Fisheries for 1859, p. 5.

¶ *Ibid.*

The operations of the Act in connection with the sprat fisheries in the Firth of Forth also caused great difficulties. There was no legislative restriction against sprat fishing *per se*, but when young herrings were captured—as they very frequently were—by the small-meshed sprat seines, the nets were seized by the fishery officers, and the fishing brought to a stop. When the Board of Fisheries revived the enforcement of the Act in 1859 the sprat fishermen resisted its application to them. They took steps to obtain legal interdict; they assailed the fishery officers with stones, riots occurred, and the commander of H.M.S. "Lizard" reported that he could not carry out the Act without arming his boats, and if he did so, that he could not be responsible for the lives of the people. The "imminent risk of conflict and bloodshed" was such that the Lord Advocate took upon himself the responsibility of advising the Board to stop the seizure of nets and to fix a boundary within which the sprat fishermen might be allowed to fish with the seine; which was done.* The Board of Fisheries, while strongly in favour of a liberating Act, were of opinion that the prohibition of seine trawling should not be simply repealed, as was recommended by the Treasury Commission. They desired that the power of regulation should be conferred upon them, so that they might permit or forbid seining for herrings according to the circumstances of any particular place or case.† In a Bill introduced into the House of Commons by the Lord Advocate, it was accordingly proposed to give such powers to the Board while repealing the existing statutory prohibition. But owing to a strong and widely - extended agitation by fish - curers and merchants, the opposition to this proposal in the House of Commons was so great that the Bill emerged from the Legislature with provisions against seine-net fishing for herrings still more absolute and stringent than those contained in the Act of 1851.‡

The Act of 1860 was enforced, as far as it could be, in Loch Fyne and the Firth of Clyde by the aid of two gunboats and a strong staff of police on shore, but the efforts to suppress seining were "still attended with difficulty" and "were found ineffective." The illegal net was the only article that could be seized, and as the trawlers were ready to sacrifice it for the sake of making their haul of herrings, by cutting

* *Ibid.* Report on the Herring Fisheries of Scotland, by Buckland and Walpole, p. 2. Report of the Commissioners on the Sea Fisheries of the United Kingdom, Vol. II., p. 579 (1866).

† Memo. by Mr. Bouverie Primrose. *Ibid.*, and Vol. I., App., p. 47.

‡ 23 and 24 Vict., c. 92. An Act to Amend the Law relative to the Scottish Herring Fisheries, 1860. Section 13 is as follows:—"For the purposes of the provisions of the sixth section of the Act fourteenth and fifteenth *Victoria*, chapter twenty-six, the herring fishery shall be held to be carried on whenever herrings are being caught, and every net, other than drift nets, which, in the opinion of such Commissioners, may be used for the purpose of taking herrings in contravention of the said Act, shall during the whole time of such herring fishery be removed and laid aside, or shall be liable to be seized and forfeited, and the owner thereof to be proceeded against accordingly; and the finding of any such other net in any open place, and not removed and laid aside as aforesaid, shall be held *prima facie* evidence of the purpose of the possessor of such net to use the same in contravention of the provisions of the recited Acts or of this Act; and unless such possessor shall prove to the satisfaction of the Sheriff, Justice or Justices of the Peace, or magistrate, before whom he may be prosecuted, that such net was not intended to be used for any such unlawful purpose, such net shall be forfeited and destroyed, and the possessor thereof shall be liable in the penalty imposed by the sixth section of the said Act; and, in addition to any superintendent or person acting under his orders, or any officer of the fishery, every constable or officer of the police of any county or burgh acting under the authority and orders of the Sheriff, or any Justice of the Peace, or magistrate of such county or burgh shall, for the purpose of enforcing the provisions of the sixth section of the said Act, have, within such county or burgh, the power to seize any such net in order to the condemnation and forfeiture thereof; and, on the requisition of any superintendent or other officer of the fishery, any constable or officer of police shall be entitled to assist and co-operate with him or them in the execution of this Act." Section 14 declares the mode of obtaining warrants to search for and seize illegal nets, the enforcing of fines and penalties, &c.

away their nets when chased, they in many cases escaped personal identification, and carried off their cargo with impunity to market.* By the aid of a strong force the sprat fishing in the Firth of Forth was completely suppressed. But as "the winter was excessively severe, the sprat fishermen, deprived of their ordinary employment and means of livelihood, became extremely impatient and restless." They raised an action for interdict in the Court of Session, and lost it; and ultimately, owing to the excitement and distress caused by the enforcement of the Act, the Home Secretary advised the Board of Fisheries that if they "should come to the conclusion that the Act in certain localities produced consequences detrimental to certain classes of fishermen, and not contemplated by the Legislature, they would be justified in abstaining from the enforcement of it in those localities, until time should be afforded to Parliament for considering the provisions in question."† An investigation was therefore made by the late Lord (then Dr.) Lyon Playfair and Vice-Admiral Dundas, both members of the Board, into the condition of the sprat fishermen and the effect of their fishing on the herring fishery; and as a result of it sprat fishing with the seine net was allowed to be resumed within a specified boundary.

Since it was found by the Board of Fisheries that the powers conferred upon them by the Acts of 1851 and 1860 were insufficient to enable them effectually to suppress seining, another Act was passed in the following year providing not only for the seizure and forfeiture of the seine net, but of the boats using it, as well as the fish they might contain. Power was also given for the suspension of the prohibition against the seine net when it was employed in sprat fishing within a specified part of the Firth of Forth. The Board were also authorised to employ the police, and under the provisions of the Police (Scotland) Act a fishery police was established.‡ These provisions enabled the law against seining for herrings to be carried into full effect, "with marked results in the suppression of trawling and all other illegal modes of fishing." Many seizures were made and the boats and fishing gear condemned. Another unfortunate occurrence took place in Loch Fyne in 1861 which forcibly drew public attention to the trawling legislation. A fisherman was shot dead by a marine in one of the superintending boats, acting under the orders of his superior officer. The officer and marine were tried before the High Court of Justiciary and acquitted.§

By these Acts seining for herring was almost entirely suppressed in 1862; the seiners joining drift-net boats or getting drift nets for themselves. A great impetus was thus given to the building of drift-net boats and the making of drift nets, and it almost appeared as if the use of the seine in the herring fishery would be permanently abandoned.||

But in August 1862 a Royal Commission was appointed "to enquire into the operation of the laws relating to trawling for herrings on the coasts of Scotland, having special reference to the Acts of Parliament" which have been cited. This Commission, usually knows as the Playfair Commission, was composed of Dr. Lyon Playfair, Professor Huxley, and Lieutenant-Colonel Maxwell. Their report was presented to Parliament in 1863,¶ and it was of a very thorough character. They summarised the objections raised by the drifters to the seining for herrings

* Report by the Commissioners for the British Fisheries, 1860, p. 3; 1861, p. 3.

† Ibid.

‡ 24 and 25 Vict., c. 72: An Act to make further Provision for the Regulation of the British White Herring Fishery. Report of Commissioners 1861, p. 3.

§ Ibid.

|| *Ibid.* 1862, p. 4.

¶ Report of the Royal Commission on the Operation of the Acts relating to Trawling for Herring on the Coasts of Scotland.

as follows—and the objections have been always of the same nature:—(1) Immature herrings may be caught by it. (2) The seine nets disturb and disperse the shoals of fish in entering the estuaries from the sea, and in consequence the fish desert the waters which they would otherwise have frequented. (3) The seine nets sweep across the beds where the fish are depositing their spawn, and not only take the spawning herrings, but destroy the spawn which has been deposited. (4) Herrings caught by the seine net are not fit for curing, on account of injury received in their capture. (5) The trawlers, or seiners, cut the drift nets and destroy the floats. (6) The two systems cannot be carried on together in narrow waters, as the trawlers get foul of the drift nets and drive away the fish. (7) The extravagant gains of the trawlers, monopolised by a few, alter the market prices by sudden fluctuations, to the great detriment of the drift-net fishermen, who prosecute their labour in a more steady and less gambling manner.

The trawlers, or seiners, on the other hand, denied these allegations, and rested their case on the following grounds: (1) They admitted that when the mesh of the net is less than the legal standard (one inch) they caught immature fish, but they denied that it is their interest to do so, and stated that larger and finer herrings were caught by the trawl than can be got by the drift net. (2) They denied that the enclosure of the herrings in a net drawn gently around them could disturb the general shoal of fish so much as their meeting numerous walls of drift netting. (3) They denied interference with the spawning beds. (4) They declared that seine-caught fish are not only good for the fresh market, which they desired to supply, but also for curing. (5) They denied injuring drift nets, and saw no difficulty in carrying on the two systems of fishing together. (6) They asserted that the large hauls got by the trawlers were of great benefit to the consumer of fish, by enabling him to get herring much cheaper than he could by drift-net fishing.

Besides making personal investigation at Loch Fyne and other parts of the coast, the Commissioners examined the statistics and other evidence placed at their disposal by the Board of Fisheries, which showed that the gross yield of the herring fishing in Loch Fyne had increased rather than diminished, notwithstanding the use of the seine-trawl, and that the same was true of the whole West Coast. "When we look back," they say, "to the records of the fishing in Loch Fyne for the last fifty or sixty years, we find many periods of bad fishing and gloomy depression on the part of the fishermen. In such times of panic they have always been ready to demand legislative protection against other classes of fishermen who were supposed to be interfering with their interests. Thus, in 1836, the Fishery Officer at Loch Fyne, expressing the views of the fishermen there, entreats the Board to protect that loch from ruin, by putting down all fishing on the East Coasts of Scotland during the only months when it was productive, because the West Coast fishermen are persuaded that it is the fish of the West Coast which travel to the East Coast to spawn. In fact, every time that there is a panic, the reasons assigned for the failure of the herring alter, but are strongly pressed upon the Fishery Board as demands for immediate prohibitory measures."

The Commission came to the conclusion that trawling, or seining, for herrings had not been injurious, and had not diminished the productiveness of the fishery in Loch Fyne, which had increased, and that this mode of fishing furnished an important means of cheapening fish to the consumer. They condemned the Trawling Acts. "Although recent legislation," they said, "has been in logicial sequence of that which has long prevailed, and may, in the absence of new inquiries, have been requisite to prevent disturbance of the peace, still, as it proceeds on the assumption that it is justifiable for the conservation of the breed of herring, we are bound to state that, in this point of view, the repressive Acts of 1851, 1860, and 1861 were altogether unnecessary; that they are essentially Acts for protecting class interests, and interfere with the invention and application of new and more productive modes of industry." They expressed the opinion that if any legislation had been requisite, it should have been applied to a regulation of the size of the mesh of the seines, which were frequently used under the legal standard. But, if seine-fishing were again made legal, they recommended that the Board of Fisheries should have discretionary powers to prohibit it "in waters which are too narrow for that and drift-net fishing being peaceably carried on simultaneously"; and they declared their opinion "that Upper Loch Fyne, *i.e.* above Otter Spit, is too narrow for this purpose, and that the Kyles of Bute offer another instance in which it would be desirable to give the Fishery Board discretionary powers to prohibit the practice of seining, but merely as a question of police."

In the year in which the Report of the Playfair Commission was published, another Royal Commission was appointed to enquire into the condition of the whole sea fisheries of the United Kingdom, and especially as to (1) whether the fish supply was increasing, stationary, or diminishing; (2) whether any methods of fishing in use involved a wasteful destruction of fish or spawn, and, if so, whether it was probable that any legislative restriction upon such methods of fishing would result in an increase of the supply of fish; and (3) whether any existing legislative restrictions operated injuriously upon any of such fisheries. This great Commission, whose labours led to the repeal of so many fishery statutes, was composed of Sir James Caird, M.P., Professor Huxley, and Mr. G. Shaw-Lefevre, M.P., and in 1864 they visited Scotland, and, *inter alia*, enquired into the question of seine-net fishing for herrings. In their Report* the Commission adopted the conclusions of the Playfair Commission. "We are unable," they reported, "to find any satisfactory proof in the evidence that has been brought before us that trawling or circle net-fishing for herrings is, when properly practised, wasteful, or destructive to the brood and spawn of the herring. We are of opinion that it has been and may be a very important means of supplying the market with an abundance of fish; and that, not unfrequently, under circumstances which preclude the capture of herrings by the drift-net fishermen."† With respect to the simultaneous prosecution of the two modes of fishing in narrow waters, they had no doubt that they might be safely carried on in Lower Lochfyne; but they expressed the same opinion as the Playfair Commission as regards Upper Loch Fyne and the Kyles of Bute. In these waters, they said, "there may be difficulties in keeping order among so large a number of fishermen collected together in a comparatively narrow space, and holding very opposite views upon the merits of their respective modes of fishing; but apart from the question of police, we see no reason why both modes of fishing should not be permitted. It is perfectly clear to us that there are times when the "trawl" will take fish, when none can be caught by the drift-net."‡ The conclusion of the Commission on this subject was as follows:—"With respect to the particular case of circle-net fishing on the west coast of

* Report of the Commissioners appointed to inquire into the Sea Fisheries of the United Kingdom. Vol. I. 1866.

†*Ibid.*, p. xlv.

‡*Ibid.*, lvii.

Scotland, we are of opinion that (except in a certain specified locality and as a measure of police) no justification whatever exists for the suppression of that method of taking herrings. There is no evidence that, when properly practised, it is a wasteful mode of fishing; while there is abundant proof that it affords a most plentiful supply of wholesome fresh fish; and that, under certain circumstances of season and weather, the fish thus obtained are not to be captured by other modes of fishing."* They recommend, *inter alia*, that all Acts of Parliament "which professed to regulate or restrict the modes of fishing pursued inshore, should be repealed; with the exceptions, purely on grounds of police, of the local Act regulating pilchard fishing at St. Ives; and, for that part of Loch Fyne which lies above Otter Spit, of the Act prohibiting trawling for herrings in Scotland."†

Effect was soon given to the recommendations of the Commission. The Acts against seine-trawling had been consistently enforced by the Board of Fisheries since 1860; and in their Report for 1866 they state that this enforcement had "given rise to a great change of opinion as to the necessity for continuing to maintain that prohibition," and that, owing to "the unsatisfactory nature of the results produced upon the fishery by their enforcement," and the enquiry held as to their operation, the Government had submitted a Bill to Parliament removing all prohibitions against the use of the seine or herring trawl net.‡ The Act referred to was passed in 1867,§ and the seine-net which had been under legal prohibition since 1851 was again at once employed in Loch Fyne and adjacent waters. "Its restoration," the Board of Fisheries reported, "was received with satisfaction as well by the fishermen of the Upper Loch as of the Lower." Many of the fishermen began to use the drift net or the seine net according as circumstances rendered the one or the other of them the most profitable; and "instead of those bitter hostilities which the suppression of the seine had created, and which had, in former years, on different occasions, led to confusion, riot, and bloodshed, the fishing this past season was pursued in an orderly and quiet manner, and with very marked success."‖ This harmony prevailed so long as the herrings were abundant and the fishing successful; but in seasons when the fishing was poor, complaints were again made against the use of the seine net.¶

In 1877, representations having been made to the Government as to the unsatisfactory state of the Scottish herring fishery, another Commission was appointed by the Home Secretary, "to ascertain whether any legislative regulations would tend to promote the welfare of the fishermen engaged in the said fishery, and to increase the supply of herrings for the benefit of the public." The Commissioners

* *Ibid.* ciii.

† *Ibid.* cvi.

‡ Report of Commissioners, 1866, p. 5.

§ 30 & 31 Vict. c. 52. An Act to alter and amend the Acts relating to the British White Herring Fishery, 1867. Section I. "From and after the passing of this Act, notwithstanding anything in the recited Acts, or any of them to the contrary, it shall be lawful to fish for and take herrings and herring fry at all places on the coasts of Scotland, in any manner of way, and by means of any kind of net having meshes of a size not less than that now permitted or required by law, and to sell, buy, or have in possession herrings or herring fry so fished for and taken; and in lieu of the larger penalties imposed by the recited Acts, or any of them, upon persons using nets having meshes of a size less than that now permitted or required by law, shall for every such offence be liable in a penalty of not less than five pounds, and not exceeding twenty pounds, together with the forfeiture of the net." By the Sea Fisheries Act, 1868, the sections in the Acts of 1851, 1860, and 1861, affecting seine-net fishing, were repealed.

‖ Report for 1867, p. 5.

¶ *Ibid.* 1868, p. 4; 1871, p. 4; 1874, p. 5; 1875, p. 3.

were Mr. Frank Buckland, Mr. (now Sir) Spencer Walpole, and Mr. Archibald Young. The herring fishing in Loch Fyne had greatly fallen off in the years 1872-1875, averaging in that period only 9889 barrels, against an average of 34,655 barrels for the preceding four years, 1868-1871, the catch in 1874 amounting to only 6934 barrels. The drift-net fishermen of Loch Fyne accordingly petitioned that the use of the seine net in the herring fishery should be prohibited at all times and places within a line drawn between the Mull of Galloway and the Mull of Cantyre; and much evidence for and against that mode of fishing was brought forward. The Commission came to the same conclusion as the previous Commissions of 1856, 1862, and 1863. "We think, then," they said, "that trawling involves little, if any, more waste than drift-net fishing; that trawl fishermen are not much more noisy than drift-net fishermen;* and we hesitate to recommend the Legislature to put down a mode of fishing which is admittedly economical, for the sake of securing an indefinite object which is by no means certain of attainment."† But, like the previous Commissions, they recommended that, "as a mere matter of police, it is desirable to prohibit the use of trawl nets (seine nets) in Loch Fyne above Otter Spit, and to give the Secretary of State the power to prohibit the use of trawl nets in other narrow waters less than one mile wide." ‡

The question of the herring-seine was again brought before the Committee of the House of Commons appointed in 1893 to consider the expediency of adopting measures for the improvement of the Sea Fisheries.§ The Committee did not make any specific recommendation, but in the Sea Fisheries Regulation (Scotland) Act of 1895, ‖ power was given to the Fishery Board, by bye-law or bye-laws, to prohibit seine trawling in any area or areas within the limits specified in Section 6 of the Herring Fishery (Scotland) Act, 1889, or in the schedule annexed to that section. Anyone contravening such bye-law is made liable to a fine, and every net so set, or attempted to be set, may be seized and forfeited. The powers conferred by this Act do not provide the same facilities for suppressing this mode of fishing as were furnished by the abortive Acts of 1851 and 1860, both of which were found to be unworkable.¶ The power of seizing nets was proved to be ineffective in Lochfyne at least.

In 1893, owing to complaints by Ayrshire fishermen that the use of the seine net was injurious to the herring fishery at Ballantrae Bank, an enquiry was held at Girvan by Mr Esslemont, the late Chairman of the Fishery Board, and it was arranged that an investigation should be made as to the action of the seine net on that spawning ground. As already stated, the fishing in each year, until last year, was a failure, and the investigation could not be made. More recently complaints were made by the drift-net fishermen of Loch Fyne that seine-trawling was proving detrimental to the herring fishery there, and the two areas have been investigated together.

The Methods of Fishing.

The modes by which the herring-fishing is carried on in the Clyde are three in number, namely—by the drift net, the seine net, and the set or

* The noise made by the seiners when working was alleged to frighten away the herrings.

† Report on the Herring-Fisheries of Scotland. xxxii. (1878).

‡ *Ibid.*

§ Report of Committee, p. 319.

‖ 58 & 59 Vict. c. 42. s. 9.

¶ *Vide* p. 245.

ground net, locally known as a "trammel." The latter are chiefly used at Ballantrae Bank and the Ayrshire coast, but they are also employed to a small extent in other localities. Many fishermen make use of more than one mode; it is common for the drift net and the seine net to be employed by the same crews at different times, according to circumstances; the former especially when the herrings are scattered, the latter when they are densely aggregated. Each drift-net boat in Loch Fyne is worked by usually three, sometimes only two, men. The nets may number from ten or twelve to eighteen or more in the train or fleet; the meshes range from about 31 to 34 in a yard, and the complete nets may cost £80, while the seine net is much cheaper, costing from £20 to £30 or £34. The drift net is used in the familiar way, floating or drifting as a wall of netting towards the surface of the sea, at a depth which depends upon the length allowed to the buoy-ropes, and which may extend to thirty-five or forty fathoms from the surface. The seine, or so-called "trawl," is said to have been first used in Loch Fyne in 1838, and was then improvised from a drift-net. It is about 150 to 180 yards in length when mounted ready for use, and of the same depth throughout, which may be as much as twenty fathoms, or 120 feet, from top to bottom. It has no "cod" or pocket, but the central part, which is called the bag, differs in having somewhat smaller meshes than the sides or wings, ranging about 35 or 36 to the yard, and they are made of stronger twine, since the pressure is greatest on this part of the net when it is being hauled. In the wings or sides the meshes are about 33 to 35 to the yard.* The rope along the upper edge of the net is corked at intervals of about two feet, and the sole rope is weighted at intervals with leaden sinkers, so that the net when in use floats perpendicularly, the upper edge being at the surface. The bottom, or draw-rope, by which the net is hauled, may be from 200 to 300 fathoms in length. While the drift net is managed by three men from one boat, the seine employs two boats with four men in each, or eight in all. The seine may be used from the shore and in shallow water as in ordinary ground-seining, and is then termed "scringing"; in such cases the net sweeps the bottom, and ground fishes, as plaice and dabs, may be captured. It is also used in deep water when the lower edge of the net is far distant from the bottom, and this is termed "ringing" or "circling." The mode of shooting and hauling is as follows:—When herrings are found one of the two boats passes one end of the rope to the other boat (which remains stationary), and then moves away paying out the net as it goes, and after making a wide sweep or circle returns to the stationary boat. The net is then hauled by the crews, care being taken to prevent the enclosed herrings from striking downward and escaping by drawing the lower edge of the net under them as the circle contracts, and this edge being brought on board, the herrings are contained in a bag formed by the breadth of the net, and are thus brought to the surface. They are then scooped out with baskets into the boat. A varying number of herrings are also meshed in attempting to make their way out through the meshes. Enormous hauls of herrings are sometimes taken with these seines, amounting, it may be, to over 200,000 fish, and the value of a single catch may reach several hundred pounds. The nets occasionally burst from the mass of fish enclosed. On the other hand, long intervals may elapse before a profitable haul is secured.

* The following particulars are given by one of the makers:—*Bag*—50 yards long, 40 score meshes deep, 36 rows to yard, 42/12 ply cotton. *Shoulder*—25 yards long on each side of bag, 40 score meshes deep, 35 rows to the yard, 45/12 ply cotton. *Wings*—75 yards on each side of shoulder, 40 score meshes deep, 35 rows to the yard, 40/9 ply cotton. The whole length is 250 yards, which, when set up in ropes, will hang about 180 yards.

The so-called "trammel" is not a trammel, but a simple set or ground net. It consists essentially of a strip of drift net, sixty to eighty meshes deep, the upper rope being corked and the lower weighted at intervals with stones, each end being anchored and its position indicated by a buoy. The net thus stands erect in the water close to the bottom and rising six or seven feet above it; it is placed across the tide. Two trains, each of about 240 fathoms in length, are usually employed by each boat, and the meshes range about 32 to 34 to the yard. This mode of fishing is effective on spawning grounds in comparatively shallow water, as at Ballantrae Bank, the herrings at the spawning season keeping close to the bottom while engaged in the deposition and fertilisation of the eggs. The "trammels" are left to fish in the sea from day to day, the fishermen at Ballantrae visiting them each morning, if the weather permits, when they are lifted, the herrings removed from them, and again set. In stormy weather the nets may not be visited for several days; they are not infrequently driven away in heavy gales.

The operations of the three modes of fishing in relation to the capture of immature herrings or the destruction of the deposited spawn of herring are these—(1) the drift net floats freely in the water towards the surface or near it, with the meshes open, and the herrings in darting through the water run against it. Small herrings, as those under six and a half inches or thereabout, and many somewhat larger, pass through the meshes and escape being caught, but the larger herrings are meshed, usually behind the gills; very large herrings may not be meshed, or only insecurely by the head. The drift net is therefore not adapted to capture very small herrings, and it secures a greater uniformity in the size of the fish caught than is the case with the seine net. The drift net is set in the evening and hauled at a varying hour in the morning—in Loch Fyne usually about 3 a.m.—and the herrings caught may be alive or dead according to the time they were meshed, and, still more, according to the state of the sea. The buoys at the surface suspending the net rise and fall with the waves, and in a rough sea the upward jerk given to the net proves fatal to many of the herrings. Drift-net fishing can scarcely ever affect deposited spawn.

(2) The seine net when being hauled must also have the meshes for the most part open, as has been shown to be the case with the beam-trawl net; but the strain at certain parts must tend to contract the aperture. In the ordinary course of fishing numbers of small herrings enclosed in the seine must make their escape through the meshes, and many larger herring are frequently meshed in this way. When, however, a large mass of fish is encircled, it is evident that comparatively few of the small herrings which may be enclosed can escape during the time taken to haul the net. In the cases that came under observation the herrings caught by the seine were as a rule alive and vigorous when the net was hauled. The seine net from its mode of operation is therefore adapted to capture greater quantities of young and immature herrings than the drift net. And since the lower leaded edge of the seine may reach to a depth of 18 or 20 fathoms, and in shallow water is dragged along the bottom, its action on a spawning ground within its reach must disturb to some extent and to a less extent destroy herring spawn deposited there.

(3) The set net or "trammel" fishes in the same manner as the drift net, the herrings being meshed by their own movements in swimming about; and the smaller herrings escape capture by passing through the meshes. When used, as at Ballantrae Bank, on a spawning ground, a certain amount of deposited spawn must be disturbed or injured in the process

of hauling and setting the net. It is a common occurrence to find the stones used for anchoring the nets, the ropes, and even the meshes of the net, covered with spawn deposited upon them while lying at the bottom.

Loch Fyne.

The great herring fishing in Loch Fyne extends from the beginning of June to the close of the year, and is carried on by a large number of drift-net and seine-net boats. By far the greater part of the herrings caught are sold at sea to the carrying steamers which frequent the fishing grounds and take the fish for the most part to Glasgow for the early markets. The investigations in Loch Fyne were carried on in the months of June, July, August, September, October, and December during the seasons of 1897 and 1898. The principal points of the enquiry concerned the alleged wasteful destruction by the seine of small immature herrings and of herring spawn. When the "Garland" was in Loch Fyne the seine boats were boarded at various parts of the loch when they were hauling their nets or had just hauled them, and the catches examined and sampled; and by going on board the carrying steamers when the boats were transferring their catches at night or in the early morning. When the "Garland" was not available the night was spent on the steam carriers, and the herring boats visited by means of the buyer's boat, the catches being examined and sampled. On other occasions part or all of the night was spent on board the fishing boats. In the course of the enquiry the catches of many hundreds of boats, amounting to several thousand boxes and some millions of fish, were thus examined, special attention being paid to the presence of young immature herrings among them. The samples taken were measured, and the condition of the reproductive organs and the nature of the food in the stomachs ascertained.

The successive shoals of herrings which enter Loch Fyne are attracted thither by the wealth of the pelagic food which exists there in the summer, and from which they derive their peculiar excellence. It was found that the herrings, especially in the earlier part of the season, fed for the most part on copepoda, almost exclusively on *Calanus finmarchicus*, which is rich in oil and extremely abundant; and later, on the schizopod crustacean *Nyctiphanes norvegica*, and also on the young of their own species, which sometimes form a considerable part of their food. In some hauls twelve per cent., or more, of the stomachs of the larger herrings examined contained young herrings ranging from $1\frac{1}{4}$ inches to $2\frac{1}{2}$ inches in length, and numbering in a given stomach from one to six. Young herrings of the sizes indicated, as well as larger individuals, were also found in the stomachs of bottom white fish caught in the beam-trawl net of the "Garland" in Loch Fyne, *e.g.* in saithe, codling, gurnards, and long rough dabs. Such young herrings were also found in the stomachs of mackerel caught in the herring nets. The loch is thus undoubtedly frequented by shoals of quite small herrings, such as are stated to be sometimes caught and destroyed by the seine net, and it was proved that they may be found at the bottom, as well as at the surface, to depths of at least 74 fathoms. Evidence of the erratic movements of the shoals in connection with their food supply was also obtained. It was sometimes found that almost all the herrings which were examined from one and the same haul had no food in their stomachs; in other cases in the same neighbourhood the opposite occurred, almost all the herrings examined from a haul containing food. In one of these cases where the herrings were caught near the surface by drift nets in the neighbourhood of Skate Island, at the mouth of the loch, and the food consisted almost entirely of *Nyctiphanes*, a series of tow-nettings was made from the "Garland," which showed that this form was quite absent from the stratum above fifty fathoms; at fifty fathoms a few were caught, while the tow-net fishing at 70 fathoms brought up about a quart. The irregularity of the catches is partly accounted for in this way, small shoals feeding near the bottom in deep water, beyond the reach of drift or seine, and then moving up towards the surface. In experiments which were made from the "Garland" in the deepest water in Loch Fyne, by sinking a large trap, constructed on the principle of a crab-pot, to the bottom, herrings were procured from a depth of 107 fathoms, or 642 feet. The depth of the water in Loch Fyne below the stratum in which the herring nets can be worked, and the abundance of food material in the deepest layers (which are frequented by the herrings), no doubt partly account for the maintenance from season to season of a considerable fishery there, notwithstanding the extensive fishing operations that are carried on. In other lochs on the west coast the fluctuations are far greater and are sometimes phenomenal.

The examination of the reproductive organs also emphasised the importance of the loch as a feeding ground and the mixture of herrings of different degrees of maturity, drawn, no doubt, from many quarters in the neighbouring seas. The great majority were immature, with developing milt or roe, extremely few ripe herrings being found, and these for the most part males. Although it is known that some herrings spawn in Loch Fyne in July and August and later in the year, it is evident that the great bulk of the shoals leave the loch and spawn outside, probably to a large extent in comparatively deep water in Kilbrennan Sound. It is generally believed by Loch Fyne fishermen that Ballantrae Bank forms a spawning ground for the herrings that frequent the loch, but the evidence in favour of this view is far from conclusive. It was also found that the degree of maturity of the reproductive organs varied very greatly among herrings of about the same size, and caught at the same period and place. The following are a few examples:—

Length in Inches.	Weight, grammes.	Weight of Roe, grammes.	Condition of Eggs.
11·6	240·8	58·6	Almost ripe.
11·5	218·4	4·5	Quite immature.
10·0	131·8	10·0	Half developed.
12·3	292·3	9·4	Immature.
13·5	340·0	73·8	Ripe.
10·7	179·9	30·2	Almost ripe.
10·6	175·0	1·3	Immature.

The loch is thus a great feeding place for diverse, more or less mixed, shoals, comprising herrings of all sizes from a little over an inch to over thirteen inches in length, which must reach maturity and spawn at a different period of the year. This mixed quality of the herrings was frequently shown in examining the catches taken by the nets. In all cases considerable range of sizes was found amongst those taken in the same haul, although the degree of admixture varied. Sometimes almost all were large and of fine quality, with little admixture of herrings of the smaller sizes. In other cases there was a considerable mixture of the smaller herrings. In other instances all the herrings were small. Hauls made by different boats working near one another not unfrequently showed this diversity. Sometimes the larger and better herrings were caught in drift nets, while seine boats working in the neighbourhood got very inferior fish. As has been stated, the largest and smallest herrings found in the hauls were measured, and an estimate was made of the preponderating or average size of the herrings in the catch. The smallest herrings found among the drift-net fish examined were seven inches in length, and the smallest found among the seine-net fish examined were five and a half inches. It was, however, not uncommon to find herrings ranging from six to eight inches among the seine-net catches. The details of some of the hauls are as follows:—

Net.	No. of Boxes of Herrings Caught.	Smallest.	Largest.	Average.
Seine	21	$5\frac{3}{4}$	$10\frac{3}{4}$	$8\frac{1}{2}$
,,	38	$8\frac{1}{2}$	$11\frac{3}{4}$	9
,,	100	$6\frac{1}{2}$	$10\frac{1}{4}$	$8\frac{1}{2}$
,,	20	$6\frac{3}{4}$	$10\frac{3}{4}$	9
,,	30	$7\frac{1}{2}$	11	$9\frac{1}{2}$
,,	16	$5\frac{1}{2}$	$9\frac{1}{2}$	$8\frac{1}{4}$
,,	131	8	$12\frac{1}{2}$	$9\frac{1}{2}$
,,	94	$8\frac{1}{2}$	$13\frac{1}{4}$	10
,,	246	8	$13\frac{1}{4}$	$9\frac{1}{2}$
,,	20	$6\frac{3}{4}$	10	9
,,	9	7	$9\frac{1}{2}$	$8\frac{1}{2}$
,,	5	$8\frac{1}{4}$	$12\frac{3}{4}$	10
,,	5	$6\frac{1}{2}$	9	7–8
,,	6	9	13	$10\frac{1}{2}$
Drift	20	8	13	$9\frac{1}{2}$
,,	18	$7\frac{1}{4}$	11	$8\frac{1}{2}$
,,	10	$8\frac{1}{2}$	$12\frac{3}{4}$	10
,,	6	$8\frac{3}{4}$	$11\frac{1}{2}$	$9\frac{1}{2}$
,,	3	$8\frac{3}{4}$	$13\frac{1}{4}$	$10\frac{1}{2}$
,,	7	$7\frac{1}{2}$	12	9–10

It is, however, stated that the seine net frequently takes large quantities of smaller herrings than those indicated, and that these are thrown back into the sea; and also that large bodies of small unmarketable herrings may be enclosed by the seine, and although not removed from the net may be suffocated and destroyed in large numbers before they are allowed to escape. Such cases did not come under personal observation, but there is no doubt that large bodies of small, immature, and unmarketable herrings are occasionally enclosed by the seine and hauled to the boat. The seiners say that in such instances, when the nature of the catch is ascertained, the net is loosed and the herrings allowed to escape, and that they escape alive, and can be seen to do so. The drifters assert that in many cases the herrings are suffocated and destroyed and sink to the bottom dead. It is quite likely that this happens to some extent when a large body is encircled and a considerable time elapses before the net is hauled. But it does not appear to be a frequent occurrence, so far as could be ascertained by careful enquiry, and from the circumstance that the fishery officer of the district, who was requested at the commencement of last season to notify when cases were reported of the destruction of large quantities of small herrings by the seine net, so that the "Garland," which was working in Loch Fyne and in the Clyde last year, might trawl over the ground for the dead herrings which had fallen to the bottom, did not communicate any such case. In the ordinary use of the seine net it would be sometimes difficult to avoid encircling a body of small fish, but it is obviously not to the interest of the seine-net fishermen to do so, because the labour of shooting, and especially of hauling, the net is very considerable; and when the "fire" in the water is strong the men are usually able to tell whether the herrings are too small to be worth the trouble of shooting the net. One of the chief signs of the presence of herrings, much relied on in dark nights, by which the fishermen are guided in putting out their seine, is what they term "fire," or "firing" or "burning"—*i.e.*, the luminous flash or trail caused by the herring darting through water containing phosphorescent organisms, especially when suddenly disturbed; and while the boat sails about in quest of fish one of the crew is stationed at the bow, peering into the water and striking the front of the boat at short intervals with a mallet, or by letting the anchor fall on the gunwale, to start the herrings in the water below. There are other signs,* but this is a very common one; and it is stated that when the "fire is strong" the fishermen can tell not only the approximate depth and abundance of the herrings but their approximate size. On one of the nights I spent on board a herring boat the time was passed as above described, without the net being once shot, because the herrings were judged to be too small to warrant the trial. The men, it may be stated, were unaware of the object of the visit. But when the "fire" is not "strong," or when other signs have to be depended on, it must happen that bodies of small herrings are sometimes encircled in the way described; and when the net is brought to the side and the nature of the catch discovered the net is slacked and the herrings set free. In other cases, no doubt, these smaller herrings are mingled with marketable fish which are secured and the rest discarded.

Another allegation against the seine net is that by its bursting when a dense body of fish is encircled, or when it is impossible to remove all the herrings enclosed, large quantities of dead herrings sink to the bottom and cause pollution of the water, so that the herrings desert the spot, and may even do so in future seasons. It is not uncommon for rupture of the net to take place under the circumstances mentioned, and in such cases, especially if a considerable time has elapsed, many of the herrings are dead. In other cases herrings may be thrown overboard when they are found to be unsaleable owing to their inferior quality; this often depends upon the quantity of larger fish which may be secured earlier in the night. The same thing may happen with drifters also, and drift nets are sometimes lost owing to the weight of fish they contain. In one case which occurred near the head of the loch the "Garland" afterwards trawled over the ground with a fine-meshed net. In three hauls 48 dead and decomposing herrings were brought up, all

* *E.g.*, "Frying" or "bubbling," caused by the rising of bubbles of gas or "air" from the shoals, and visible when the weather is calm; oily appearance on the surface, no doubt due to excrementitious matters; "playing" on the surface, when the herrings, probably pursued by enemies, rise to the surface and move swiftly, furrowing the water in all directions, the noise produced being comparable to that caused by a heavy shower of rain.

of which were of large size. Whether or not such cases—which, as has been said, sometimes occur also with drift nets and with trammel nets, lost from weight of fish or stormy weather—tend to prevent herrings from frequenting the same grounds when in shallow water has been much discussed both in this country and abroad, and it is frequently assigned as a cause for their desertion. The loss of trammel nets loaded with fish at Ballantrae Bank has been cited by those opposed to the use of the trammel as a reason of the failure of the fishery there. But the explanation is not generally accepted. In the instance in Loch Fyne referred to, it was found that the presence of the decaying herring scattered over the bottom was not detrimental to other fishes, for common dabs, long rough dabs, plaice, codling, gunnel, pipe-fishes, and gobies were brought up in the "Garland's" trawl, as well as numerous invertebrates. The occurrence must happen more or less frequently all over Loch Fyne in every season, and yet the herrings have returned in abundance.

It has been shown that the seine net is adapted to capture quantities of immature herrings that would not be caught by the drift net, and also that it is probable a certain quantity of immature as well as marketable herrings are destroyed by its normal operation in the herring fishery; and it has to be considered whether these occurrences are likely to be detrimental to the preservation of the supply of herrings from Loch Fyne. The capture of immature fish is incidental to all modes of fishing and can hardly be avoided; but if it can be clearly shown to occur to such an extent as to cause a permanent diminution of the supply of the marketable individuals, it is right that measures should be taken to deal with it. So far as concerns the herring fishery in Loch Fyne there is sufficient proof that the continued employment of the seine net over a long period has not proved detrimental in this sense. Seine-net fishing has been continuously and legally pursued since 1867, and has greatly extended since that time, while the supply of herrings has on the whole increased. According to the figures supplied by the fishery officer of the district the estimated quantity of herrings caught in Loch Fyne during each of the ten years 1889-1898 is as follows:—

1889....	26,249 cwts.	1894....	130,721 cwts.
1890....	33,650 cwts.	1895....	63,046 cwts.
1891....	51,887 cwts.	1896....	64,422 cwts.
1892....	50,158 cwts.	1897....	183,309 cwts.
1893....	51,124 cwts.	1898....	131,918 cwts.
	213,068 cwts.		573,416 cwts.

The total catch in the five years 1889-1893 amounted to 213,068 cwts., and in the five years 1894-1898 to 573,416 cwts., or much more than double the quantity. The quantity caught in 1897, viz., 183,309 cwts., is said to be the largest for a very long time. During these years, and ever since the repeal of the Trawling Acts in 1867, trawling or seining has been practised on a very large scale in Loch Fyne and the neighbouring waters, and while great fluctuations have occurred in different seasons, the supply has on the whole been fully maintained. Earlier statistics, prepared mostly in connection with the various enquiries which have been held on seining for herrings, show the same result.* A table prepared by Mr. Reiach, the late Chief Inspector of the Herring Fishery, for the Commission of 1876 gives information extending over a long period. It is as follows:—†

Ten Years from	Average Number of Boats.	Average Number of Barrels.	Average Number Barrels per Boat.	Minimum Catch in Decade.	Maximum Catch in Decade.
1827–36	300	3,469	11·5	1,453 (1830)	4,898 (1832)
1837–46	350	7,388	25·1	3,225 (1839)	9,400 (1846)
1847–56	396	19,949	50·4	10,630 (1852)	32,726 (1851)
1857–66	558	33,096	59·3	16,151 (1864)	79,893 (1862)
1867–76	479	25,561	53·4	6,934 (1874)	34,471 (1876)

These statistics do not distinguish between the quantities of herrings caught by the drift net and the seine net, but they show a general increase in the catch. There is less information with respect to the relative numbers of drift-net and seine-net boats that took part in the fishery in Loch Fyne, except during the period from 1850 to 1862, when a return was prepared for the use of the Playfair Commission as follows:—

Years.	Seine Boats.	Drift Boats.	Years.	Seine Boats.	Drift Boats.
1850	40	538	1857	121	409
1851	60	518	1858	143	377
1852	55	515	1859	122	409
1853	60	490	1860	90	405
1854	72	475	1861	84	432
1855	103	407	1862	—	772
1856	106	414			

* The statistics as published in the Reports of the Board of British White Herring Fishery are imperfect.

† Report of Commission, p. 134. The quantities (in barrels) caught in each of the ten years from 1867 to 1876 were these:—40,964, 46,813, 43,088, 26,716, 22,005, 11,358, 8,166, 6,934, 15,097, 34,471. In a Table prepared for the enquiry in 1862 (*Report*, p. 8), the years are grouped in different series.

Years.	Barrels.	Maximum.	Minimum.
1834-38	17,869	—	—
1839-43	20,119	—	—
1844-48	15,427	15,560	13,816
1849-53	19,149	32,726	10,630
1854-58	25,744	31,423	16,999
1859-62	42,165	79,893	20,246

As we have seen (p. 242), trawling or seining was made illegal in 1851, but the prohibition was ineffectually enforced, and was in abeyance from 1854 to 1859; it was entirely suppressed in 1862. It would be of considerable importance if statistics were available for a period of years showing the number of seine- and drift-net boats pursuing the fishery, and the quantity and value of the herrings caught by each of these methods of fishing. That the number of seiners has very greatly increased in proportion to the drifters is shown by two returns specially prepared, one in connection with Mr. Esslemont's inquiry in 1893, and the other referring to last year; and they also indicate the quantity and value of the herrings taken by each class of fishermen. The return referring to Loch Fyne for 1893 is as follows:—

	Boats.	Men.	Herrings.	Value.
			Crans.	£
Drift net, . .	135	376	15,030	15,317
Seine net, . .	160	640	25,760	25,200

The statistics for the Inveraray district in 1899 show that while the numbers of both drift- and seine-net boats have diminished since 1893, the latter mode of fishing fully maintains its preponderance. The figures are these:—

	Boats.	Men.	Herrings.	Value.
			Crans.	£
Drift net, . .	105	276	7,847	6,815
Seine net, . .	138	552	23,541	34,074

It is thus evident that during the years since the earlier inquiries were made, the use of the seine net has greatly extended relatively to the use of the drift net; while, as has been shown, the supply of herrings has increased rather than diminished. The corresponding statistics for the adjoining district of Campbeltown for the same years exhibit similar features, the preponderance of seine-net fishing being as marked as in Loch Fyne. The fishermen of each district fish both in Loch Fyne and Kilbrennan Sound.

	Boats.	Men.	Herrings.	Value.
1893.			*Crans.*	£
Drift net, . .	149	447	33,087	24,067
Seine net, . .	132	594	37,763	31,892
1899.				
Drift net, . .	95	320	4,357	6,579
Seine net, . .	140	630	27,541	33,672

The preponderance of the seine-net fishing for herrings in the Firth of Clyde, taken as a whole, is further shown in the following Table for the years 1893 and 1899, which also includes particulars respecting the trammel-net fishery—a method which is for the most part restricted to the coast of Ayrshire:

	Boats.	Men.	Herrings.	Value.
1893.			*Crans.*	£
Drift net, . .	436	1,279	53,348	45,440
Seine net, . .	352	1,474	63,854	57,449
Trammel net, .	79	250	695	693
1899.				
Drift net, . .	404	1,262	15,965	18,009
Seine net, . .	328	1,382	54,059	70,325
Trammel net, .	22	74	757	751

Thus in 1893, in the whole area of the Clyde, there were, according to the returns of the Fishery Officers, 436 boats and 1272 men employed in drifting for herrings, and 352 boats and 1474 men employed in the seine-net fishing. The herrings landed by the seine-net boats exceeded those of the drift-net boats in quantity by 10,506 crans and in value by £12,009. The average price of seine-net herrings was about 18s. per cran, and of drift-net herrings 17s. 0½d. per cran. Moreover, the average catch per boat of the drifters was 122·3 crans, and the average earnings £104 4s. 5d.; while the average catch of the seine-net boats was 181·4 crans, and the average earnings £163 4s. 2d. The average catch per man of the drifters was 41·7 crans, and the earnings £35 10s. 6d., as against an average catch by the seiners of 43·3 crans and earnings of £38 19s. 6d. per man. In 1899 the difference in favour of the seiners was more marked. While the 404 drift boats landed only 15,965 crans of herrings of the value of £18,009, the 328 seine boats landed 54,059 crans, valued at £70,325. There was thus an excess in favour of the seiners of 38,094 crans and £52,316. The average catch and earnings rose also in proportion.

It is therefore evident that the seine-net fishing for herrings has grown to be of very considerable importance in the Clyde, and that it has largely increased relatively to drift-net fishing since the time when it was alleged to be ruining the Loch Fyne herring fishery, and the Trawling Acts were passed to suppress it; while, at the same time, the supply of herrings for the consumer has been fully maintained.

Ballantrae Bank.

It has already been stated that in consequence of complaints made by Ayrshire fishermen against the use of the seine net on that coast, and especially at Ballantrae Bank, an enquiry on the subject was held at Girvan in 1893. Seine-net fishing was alleged to be wasteful and injurious on the following grounds:—1. That it involves the capture of large quantities of immature herrings, which when brought to shore are found to be practically of no use except for manure; and that in addition large quantities of immature herrings are smothered in the seine nets, and fall to the bottom and are lost. 2. That it is an irregular mode of fishing in the sense that on one day a huge catch may be obtained, which gluts the market, while on the next day no herrings may be caught. 3. That it "breaks the eye of the herring" or "the head of the shoal"—*i.e.*, it breaks up and scatters the shoals, diverting them from their course to the spawning grounds. 4. When prosecuted on the spawning ground—Ballantrae Bank—it disturbs the herring-spawn on the bottom, and destroys it. 5. That it cannot be beneficially carried on alongside the trammel-net fishing, because it damages the trammel nets in the same way as beam trawling damages the lines and nets of other fishermen; and that since trammel-net fishing is the old and native mode of fishing on Ballantrae Bank, and seine trawling was introduced by stranger fishermen and is prosecuted by them only, it should be prohibited during the months of February and March. It was decided that an investigation should be made at Ballantrae Bank on the action of the seine net, with especial reference to the alleged destruction of the deposited spawn of the herring and the capture or destruction of immature herrings. Arrangements were accordingly made in each year to carry out this investigation, but owing to the repeated failure of the fishing very few seine-net boats carried on their operations there, and the observations could not be made until last year and this, when the herrings returned to the bank in considerable numbers, and seine-net fishing was resumed. The work has been materially assisted by Mr. R. Duthie, the fishery officer of the district, who has at various times given valuable aid to the enquiry.

The herring fishery at this part of the coast is very different from what it is in Loch Fyne. It is prosecuted in February and March by local trammel boats and by seine-net boats, chiefly from Argyllshire, and it is liable to sudden interruption from storms. The great majority of the herrings taken are ripe and spawning; it is a fishery for spawning herrings. The bank, which is of an irregular elongated form, lies off the coast between Bennan Head and the southern part of Ballantrae, and is parallel to it. It begins about one mile from the shore, and extends to a distance of somewhat over three miles from it. The depth of water ranges from about seven to thirteen fathoms, and the bank is composed principally of stones, gravel, and coarse sand. That is the position and extent of Ballantrae Bank proper, although an elevation of the bottom extends more or less from Girvan to Loch Ryan.

The fishery was at one time of considerable importance, and was carried on at the bank and in its neighbourhood by a large number of drift and trammel-net boats, many of which came from distant parts of the coast. From the same influences that caused the Acts to be passed for the suppression of seining, the Ballantrae winter fishing was put a stop to from 1860 to 1868 by reason of clauses in the Acts of 1860 and 1865 establishing a close-time from 1st January (or 1st February in the Act of 1865) until 31st May between Ardnamurchan Point and the Mull of Galloway.* This was done on the supposition that Ballantrae Bank was the spawning ground for Loch Fyne herrings. But after 1868, on the repeal of the Acts, the fishing was resumed, and was frequently very successful. The quantity and value of the herrings caught at the winter fishing off the coast in each of the last twenty-five years are shown in the following Table, with the number of the boats engaged:—

* 23 and 24 Vict., c. 92, s. 4; 28 Vict., c. 22, s. 2.

[TABLE.

Year.	Boats Employed.			Herrings Caught.					
	Trammel or Drift.	Seine.	Total.	By Trammel or Drift.		By Seine.		Total.	
				Crans.	*Value.* £	*Crans.*	*Value.* £	*Crans.*	*Value.*
1876			123					6,071	£13,610
1877			175					10,254	23,625
1878			191					17,830	44,575
1879			304					20,092	50,230
1880			364					31,292	73,536
1881			407					24,294	65,100
1882	152	270	422					8,708	22,770
1883	120	288	408					31,374	78,435
1884	123	320	443					14,564	43,692
1885	111	300	411					27,671	46,673
1886	100	192	292					4,760	5,168
1887	78	100	178					9,876	3,291
1888	65	90	155					9,515	3,983
1889	60	144	204					10,615	4,940
1890	60	114	174	1,608	—	6,586		8,194	5,147
1891	53	172	225	945	—	5,955		6,901	6,391
1892	51	46	97	1,618	—	1,695		3,313	2,404
1893	48	56	104	423	393	31	25	454	393
1894	25	—	25	75	80	—	—	75	80
1895	42	24	66	1,170	1,220	351	417	1,521	1,637
1896	19	6	25	158	40	371	93	529	133
1897	18	2	20	466	295	3	—	469	295
1898	5	—	5	25	20	—	—	25	20
1899	7	32	39	260	93	977	356	1,237	449
1900	28	42	70	1,824	1,428	2,286	1,607	4,110	3,035

These statistics clearly indicate the former importance of this herring fishery and the poor condition to which it has sunk in recent years, which is ascribed by the local fishermen to excessive "trawling" or seining. Prior to 1878 the only methods in use for the capture of herrings at Ballantrae Bank and its immediate neighbourhood were the drift net and the trammel, the former being employed principally beyond the Bank, while the trammels were set upon it. But in 1878 the seine net began to be employed on the Bank by fishermen from Argyllshire, and with so much success, that its use rapidly extended. The quantity of herrings, it will be observed, rose very largely in the years following its introduction, over 31,000 crans being secured in 1880 and 1883, their gross value amounting to no less than £73,536 and £78,435 respectively; whereas in 1894 the quantity taken was only 75 crans, of the value of £80, and in 1898 only 25 crans, of the value of £20. Down to about the year 1884 the largest herrings were secured by the seine net, and in one season the crews of two seine-net boats (eight men) earned in five weeks the sum of £900.* But after the year named the herrings caught were generally much inferior in size, and in some seasons a considerable proportion of the seine-net fish were so small as to be unmarketable, and were in some cases used for manure. It may be stated that the price, as well as the gross value, has greatly diminished of late years. Thus in the ten years 1876-1885 the average price was never under £2 per cran,

* *Fifth Report Fishery Board for Scotland*, p. 434.

it was usually £2 10s., and in one year (1881) it was £2 12s. per cran. In 1886 it had sunk to £1 1s. per cran; in 1890 to 12s. 6d., in 1896 to 5s., and in 1899 it was 7s. 3d.; in only one year since 1890 has the price reached £1 per cran—namely, in 1895. The decline in the price is not, however, chiefly due to the quantity of small herrings landed but to other causes regulating the markets, and principally the development of the winter fishery at other parts of the coast, and the importation of Norwegian herrings.

It is difficult to decide whether or not the extensive use of the seine net has produced detrimental effects on the fishery. It is contended that the great catches in nearly all the years from 1878 to 1885, when the seine net was so largely used, were excessive, and that the shoals of herrings which habitually frequented the spawning ground were either depleted, or so disturbed that they abandoned the Bank, and went elsewhere to spawn. The failure may, on the other hand, be due merely to natural fluctuations, the causes of which are obscure, but which at all events profoundly affect the herring fishery in many localities. Many cases might be cited in which the herrings deserted a favourite ground for years without apparent cause, and as suddenly reappeared. On a former occasion, namely in 1855, the herrings abandoned Ballantrae Bank, and did not return until 1862. Their disappearance then was also attributed by the trammel-net fishermen to the use of the seine net, not at the Bank itself in February and March, but on the northern coast of Ayrshire in December, when the shoals were making their way to the spawning ground. The other classes of fishermen held that it was caused by the excessive use of the trammel net, by which very large numbers of spawning herrings were captured and much spawn destroyed.*

With regard to the capture of small or immature herrings, there is no doubt that the seine net takes far greater quantities than the trammel net does; in this respect the trammel is comparable to the drift net. In seasons when small herrings abound very large quantities have been landed, and in some years have been found unsaleable and used for manure. Sometimes the catch of the seine boats consists of herrings as large and fine as those got by the trammels, but as a rule there is a considerable admixture of inferior fish. If the net is torn on the bottom, which is not an infrequent occurrence, or if a larger quantity is enclosed than the boats can well carry, and part is allowed to escape, the proportion of small herrings in the catch may be increased, inasmuch as large numbers of them are meshed. Herrings of seven to eight or eight and a half inches are not uncommon in the catches of the seine net. It was found, however, that herrings of comparatively small size may be sexually mature and propagating at Ballantrae Bank. Specimens, both male and female, not more than eight inches in length, were occasionally found to be spawning or spent; and many between eight and nine inches were in the same condition. The majority at these sizes were, however, not ripe; and many of them were found to have been feeding on the deposited herring spawn. The question of the pollution of the ground by dead herrings has also been raised in connection with this fishery, but it is probable that the seine-net boats are not chiefly responsible for the presence of dead herrings on the Bank. There is no doubt that, as in Loch Fyne, dead herrings fall upon the ground in the operations of the seine, and much more here owing to the not uncommon tearing of the net by catching on the bottom. But the same thing occurs, and probably to a greater extent,

* Report of Playfair Commission, p. 16. Report Royal Commission, vol. ii., p. 1189, 1190.

from the trammel net. These nets are left in the water, and are usually visited in the morning by the fishermen, who remove the herrings and re-set the net; the boats do not stand by their nets. It often happens that, owing to bad weather, the nets cannot be visited for many days, and they may become so weighted with fish as to lie flat on the bottom; and sometimes a gale sweeps them away or casts them into heaps, and in such cases putrefaction of the herrings contained in them causes pollution of the water. There is no evidence to show that such occurrences have affected the fishing detrimentally in succeeding years, although they have been sometimes adduced as a reason for putting a stop to the fishery on the Bank.

The question whether or not the seine net disturbs or destroys the deposited spawn of the herring was specially investigated during the present year (1900), when a considerable number of seine-net boats resumed the fishing at Ballantrae Bank. By means of the "Garland" Mr. Pearcey was able to visit the boats when they were hauling their nets, and also to make dredgings at various parts of the Bank in order to ascertain the presence or absence of herring spawn at different points. The dredgings showed that, while no spawn existed at certain points of the Bank, it was in great abundance at other parts, and this largely accounted for the diversity of the results respecting the action of the herring seine. The following dredgings may be specified :—

6th March. Ballantrae village bearing S.E. $2\frac{1}{4}$ miles distant, ten fathoms of water. A small quantity of clean shelly sand and small stones brought up; no deposited herring spawn.

7th March. (1) Ballantrae village bearing E.S.E. 2 miles distant, nine fathoms. Dredge full of sand, stones, gravel, with shells and a few fronds of *Laminaria*, nearly all of which were thickly coated with deposited herring spawn; (2) Ballantrae bearing S.E. $\frac{1}{2}$ S., distant $2\frac{1}{2}$ miles; $9\frac{3}{4}$ fathoms. Dredge full of sand, stones, gravel, and *Laminaria*, without any trace of herring spawn; (3) Ballantrae village bearing E. by S., 2 miles distant; $9\frac{1}{2}$ fathoms. Dredge filled with sand, gravel, and a few stones (1 to $3\frac{1}{2}$ inches in diameter). Herring spawn thickly deposited on the shingle and on some of the stones.

The number of seine nets which were examined immediately they were brought from the water was 79, of which 63 showed no trace of deposited herring spawn, while in sixteen it was found in more or less abundance, chiefly on the broad fronds of *Laminaria* and the stones at their roots, and fine specimens of the deposited spawn were obtained. All the nets examined, except four, furnished evidence of having come in contact with or swept the ground, on which they sometimes became fast. In most cases stones, shells, weeds, or specimens of bottom-living animals were brought up. A summary of the records made on board the "Garland" by Mr. Pearcey is here given:—

March 1st, 1900.

1. 5.30 P.M. Net shot in 12 fathoms about $2\frac{3}{4}$ miles N.E. of Ballantrae. Became fast on bottom, and was got up with difficulty; much damaged. One specimen of *Ophiothrix fragilis* was obtained, net otherwise quite clean. No fish of any kind captured.

2. 6.50 P.M. Near the same locality, in 10 fathoms. Net caught on the bottom and brought up much torn from sole-rope; 1 *Asterias rubens*, 1 stone $2\frac{1}{2}$ inches, taken from foot of net. No spawn recent or deposited. No fish captured.

3. In 10 fathoms. Net got caught on the bottom and was somewhat damaged. One basket of herring captured. No deposited spawn. Net quite clean.

4. In $10\frac{1}{4}$ fathoms. Net said not to have touched the bottom. No deposited spawn or any bottom-living organisms obtained. Net quite clean. 14 baskets of herring captured.

5. In $9\frac{1}{2}$ fathoms. Net caught on bottom and considerably damaged. Two pieces of rock fragments $7\frac{1}{4}$ and 5 inches long, 2 *A. rubens*, 2 *Solaster papposus* were obtained in body of net and near sole-rope.

6. 8.30 P.M. In $9\frac{3}{4}$ fathoms. Net had touched the bottom, sole-rope damaged. Net quite clean. A few baskets of herring captured.

7. 9.30 P.M. In 10 fathoms. Net became fast on bottom and was slightly damaged. No deposited spawn found. Net quite clean. Only a few herring captured

8. In $9\frac{1}{2}$ fathoms. Net caught on the bottom and slightly damaged. Only a few herring captured, otherwise net quite clean.

9. In 10 fathoms. Net had touched the bottom. Nothing found on net or sole-rope. Fully 50 baskets of herrings captured, all ready for spawning.

10. In $9\frac{1}{2}$ fathoms. Net said not to have touched the bottom. Net found to be quite clean. Fully 100 baskets of herring captured, the males giving off milt freely, females about ready for depositing spawn.

11. 10.50 P.M. In $9\frac{1}{4}$ fathoms. Net had touched the bottom but found to be quite clean. 150 to 200 baskets of herring captured.

12. In 10 fathoms. Net caught on the bottom and got torn from sole-rope. Two rock fragments $8\frac{1}{2}$ and 10 inches, 2 *Ophiothrix fragilis* in foot of net, but no deposited spawn observed. 20 baskets of herring captured, males giving off milt freely and females ready for spawning.

13. In $10\frac{1}{2}$ fathoms. Net caught on the bottom and badly damaged. One rock fragment, 1 *Asterias rubens*, 1 *A. gracilis*, and 2 *Ophiothrix fragilis*. No deposited spawn found; otherwise net quite clean. No fish captured.

14. In $10\frac{1}{4}$ fathoms. Net caught on the bottom and somewhat damaged, but found to be quite clean. No deposited spawn or bottom-living animals found. 10 baskets of herring captured.

All the trawl boats visited had their nets so prepared that they should drag the bottom, the sole-rope being heavily weighted with lead.

March 2nd—Came up with the herring fleet on Ballantrae Bank at 4.50 P.M.; 40 in number. Shortly after 5 P.M. a number commenced to shoot nets S.W. and N.E. off Ballantrae village, about $1\frac{3}{4}$ to $2\frac{1}{2}$ miles distant.

15. In $12\frac{1}{2}$ fathoms. Net did not touch the bottom and was quite clean. No deposited spawn found. Two baskets of ripe herring captured.

16. In $9\frac{1}{2}$ fathoms. Net caught on the bottom; examined net carefully and found it to be quite clean, no bottom-living animals of any kind or deposited spawn. Some 20 baskets of ripe herring captured.

17. In $10\frac{1}{4}$ fathoms. Net had dragged the bottom slightly, but was found to be quite clean. No deposited spawn or any bottom-living organisms found. About half-dozen baskets of ripe herring captured.

18. In $10\frac{1}{2}$ fathoms. Net did not touch the bottom; found to be quite clean. 30 baskets of ripe herring, 2 saithe, and 1 haddock captured.

19. In $9\frac{1}{2}$ fathoms. Net had dragged the bottom slightly, but came up quite clean. 14 baskets of spawning herring were captured.

20. In $10\frac{1}{4}$ fathoms. Net dragged the bottom slightly, but found to to quite clean. No deposited spawn observed or any bottom-living animals. A few baskets of ripe herring and one cod captured.

21. In 10 fathoms. Net had touched the bottom slightly, but no deposited spawn or any animals from the bottom found; net quite clean. A few baskets of spawning herring and one ling captured.

22. In $10\frac{1}{2}$ fathoms. Net had dragged the bottom a little. Two small stones 2 and $2\frac{1}{4}$ inches obtained in net, and one *Ophiothrix fragilis* and a few ripe herring; otherwise the net was found quite clean.

March 6th, at 5.30 P.M., the trawl boats commenced to shoot their nets.

23. In $9\frac{1}{2}$ fathoms. Net dragged on bottom a little. One large irregular rock fragment, $12 \times 6 \times 5$ inches, and a smaller piece $5 \times 3\frac{1}{2}$ inches, with various bottom-living animals, but no deposited spawn either on these or the net. Eight cod and saithe were captured, but no herring.

24. In $9\frac{3}{4}$ fathoms. Net had touched the bottom and brought up two fronds of *Laminaria*, with stones attached to roots, but no deposited spawn was found. Only one cod was captured.

25. In $9\frac{3}{4}$ fathoms. Net became fast on the bottom. One *E. esculentus* and 1 *A. rubens* were found in net, but no deposited spawn. A few herring only were captured.

26. In $10\frac{3}{4}$ fathoms. Net became fast on the bottom for a time, and was brought up split in several places, but found to be quite clean. Three cod and 2 saithe were captured.

27. In 9 fathoms. Net had touched the bottom; no deposited spawn found. Ten baskets of herring captured.

28. In 8 fathoms. Net became fast on bottom and was badly damaged. Several small stones, 1 *A. rubens*, several *O. fragilis*, 1 *E. esculentus*, and several *Laminaria* fronds found, but no deposited spawn. Net otherwise quite clean. No fish captured.

29. In 8 fathoms. Net had touched the bottom. One *A. rubens* found, but no deposited spawn. Fully 100 baskets of ripe herring captured.

30. In $6\frac{1}{2}$ fathoms, near south edge of Bank. Net had touched the bottom and was slightly damaged. No deposited spawn found, net being quite clean. Fully 40 baskets of herring captured.

31. In 10 fathoms. Net dragged a little on bottom. Two *E. esculentus*, 2 fronds of *Laminaria*, with stones at roots, taken from net near sole-rope, but no deposited spawn found. Three cod and 1 saithe were the only fish captured.

32. In $9\frac{1}{4}$ fathoms, near south edge of Bank. Net had touched the bottom, but came up quite clean. Three saithe, 2 cod, and 1 haddock were all the fish captured.

33. In 7 fathoms, about 3 miles to the south of Ballantrae village. Net had slightly dragged the bottom; no deposited spawn found. An enormous catch of herring was obtained at first in this haul, so large that the two boats could not manage it, and the assistance of two other boats was obtained, when a great effort to secure the catch was made; but the body of fish was so great and heavy that before any could be taken from the net they again sank to the bottom, and the net split with the strain, all but some 10 to 15 baskets of herring being lost. It appeared to me that most of these fish got clear living and in good condition.

34. In $8\frac{1}{4}$ fathoms. Net slightly dragged the bottom, but was brought up quite clean; no deposited spawn found on net or sole-rope. Thirty to 40 baskets of herring captured.

35. In $8\frac{3}{4}$ fathoms. Net dragged on bottom a little. Four stones, largest $2\frac{3}{4}$ inches; 1 *Buccinum undatum*, with *Eupagurus bernhardus*, a few *O. fragilis*, and 1 frond of *Laminaria* found in net near sole-rope. No deposited spawn; otherwise net quite clean. 25 baskets of herring and 1 saithe captured.

36. In 6½ fathoms, N.E. side of Ballantrae Bank. Net had dragged the bottom slightly, but nothing was obtained from the bottom, and no deposited spawn found on net or sole-rope. Fully 80 baskets of herring captured.

37. In 7½ fathoms. Net became fast on bottom and damaged. A few meshed herring obtained, but otherwise net quite clean.

38. In 6 fathoms, near south end of Bank. Net had touched bottom. Three stones from 2¼ inches to 4¾ inches, a few *O. fragilis*, several fronds of *Laminaria* with gravel attached to roots, 1 *E. escutentus*, 2 *A. rubens* found near sole-rope. No deposited spawn. Fully 60 baskets of herring captured.

39. In 9 fathoms. Net become fast on bottom. Two stones, 3 *E. esculentus*, 2 *A. rubens*, 1 *Laminaria* frond taken from net. No deposited spawn found; net otherwise quite clean. A few baskets of herring captured. This boat shot again near the same spot in 9 fathoms. Net touched bottom, but came up quite clean. Fully 60 baskets of herring captured.

40. In 6½ fathoms, about 1¾ miles to the south of Ballantrae village. Net had dragged the bottom slightly. Several small stones, 1 *E. esculentus*, 2 *A. rubens*, and a few *O. fragilis* found in net near sole-rope, and in body; no deposited spawn. Fully 50 baskets of herring captured.

41. March 7th, 7.50 P.M. In 9½ fathoms. Net became fast for a time on the bottom and badly damaged. Two fronds of *Laminaria*, with stones 2½ to 3 inches attached to roots, taken from near sole-rope of net. No deposited spawn; net otherwise quite clean. 20 to 30 baskets of herring captured.

42. In 8 fathoms. Net had touched the bottom. One *Buccinum undatum* found in body of net; no deposited spawn. Fully 50 baskets of herring captured.

43. In 8½ fathoms. Net had dragged the bottom slightly. No deposited spawn found, and nets quite clean. 50 baskets of herring captured.

44. In 8 fathoms. Net became fast on bottom and was badly damaged, but quite clean. No fish captured.

45. In 9 fathoms. Net caught on bottom and was torn from sole-rope; quite clean. No fish captured.

46. In 8 fathoms. Net dragged slightly on bottom; taken up quite clean. 20 baskets of herring captured.

47. In 9 fathoms, near south edge of Bank. Net dragged on bottom a little. One stone 3½ inches and 1 dead *Pectunculus* shell taken from body of net; otherwise net quite clean. No deposited spawn observed.

48. In 9 fathoms. Net became fast for a little on bottom. Two stones 3¼ and 5¾ inches thinly coated with deposited herring spawn taken from near the sole-rope; otherwise net quite clean. A few herrings were captured.

49. In 8 fathoms. Net dragged the bottom slightly. Three fronds of *Laminaria* with stones at roots taken from near sole-rope, the fronds being thickly coated with herring spawn on the exposed surfaces, but none upon the stones at roots. A small quantity of deposited spawn with small stones was taken from the body of the net, also distinct traces of spawn found on sole-rope. About 15 baskets of herring were captured.

50. In 8 fathoms. Net touched the bottom, but came up quite clean. Five baskets of herring captured.

51. In 8½ fathoms. Net slightly dragged on bottom, but was found to be quite clean. Fully 100 baskets of herring captured.

52. In 7¾ fathoms. Net caught on bottom. Several fronds of *Laminaria* and 5 stones found in net near sole-rope; no deposited spawn. 40 baskets of herring captured.

53. In 9½ fathoms. Net dragged slightly on the bottom, becoming fast for a little. Two fronds of *Laminaria*, thickly coated with deposited herring spawn, taken from body of net; traces of deposited spawn observed also on body of net and sole-rope. A few baskets of herring captured.

54. In 7 fathoms. Net had touched the bottom. No deposited spawn found. About 3 baskets of herring captured.

55. In 8½ fathoms. Nets had touched the bottom, but found to be quite clean. Only a few herring captured.

56. In 7½ fathoms. Net became fast on the bottom, and was badly damaged, but came up quite clean. No deposited spawn, and only a few herrings captured.

57. In 7¾ fathoms. Net got fast on bottom and was badly torn. One *Laminaria* frond thickly coated with deposited spawn, with stones at roots, also thickly covered with spawn, and distinct traces of deposited spawn on sole-rope and body of net. Three baskets of herring captured.

58. In 7½ fathoms. Net became fast on bottom, and was badly torn. No deposited spawn found on net or sole-rope. No fish captured.

March 9th, 5.45 P.M.—Arrived on Ballantrae Bank among herring fleet; 48 boats counted.

59. In 8 fathoms, about 2 miles S.W. of Ballantrae village. Net dragged the bottom slightly. Three fronds of *Laminaria* with stones at roots, all thickly coated with deposited herring spawn; the sole-rope and body of net also showed distinct traces of deposited spawn. Only one spent herring was captured.

60. In 8 fathoms, a little to the N.E. of shot 59. Net dragged the bottom slightly; two fronds of *Laminaria* with stones at roots, all very heavily coated with deposited herring spawn on exposed surfaces, and a quantity of deposited spawn was found on the body of net. None observed on sole-rope. No fish of any kind captured.

61. In 8½ fathoms, near shot 60. Net had dragged the bottom slightly. One large frond of *Laminaria* heavily coated with deposited herring spawn, but none on stones at roots. Net otherwise quite clean. Fully 20 baskets of herring, mostly spent, and 3 saithe were captured.

62. In 8½ fathoms, about ¼ mile to the north of shot 61. Net caught on the bottom, and was brought up quite clean. One basket of spent herring captured.

63. In 8½ fathoms, near shot 62. Net caught on bottom, but came up quite clean. A few baskets of spent herring captured.

64. In 8½ fathoms. Net slightly dragged on the bottom. Three fronds of *Laminaria* with stones at roots, thickly coated with deposited herring spawn, taken from net near sole-rope; also one specimen of *Stenorhynchus*, with deposited spawn attached to the carapace and legs. One *Trochus* shell also coated with spawn; traces of spawn also observed on sole-rope and body of net. A few baskets of herring, mostly spent, were captured.

65. In 9 fathoms. Net fast on bottom, and got badly damaged. One frond of *Laminaria* with stones at roots, heavily coated with deposited herring spawn, taken from net near the sole-rope. One basket of herring, chiefly spent, captured.

66. In 8½ fathoms. Net caught slightly on bottom, but found to be quite clean. A few baskets of spent herring captured.

67. In 8¼ fathoms. Net dragged on the bottom slightly. One frond of *Laminaria* with stones at roots, all thickly coated with deposited

herring spawn, and traces of deposited spawn were observed on body of net and sole-rope. A few baskets of herring, chiefly spent, were captured.

68. In 7½ fathoms, near the north edge of Bank. Net dragged slightly on bottom. Two stones, 7½ inches and 5¾ inches, brought up, also a frond of *Laminaria*, which was heavily coated with deposited herring spawn. A few spent herring were captured.

69. In 8½ fathoms. Net slightly dragged on the bottom, becoming fast for a time. Four fronds of *Laminaria*, with stones at roots, very heavily coated with deposited herring spawn; the sole-rope and body of net also showed traces of deposited spawn. A few herring, chiefly spent, captured.

70. In 8 fathoms, near No. 69. Net slightly dragged on the bottom. One frond of *Laminaria* taken from near sole-rope and a fragment from body of net were thickly coated with spawn. 20 baskets of herring were captured.

71. In 8 fathoms, about 2½ miles S.W. of the village of Ballantrae, near edge of Bank. Several fronds of *Laminaria*, with stones at roots, thickly coated with deposited herring spawn, were taken from net near the sole-rope; a quantity of deposited spawn was also found on the sole-rope and about the body of the net. About 15 baskets of herring were captured, as well as 1 saithe of 31 inches and 1 cod of 6½ inches, both containing deposited herring spawn in their stomachs.

72. In 8½ fathoms, near N.E. edge of Bank. Net became fast on the bottom for a time, and was somewhat damaged. Five fronds of *Laminaria*, with stones at roots, heavily coated with deposited herring spawn; deposited spawn was also found on the sole-rope and the body of the net. No herring were captured.

73. In 9½ fathoms. Net slightly dragged on the bottom. Two fronds of *Laminaria*, with stones at roots, heavily coated with deposited herring spawn; small quantities of deposited spawn also taken from sole-rope and about the body of the net. Three baskets of herring, chiefly spent, were captured.

74. 10.35 P.M. In 9½ fathoms, as near as could be judged about the centre of the Bank, to the south of Ballantrae, towards the entrance to Loch Ryan. Net had dragged somewhat on bottom. 10 or 12 fronds of *Laminaria*, with stones at roots, 7 stones and rock fragments, a few *O. fragilis*, and 1 *E. esculentus* were taken from the net, but no deposited spawn was found. 20 to 30 baskets of spent herring were captured.

75. In 8½ fathoms, not far from shot 74, but a little farther north. Net had dragged on the bottom. Several fronds of *Laminaria*, with stones at roots, but no deposited spawn on either, and nets and sole-rope quite clean. No fish of any kind captured; net badly damaged.

76. In 8 fathoms. Net became fast on the bottom. Three fronds of *Laminaria*, with stones at roots, and several bottom-living animals. No deposited spawn found; net and sole-rope quite clean. A few spent herring captured.

77. In 8 fathoms. Net dragged the bottom slightly, and was badly damaged. No deposited spawn, net quite clean, and no fish captured.

78. In 9¼ fathoms. Net became fast on bottom, and was brought up damaged. Six stones and rock fragments, 2¾ to 9¼ inches, were taken from the net. No deposited spawn found; nets and sole-rope quite clean. No fish captured.

79. In 7¼ fathoms. Several stones, 1¾ to 6½ inches, taken from the net, but no deposited spawn found. A few spent herring were captured. Net found to be perfectly clean.

Both the dredgings made by the "Garland" and the examination of the seine nets show that during last season large areas of the Bank were not utilised by the herrings as spawning ground. The deposited spawn was mostly got near and about the south and north-west edges, where *Laminaria* was abundant; the central region was practically devoid of spawn. In places where herring spawn exists it may be said that each haul of the seine net necessarily disturbs, and to some extent must destroy, some of it, as it lies on the bottom or attached to the fronds of the sea-weed, since the sole-rope sweeps over the bottom. But it is doubtful if the injury so caused is considerable or of much importance. The stones and weeds brought up by the net, whether coated with spawn or not, are thrown back into the sea by the fishermen. The destruction of herring eggs in this way cannot be great, and it is certainly quite insignificant compared with the depredations of predacious fishes, or the loss of eggs involved by the capture of large numbers of herrings in the act of spawning. At the spawing season at Ballantrae Bank not only are the herrings themselves preyed upon in enormous numbers by cod, saithe, ling, dog-fish, cetaceans, gannets, and other enemies, but their freshly-deposited spawn is also devoured in immense quantities, especially by haddocks, codling, and saithe, as well as by their own species. Haddocks are sometimes taken in large numbers in the seine nets at Ballantrae, and I found their stomachs to be full of herring spawn, frequently mixed with fine gravel, while as much as 1 lb., and even 24 ounces, of spawn has been taken from the stomach of a single cod.* The destruction of spawn in this way by enemies must, however, be regarded as a normal condition in the life-history of the herring. But there is also an immense loss in the fishing operations. The majority of the herrings taken are captured in the act of spawning, with the ripe eggs and milt running from them, and when a large catch is obtained the quantity of spawn and milt that is emitted in the handling of the fish is very great, and gives the herrings a very unsightly appearance. The boats, nets, and gear, and everything that comes in contact with the mass of fish becomes coated with spawn; the parts of the quay at which they are landed from the boats may be covered with a layer of spawn half an inch or more in thickness; and the spawn thus accumulated and discharged in the selection and handling of the fish may form considerable ill-smelling heaps. It was this loss of spawn, as well as the capture and disturbance of the spawning shoals, that led to the close-time by which the winter fishing at Ballantrae was put down; and it caused the Board of British White Herring Fishery many years before that to strongly urge the complete suppression of the fishery.

The destruction of deposited spawn, and the loss of eggs in the way described, is not peculiar to the seine net. The trammel net must also cause disturbance and loss of deposited spawn while being hauled and set. All the appendages of the net may be coated with fertilised spawn—the sole-rope, the stones used as anchors, and the meshes. So abundant is the deposition that frequently boats anchoring on the Banks, as the seine boats, bring up their anchors whitened with the deposition of eggs; this occurred also with the anchor of the "Garland." The trammels also cause loss of unfertilised spawn, although not as a rule to the same extent as the seine, because the herrings may remain a

* The contents of some of the stomachs were weighed and the number of herring eggs calculated. A haddock of between 2 lbs. and 3 lbs. in weight was found to contain more than two ounces of spawn, or nearly the whole of the eggs produced by two adult herrings. In February of 1890 nine tons of haddocks were taken from Ballantrae Bank, which would be equivalent to about 7000 individuals; and if each of these consumed daily a similar quantity of herring spawn as the one referred to, the spawn of over 300,000 herrings, or about 9,000,000,000 eggs, would be destroyed by that number alone in the course of the month or six weeks involved.

considerable time in the net before it is hauled, and a proportion of the eggs are discharged and no doubt fertilised. There is not so much spawn intermingled with the fish in the catches from the trammel boats as there is from the seine boats.

To what extent the loss of spawn at Ballantrae Bank or the disturbance of the shoals may have proved detrimental to the permanence of the fishery from season to season, it is not easy to decide. If it could be clearly shown that this spawning ground for the herring was in close relationship to important herring fisheries at other parts of the coast, as in Loch Fyne, and that the fishery there exercised an injurious effect on the more important fisheries, there might be reasonable grounds for interference on this score. But the evidence on either point is not convincing. It is generally agreed that the large herrings which are known to leave Loch Fyne towards the close of the season do not spawn at Ballantrae Bank. On the other hand, it is very widely held that the mixed and smaller class of herrings that leave Loch Fyne in many seasons pass over to the northern part of the coast of Ayrshire, give rise to the winter fishing there, and then pass on to Ballantrae Bank; and that after spawning the herrings return to Loch Fyne by way of the Sound of Kilbrennan. But in some seasons the bulk of the herrings from Loch Fyne pass down by the Sound of Kilbrennan, and the relation of these movements to the Ballantrae fishing is not clear. On the other hand, the herring shoals are sometimes first found coming to Ballantrae from the south by way of Loch Ryan, and it is quite possible that they may come from off the Irish coast, which is considerably nearer than is Loch Fyne. Experiments on the point were made by marking and then liberating many hundreds of herrings, both at Ballantrae and in Loch Fyne and the Sound of Kilbrennan, but only two of the marked fish are known to have been recovered, and they throw no light on the problem.

Conclusion.

With regard to the destructive action of the seine net in the capture of immature herrings, there is no doubt that this net from its mode of working may take considerable quantities of small herrings that would escape capture by the drift net or the trammel net, and in this respect the seine net might be regarded as destructive. But there is no evidence to show that its action is wasteful or injurious to the permanence of the supply of herrings in Loch Fyne. The contrary is indicated by the statistics of the fishery, which prove that, while the use of the seine net has increased, the supply has not only not diminished but has been augmented. The capture of immature fish is incidental to all modes of fishing, whether by net, line, or trawl. There is no fishery in which the fluctuations are more marked than in the herring fishery; there is none pursued so extensively, and yet the permanence of the supply over a period has been well established.

With regard to the winter fishery at Ballantrae Bank, the conditions are very different from what they are in Loch Fyne. The area of the Bank proper is limited; the water is comparatively shallow, and the bulk of the herrings are captured while spawning. In Loch Fyne the water is deep, and the fishing operations, unless when conducted close to the shore, are confined to the stratum near the surface, and the fishery is not for spawning fish. The seine net, when used at Ballantrae Bank, extends from the surface to the bottom and encloses everything that comes within its reach, and there is little doubt that it is in the power of seine-net fishermen to sweep this limited area almost clean of herrings for the time. The destruction of deposited spawn does not appear to be of much importance, but an excessive fishing on the Bank among the spawning shoals and constant sweeping of the bottom is not unlikely to prove injurious. The extent of the spawning ground off Ballantrae is not great. Even with the 70 boats which were sometimes fishing there during the season just passed the area appeared to be considerably crowded, and it is not surprising that damage occurs to the set nets as alleged by the trammel fishermen. There are reasons to believe that the prohibition of the use of the seine net during a part of February and March in each year might prove beneficial to the herring fishery in future seasons, and would not cause much, if any, hardship to the seiners. Their nets can still reach the bottom in the somewhat deeper water outside, beyond the actual spawning ground, where abundant catches are frequently obtained. The following boundaries would include the area in question, viz., a straight line passing seawards in a N.W. direction for three geographical miles from Bennan Head; a similar line passing for the same distance from Downan Point; and a line, parallel with the shore, between the extremities of the above lines.

VI.—THE FISHES OF THE FIRTH OF CLYDE.

By THOMAS SCOTT, F.L.S., Mem. Soc. Zool. de France.

It has been considered desirable that a list should be prepared of the fishes which have from time to time been observed within the limits of the Clyde estuary. The list is not a descriptive one, but is merely an enumeration of the various species which have come under the notice of the writer, together with those which have been recorded by different authors who have written on the fauna of the Clyde, or which have been seen by persons whose accuracy may be relied on. The following are the chief sources from which my information concerning Clyde fishes has been obtained:—

(1.) A List of Loch Fyne Fishes, prepared for the most part by the late George Brook, Esq., F.L.S., and published in the *Fourth Annual Report of the Fishery Board for Scotland* (1886). (A Revised List of Loch Fyne Fishes is published in the Board's *Fifteenth Annual Report*, Part III., 1897).*

(2.) A paper by Dr. Albert C. L. G. Günther, F.R.S., entitled, "Report on the Fishes obtained by Mr. (now Sir) J. Murray in deep water on the North-West Coast of Scotland, between April 1887 and February 1888," published in the Proceedings of the Royal Society, Edinburgh, Vol. XV. (1888). In this report 31 species are recorded, one of which was new to science, while two were additions to the British fauna. The species recorded in Dr. Günther's paper were mostly from the Clyde area, and there are some interesting notes on the bathymetrical distribution of the species.

(3.) *A Vertebrate Fauna of Argyle and the Inner Hebrides*, by J. A. Harvey-Brown and Thomas E. Buckley, published in 1892. The part of this work which is referred to in the present paper is the separate reprint of the list of fishes. In the list of fishes given in this work, the authors include Dr. Günther's records mentioned above, in the form of foot-notes under each of the species to which the records specially refer; additional Clyde records are also given in this work.

(4.) The statistics published in the *Annual Reports of the Fishery Board for Scotland*, in so far as they relate to the fishes of the Firth of Clyde, and especially to those fishes which have been captured by the Fishery steamer "Garland."

I have also to acknowledge my indebtedness to Mr. Duthie, the Fishery Officer at Girvan, and to Mr. Gray of the Marine Station, Millport, Cumbrae, for interesting information relating to Clyde fishes. Other sources of information are duly acknowledged in the sequel.

Before proceeding with the enumeration of species, it may be of interest to refer to some points concerning the distribution of one or two of the forms which are usually considered to be more or less rare in the Clyde area. Previous to the investigations carried on by Dr. (now Sir) John Murray, by means of the s.s. "Medusa," the fish usually called the Sharp-tailed Lumpenus, *Lumpenus lampetræformis*, was not known to occur within the limits of the Clyde; but now, by the use of a small-mesh trawl-net, this fish is found to be comparatively frequent

* The compiler of this revised list had the privilege of consulting the records of Loch Fyne fauna obtained by the s.s. "Medusa" as the result of the investigations carried on by Sir John Murray on the West Coast.

and more or less generally distributed, especially in the deep-water area. The same may be said of the Argentine, *Argentina sphyræna.* This fish, which used to be considered a rare species in the Clyde, is really not very uncommon when sought for with suitable appliances. It may be pointed out further that if anyone were to look through the lists of Clyde fishes captured by the "Garland," he would fail to find a single record of a Halibut, which is only occasionally taken by a trawl. Moreover, the halibut is not mentioned for the Clyde in Dr. Günther's paper, nor in the work published by Harvey-Brown and T. E. Buckley already cited, yet the Fishery Officer at Girvan informs me that halibut are not very rare in the seaward part of the Clyde estuary, and that they are sometimes caught in the deep water off Ayr; while in a letter, dated the 28th December last, he states that he had seen, a few days before, a young halibut landed at Girvan, which had been caught between that place and Ailsa Craig, and which weighed about a stone.

In looking through the statistics of the steamer "Garland," it will also have been observed that Turbot and Brill are not very frequently mentioned in the lists of fishes captured by the steamer in the Clyde estuary, yet there is a more or less regular turbot fishery carried on off Girvan, and sometimes a considerable number of these fishes, captured in the Clyde by gill-nets, are brought to market. It is obvious from facts such as these that, though one mode of fishing may yield negative results in respect of certain species, it does not necessarily follow that these species are absent or even rare. The results obtained by the use of the ordinary beam or otter trawl are usually very different from those obtained by the use of special nets or lines, therefore a kind of fish that may be seldom or never captured by one set of appliances, may by the use of a different set be found comparatively frequent.

The present enumeration comprises 113 species of Clyde fishes, but the occurrence of one or two of these appears to be somewhat doubtful; and it is also very desirable in the case of one or two others which, though their presence in the Clyde seems to be fairly well attested, further information should be obtained concerning them. I have indicated such species by enclosing their names within square brackets, and also by the notes referring to them.

There are several kinds of fishes which appear to be equally at home in the sea and in brackish water, and in some cases even in water that is fresh or nearly so; and there is a considerable divergence of opinion as to which, and how many, of these should be included in lists of *marine* species, and of those which should more properly be regarded as *fresh-water* forms. One has only to compare Professor H. G. Seeley's interesting work on *The Fresh-Water Fishes of Europe* with that of *The British Marine Food-Fishes*, by Professor M'Intosh and Mr. A. T. Masterman, to find examples of this difference of opinion. In the present list there will probably be found species which, in the opinion of some people, should have been excluded as belonging more properly to the fresh-water group; but when we find distinguished writers failing to agree on such a point as this, I may be excused if unable to prepare a list perfect in this respect. The basis of this list is the enumeration of Loch Fyne fishes, already referred to, prepared by the late George Brook, Esq., and published in 1886.

I have followed as far as possible the nomenclature used by Professor M'Intosh and Masterman in their *British Marine Food-Fishes*, while the arrangement of the species is in accordance with that of the *History of British Fishes* by Dr. Francis Day.

The following abbreviations are also used :—

(B. & S.) Refers to the list of Loch Fyne fishes published in the *Fourth Annual Report of the Fishery Board for Scotland.*

(Günther) Refers to Dr. Günther's paper published in the Proceedings of the Royal Society, Edinburgh, 1888, Vol. XV., pp. 205-220.

(H.B.) Refers to the separate reprint of the List of Fishes published in Harvey-Brown and Buckley's work on the Vertebrate Fauna of Argyle and the Inner Hebrides.

(G.) Refers to the "Garland's" statistics.

(M.) Refers to MS. records for Loch Fyne of the s.s. "Medusa," showing some of the records obtained by Sir John Murray while investigating the marine fauna and flora of the West Coast.

SUB-CLASS TELEOSTEI.

Order ACANTHOPTERYGII.

Fam. PERCIDÆ.

Polyprion americanus (Bl. Schneider). The Stone Basse.

This is the *Polyprion cernium* of Day's *British Fishes.* "One was taken years ago at the mouth of the Clyde" (Aflalo). "It was also taken off Little Cumbrae in 1870 by Dr. J. Young" (H.B. p. 184). The Stone Basse appears to be only an occasional visitor to the Clyde, for although it is included in the *Vertebrate Fauna of Argyle and the Inner Hebrides* the above is the only locality for the species given by the authors.

Fam. MULLIDÆ, Swainson.

Mullus barbatus, Linné. Surmullet, Red Mullet.

Loch Fyne (Captain Campbell of Inverneil). Captain Campbell in referring to this species says :—"I caught one in Loch Fyne . . . in a trammel net in 10 fathoms, and though I tried in many places for them I never got another" (*see* H.B., p. 185).

Fam. SPARIDÆ, Cuvier.

Pagellus centrodontus (De la Roche). The Common Sea Bream.

One specimen of *Pagellus centrodontus* was taken by Mr. M. P. Bell at Cumbrae, on July 12th, 1885 (*see* Robertson in Proc. N.H.S. Glasgow, Vol. I., p. 119). When at Tarbert in 1885–86, I remember seeing a specimen which was washed ashore in East Loch Tarbert, and which appeared to have been but a short time dead. It was probably captured in the nets of the herring boats fishing in the vicinity of East Tarbert and having been thrown back into the sea had drifted ashore. In the *Vertebrate Fauna of Argyle and the Inner Hebrides, Pagellus centrodontus* is described as "locally numerous throughout the West of Scotland." The species is sometimes brought in in large numbers to the fish market at Aberdeen.

Fam. COTTIDÆ.

Cottus scorpius, Linné. The Sea Scorpion.

Cottus scorpius is generally distributed throughout the Clyde and Loch Fyne, but it seems to be more frequent inshore than in deep water. "Two immature specimens were taken between Cloch Lighthouse and

Whiting Bay in 15 to 30 fathoms in July, and one immature specimen between French and Kilbrennan Sound in 10 to 14 fathoms in March" (Günther). The variety *grœlandicus* is also occasionally obtained in Loch Fyne; a specimen of the variety in the Fishery Board's collection at Bay of Nigg measures slightly over one foot in length. Dr. Day remarks that the sea scorpion is said to attain to six feet in length in the Greenland seas, while the largest recorded example in Great Britain is fifteen inches.

Cottus bubalis, Euphrasén. The Father Lasher.

Moderately common in Loch Fyne (B. & S., 1886). "A very young specimen was obtained at the Mull of Cantyre in 60 fathoms in February, and another immature one in the Sound of Sanda in 20 fathoms in March, 1885" (Günther). Little Harbour, Upper Loch Fyne, December 1896. Off Inveraray, 1897. Young specimens are moderately frequent amongst seaweed in the shallow inshore bays of Loch Fyne.

Cottus lilljeborgii, Collett. The Norway Bullhead.

"Off Ardrossan, 15 to 30 fathoms; Sound of Sanda, 20 fathoms" (Günther). This is one of the species added to the British fauna by Dr. (now Sir) John Murray. It seems to be a small species. The specimen caught off Ardrossan measured $2\frac{1}{2}$ inches in length, while that from the Sound of Sanda was only $1\frac{3}{4}$ inches long.

Trigla lineata, Gmelin. The Streaked Gurnard.

East Loch Tarbert, Loch Fyne, not common (B. & S.). One was obtained in the trawl of the s.s. "Garland" at trawling Station VI.* (near the mouth of the Clyde) on November 25th, 1895. Two were captured at trawling Station XI. on April 21st, 1897, and another at Station VIII. in September of the same year. Mr. Pearcey records that five were caught last year (1899) at Stations I., VI., VII., and IX. Dr. Day refers to one specimen of *T. lineata* having been procured near Ayr, and a second in October 1844 at Glasgow.† It appears to be a rare species in the Clyde.

Trigla cuculus, Linné. The Red Gurnard.

Red Gurnards are occasionally captured by the "Garland" in the seaward part of the Clyde estuary, but do not seem to be very common. They appear to have been more frequently recorded from the Clyde last year (where the "Garland" was chiefly employed) than for some years previously. In looking over the returns of the "Garland" for 1899, it is interesting to observe that while these fishes were captured in every haul made at Station VI., at Station VIII. they occurred in three of the hauls, and in only two of the hauls made at each of the Stations I., VII., IX., and X. At Stations III. and XII. they were only once captured, and none are recorded from any of the hauls made at Stations II., IV., V., and XI.

Ninety hauls were made by the "Garland" last year at Stations I. to XII., and Red Gurnards were obtained in twenty-one of them; the number of specimens recorded from these twenty-one hauls is 73, and the number obtained in each haul may be summarised as follows:—

* The situation of the Stations is described on p. 20 of this Report.

† *British Fishes*, Vol. I., p. 58.

7	hauls	contained	1	Red Gurnard	each	= 7.
3	„	„	2	Red Gurnards	each	= 6.
3	„	„	3	„	„	= 9.
3	„	„	4	„	„	= 12.
1	„	„	5	„	„	= 5.
1	„	„	7	„	„	= 7.
2	„	„	8	„	„	= 16.
1	„	„	11	„	„	= 11.
21						73

Fifteen specimens of Red Gurnards were obtained in one haul at Station VIII. in December 1898, but such a large number in one haul is exceptional. They are also recorded by Landsborough in his *Natural History of Arran*, p. 492.

Trigla lucerna, Linné. The Sapphirine Gurnard.

This, which is the *Trigla hirundo* of Day's *British Fishes*, appears also to be moderately rare in the Clyde. Thompson remarks that he has seen this species in autumn captured in salmon nets at Ballantrae, in Ayrshire, and on different parts of the coast in the country (Day).* I do not find it recorded amongst the captures of Clyde fishes made by the Fishery steamer "Garland."

Trigla gurnardus, Linné. The Grey Gurnard.

Common, and generally distributed throughout the seaward part of the Clyde and in Loch Fyne, especially during the summer months. This seems to be a common species throughout the Scottish seas. Large quantities of gurnards are sometimes landed at the fish market at Aberdeen, and they nearly all belong to this species.

Triglops murrayi, Günther. Murray's *Triglops.*

"Several specimens from 2½ to 4 inches long were obtained at the Mull of Cantyre at a depth of 64 fathoms in the months of February and March, and 4 miles south-east of the Island of Sanda in 35 fathoms in the middle of March 1887" (Günther). One specimen 2½ inches long was captured in the shrimp-trawl of the "Garland," in the vicinity of Sanda, November 1896. *Triglops murrayi* is described as closely allied to *Trigla pengellii*; it is one of the species added to the British fauna by Dr. (now Sir) John Murray.

Fam. Cataphracti, Müller.

Agonus cataphractus, Linné. The Pogge.

Ardrishaig (Dr. Scouler). Occasionally in other parts of Loch Fyne and the Clyde estuary. "Five specimens from the Mull of Cantyre, 49 to 50 fathoms, February. Two specimens from Kilbrennan Sound, 10 to 20 fathoms, March 1888" (Günther). It has also been got by the "Garland" at Stations I. and VI.

Fam. Pediculati, Cuvier.

Lophius piscatorius, Linné. The Angler.

The Angler is frequently taken in the trawl-net of the Fishery steamer "Garland," and especially at those stations where the water is

* *British Fishes*, Vol. I., p. 62.

moderately deep. One or more are got in most hauls of the trawl at all the Stations, except in Loch Fyne, where it is much less common. No specimens have been caught at Stations XV. or XVII.; one was taken at Station XVI. in over 60 fathoms. The largest obtained was 49 inches (Station I., 30th May 1899). *Lophius* is sometimes obtained larger than any of the Clyde specimens; in December 1841 Thompson examined one that was four and a half feet in length.*

Fam. TRACHINIDÆ, Risso.

Trachinus vipera, Cuvier. The Lesser Weaver.

Recorded from Arran by Dr. Landsborough in his *Natural History of Arran*, p. 318. He states that the lesser weaver is known to the people at Lamlash as the "Stangster" or "Stang-fish."

Fam. SCOMBRIDÆ, Cuvier.

Scomber scombrus, Linné. The Mackerel.

Shoals of mackerel are occasionally observed both in the Clyde estuary and in Loch Fyne, and considerably over a thousand cwts. are usually landed by fishermen each year. Dr. Day, though he gives a very full description of the habits, habitats, etc., of the mackerel, makes no allusion to its occurrence in the Clyde or Loch Fyne, neither is any notice taken of its occurrence in these places in the *Vertebrate Fauna of Argyle and the Inner Hebrides.*

Orcynus thynnus, Linné. The Tunny.

Pennant records a specimen weighing 460 lbs. taken at Inveraray in 1769. An example, 9 feet long, was captured in the Gareloch, nearly opposite Greenock, in July 1831.† This last specimen is said to have been in pursuit of herrings.

Thynnus pelamys, Linné. The Bonito.

One was captured in the Clyde in July 1832,‡ and purchased for the Andersonian Institute of Glasgow.§ Jenyns is doubtful if the fish recorded by Dr. Scouler is the true *Thynnus pelamys*, but suggests that it is more likely to be the next one.

Pelamys sarda, Bloch. The Belted Bonito.

One was captured in the Clyde in 1859, and is now in the Hunterian Museum, Glasgow.

Fam. CORYPHÆNIDÆ (part), Swainson.

Brama raii, Bloch. Ray's Bream.

One specimen in the Hunterian Museum was taken near Ayr (H.B., p. 188).

Lampris luna, Gmelin. The Opah or King Fish.

One was taken in the Clyde in 1833 (Scouler). A specimen of the king-fish in the Hunterian Museum, Glasgow, was captured in the Clyde in 1864.

* Day, *British Fishes*, Vol. I., p. 76.
† Day, *British Fishes*, Vol. I., p. 97.
‡ Scouler, *Mag. Nat. History*, Vol. VI., p. 529 (1833).
§ Day, *British Fishes*, Vol. I., p. 101.

Fam. Cyttidæ, Kaup.

Zeus faber, Linné. The John Dory.

The John Dory has been taken off Rothesay (H.B., p. 186); in Loch Fyne (B. & S.); in Kilbrennan Sound in the shrimp-trawl of the Fishery steamer "Garland," and in other parts of the Clyde estuary (Stations I., II., III., VI., and VII.), but most of the Clyde specimens I have seen are small and immature. Those taken by the "Garland" usually range from 10 to 14 inches; the largest was 19 inches and the smallest three inches.

Fam. Gobiidæ, Cuvier.

Gobius flavescens, Fabricius. The Two-Spotted Goby.

Loch Fyne (Dr. Scouler); common amongst *Zostera* in East Loch Tarbert (B. & S.); Upper Loch Fyne (M.); also in various parts of the Clyde estuary (G.). Though *Gobius flavescens* is widely distributed throughout the Clyde area it does not appear to be very common. This is the *Gobius ruthensparri* of Day's *British Fishes.*

Gobius niger, Linné. The Black Goby.

Taken in the Clyde area (H.B., p. 193). Moderately common, especially off shore; but most of the specimens captured by the "Garland" are of comparatively small size, few of them reaching a length of four inches.

Gobius minutus, Gmelin. The Spotted or Speckled Goby.

Common, and generally distributed throughout the estuary, including Loch Fyne and the other sea-lochs within the Clyde area. Günther records *Gobius minutus* from Loch Goil in 45 fathoms, and in the vicinity of Cloch Lighthouse in 43 fathoms. It has also been taken by the "Garland" at the head of Upper Loch Fyne in from 17 to 35 fathoms.

Gobius jeffreysii, Günther. Jeffrey's Goby.

"Three specimens were obtained in April, viz., in Lamlash Bay (6 to 18 fathoms), off Whiting Bay (20 fathoms), and off Cumbrae Light (56 fathoms). Five specimens in August off the Cloch Lighthouse in 43 fathoms. Two adult specimens, male and female, obtained in Kilbrennan Sound at an uncertain depth (10 to 45 fathoms) on March 22nd, 1888" (Günther). This species has not yet been obtained by the Fishery steamer "Garland."

Several of the species of *Gobius* are somewhat difficult to make out, and it is just possible that other species in addition to those named may also occur in the Clyde.

Fam. Callionymidæ, Richardson.

Callionymus lyra, Linné. The Dragonet or Gemmeous Dragonet.

The dragonet is not uncommon in the Clyde and Loch Fyne; it is frequently mentioned amongst the captures of fishes made by the Fishery steamer "Garland," and especially amongst the fishes taken with the shrimp-trawl. As many as 47 specimens were recorded from one haul made on November 11th, 1896, and Mr. Pearcey records 125 specimens captured in a single haul on September 5th 1897, between Cantyre and Ailsa Craig.

Callionymus maculatus (Bonaparte). The Spotted Dragonet.

Kilbrennan Sound, rather abundant at 26 fathoms ; Sound of Sanda, 24 to 28 fathoms (H.B., p. 194). Occasionally captured in the shrimp-trawl of the Fishery steamer "Garland."

Fam. Discoboli, Cuvier.

Cyclopterus lumpus, Linné. The Lumpsucker or Cock-Paidle.

The lumpsucker is occasionally captured in the Clyde by the "Garland." Young specimens are sometimes observed in the tow-net gatherings collected in Loch Fyne as well as in other parts of the Clyde estuary. Thompson mentions its existence in the vicinity of Ayrshire.*

Cyclogaster liparis, Fleming. The Sea Snail or Sucker.

The sucker is not uncommon in Loch Fyne, and also in the Clyde, but usually inshore where the water is shallow and the bottom weedy. It is, however, recorded from water that is also of considerable depth. Dr. Günther in his report to the Royal Society of Edinburgh † records many specimens from 49 and 64 fathoms in the vicinity of the Mull of Cantyre, and three specimens from 30 to 40 fathoms between Cumbrae and Wemyss Point. It has been got by the "Garland" in 66 fathoms, 8 miles W. by N. of Corsewall Point, and in the same depth S.E. of the Mull of Cantyre.

Cyclogaster montagui, Donovan. Montagu's Sucker.

Not so common as the last, but the habitat is somewhat similar.

Fam. Gobiesocidæ, Bleeker.

Lepadogaster gouanii (Lacep.). The Cornish Sucker.

This species has been taken at Millport (H.B., p. 198). I have not yet seen a Clyde specimen of *Lepadogaster gouanii* ; but probably it may not be very rare if sought for in the right places.

Lepadogaster bimaculatus (Cuvier). The Doubly-spotted Sucker.

Recorded by Dr. Landsborough from Lamlash Bay, Arran. He describes it as "far from being rare."‡ Taken in the Clyde area (H.B.).

Anarrhichas lupus, Linné. The Wolf Fish, Cat fish.

Not uncommon amongst the captures of fishes made by the s.s. "Garland," both in the Clyde and Loch Fyne.

Fam. Blenniidæ, Swainson.

Blennius pholis, Linné. The Shanny.

In Clyde area (H.B., p. 185). Mr. Alex. Gray, of the Marine Station, Millport, Cumbrae, in a note dated December 11th, 1899, says:—"Last spring I caught a specimen of *Blennius pholis* here, and kept it alive for about four months. Unfortunately it managed somehow to jump out of the tank, and in the morning I found it on the floor, dead. It is now in our collection, preserved in formaline."

* Day, *British Fishes*, Vol. I., p. 182.

† Proc. Vol. XV., p. 41.

‡ *Natural History of Arran* (1875), p. 328.

Chirolophis galerita, Linné. Yarrell's Blenny.

One specimen was taken amongst boulders at low water in East Loch Tarbert in 1885 (B. & S.). Ballantrae Bank, one specimen in January 1899 (G.).

Pholis gunnellus, Linné. The Gunnel or Butter-fish.

The butter-fish is common and generally distributed, and especially inshore amongst weed and stones, where it may frequently be found when the tide recedes.

Euchelyopus (*Zoarces*) *viviparus*, Linné. The Viviparous Blenny.

A specimen of this species, captured in the vicinity of Row, near Helensburgh, is in the collection of the late Dr. Robertson of Millport at the Marine Station there. I am indebted to Mr. Gray, the Curator, for this record.

In the *Vertebrate Fauna of Argyle and the Inner Hebrides*, the viviparous blenny is recorded from Loch Creran, the Sound of Jura, and from Glenshiel, "but it seems to be rare on the West Coast." There is no Clyde record for the species in this work.

Lumpenus lampetræformis (Walbaum). The Sharp-tailed Lumpenus.

"Three adult specimens were found between Cumbrae and Skelmorlie Lighthouse in 20 fathoms in April 1887, and at Cumbrae Lighthonse in 60 fathoms in February 1888" (Günther). Occasionally captured off shore in the shrimp trawl-net of the Fishery steamer "Garland." As many as a dozen specimens of this rare species have been taken at one time by the Fishery steamer in the lower part of the Clyde estuary, whilst in 1896 four specimens were captured near the head of Upper Loch Fyne.

It requires a net with moderately close meshes to capture this species—an ordinary trawl-net is usually ineffective.

In a work on British Natural History published in 1898, the author, F. G. Aflalo, has the following note within square brackets at p. 371 :—"The sharp-tailed lumpenus was once trawled (1884) off the Carr Lightship," and he adds that he gives this record "on the authority of M'Intosh and Masterman"; evidently he was unaware of Dr. Günther's records for the Clyde, and the Fishery Board's for the Firth of Forth.

Fam. CEPOLIDÆ, Bleeker.

Cepola rubescens, Linné. The Red Band Fish.

One $15\frac{1}{2}$ inches long was taken on a whiting line 7 miles south of Ayr (Harvey). Another $19\frac{1}{2}$ inches long was found on the beach at Ballantrae after a storm (Thompson). "Two have been taken on the Ayrshire coast just inside the Clyde area" (H.B., p. 195). Perhaps this last record refers to the same specimens mentioned by Harvey and Thompson.

Fam. ATHERINIDÆ, Günther.

Atherina presbyter, Cuvier. The Sand Smelt or Atherine.

Frequent amongst zostera in East Loch Tarbert in the spring of 1885, but not met with later (B. & S.). Mr. Gray, of the Millport Marine Station, states :—"On two occasions I saw shoals of these little fishes in Campbeltown Loch—once at the Kilbrennan shore, where they were pursued by a number of guillemots, which chased them so keenly that they jumped clean up on the gravelly beach, and I collected quite a number of living specimens. Many of the fishes were fully two feet from the water's edge."

Fam. Mugilidæ.

Mugil capito, Cuvier. The Grey Mullet.

The "ear-stones" (*otolites*) of a grey mullet (*Mugil capito*, Cuv.), captured in the Clyde off Fairlie, are in the collection of the late Dr. Robertson of Millport, at the Marine Station there. I am indebted to Mr. Gray, the Curator, for this record.

In the *Vertebrate Fauna of Argyle and the Inner Hebrides*, *Mugil capito* is recorded from several localities on the West Coast of Scotland, but there is no record of it from the Clyde.

Fam. Gasterosteidæ.

Gasterosteus aculeatus, Linné. The Three-spined Stickleback.

Captured occasionally with the push-net at various parts of the shores of Loch Fyne ; we have it also from other parts of the Clyde estuary.

Gasterosteus spinachia, Linné. The Fifteen-spined Stickleback.

The fifteen-spined stickleback is more or less common amongst sea-weed in shallow water; it is generally distributed along the shore line, both of the Clyde estuary and the lochs branching from it.

Fam. Labridæ, Cuvier.

Labrus bergylta, Ascanius. The Ballan Wrasse.

The Ayrshire and Wigtown coasts (Thompson). In the Clyde area (Dr. J. Young, *vide* H.B., p. 199). Frequent in Loch Fyne in the autumn (B. & S.).

Labrus mixtus, Linné. The Striped Wrasse.

Taken occasionally at the mouth of East Loch Tarbert, Loch Fyne (B. & S.). It is also recorded in Harvey-Brown's *Vertebrate Fauna of Argyle and the Inner Hebrides*, and on the authority of Dr. J. Young as occurring in the Clyde area.

A male and a female of this species were captured in Ayr Bay by a fisherman on January 30th this year (1900); the specimens were secured by Mr. Duthie, Fishery Officer, Girvan, who happened to be in Ayr at the time, and were forwarded by him to the Laboratory at Bay of Nigg.

Crenilabrus melops, Linné. The Goldsinny or Corkwing.

A small specimen of the goldsinny was captured by the "Garland" near Cairndow, at the head of the Loch Fyne, in August 1899. One specimen from Lamlash Bay in 6 to 18 fathoms, April (Günther).

Ctenolabrus rupestris, Linné. Jago's Goldsinny.

Common, especially near Skate Island, Loch Fyne (B. & S.). Occasionally obtained in the trawl-net of the Fishery steamer "Garland." One specimen was obtained in Lamlash Bay in 6 to 18 fathoms, in April, and another between Cumbrae and Skelmorlie Buoy in 20 fathoms, in the same month, 1887 (Günther).

Centrolabrus exoletus, Linné. Small-mouthed Wrasse, Rock Cook.

Taken occasionally in Loch Fyne (B. & S.).

Coris julis (Linné). The Rainbow Wrasse.

Recorded for the Clyde area on the authority of Dr. J. Young (H.B., p. 200).

Order ANACANTHINI.

Fam. GADIDÆ, Cuvier.

Gadus callarius, Linné. The Cod.

Common and generally distributed. The natural habitat of the cod is in moderately deep water; this is shown by the fact that if they are exposed for a lengthened period to daylight their eyes become more or less diseased. When at Rothesay Aquarium in 1886–87 I observed that the eyes of almost all the specimens of cod kept there were diseased, and one specimen was entirely blind and had to be fed separately. This disease, which at first took the form of an opaque white spot, but which gradually extended all over the eye, was ascribed to the fish being kept exposed to the daylight. The cod were the only fishes in the Aquarium that were affected in this way.

Gadus æglefinus, Linné. The Haddock.

More or less frequent, and generally distributed throughout the Clyde area, but much less abundant than on the East Coast. Upper Loch Fyne in the centre in 65 to 70 fathoms (M.).; between Pennymore and Inveraray (G.).

Gadus luscus, Linné. The Bib, or Whiting Pout.

Occasionally in Tarbert harbour (B. & S.); Tarbert Bank, Lower Loch Fyne; and between Dunderawe and Cairndow, Upper Loch Fyne (G.). Generally distributed throughout the Clyde estuary, but seldom more than 8 to 10 inches in length. Two, 13 inches in length, were obtained near Sanda Island in May 1897. A specimen in the Fishery Board's collection in the Laboratory at Bay of Nigg measures fully 15 inches in length.

Gadus minutus, Linné. The Poor or Power Cod.

Dr. Günther in his paper on Clyde Fishes states that "the specimens obtained on March 10th and 17th were ready to spawn, and had fed on *Nyctiphanes*, sand eels, and *Aphrodite*." This *Gadus* is usually more or less in evidence amongst the contents of the shrimp-trawl of the Fishery steamer "Garland."

Gadus esmarkii (Nilsson). The Norway Pout.

According to Dr. Günther, the distribution of this species in the Clyde extends from Kilbrennan Sound to Lower Loch Fyne, where young specimens were found in tolerable abundance at 80 fathoms. He also remarks that "the species does not appear to be unfrequent in Kilbrennan Sound." He states further that "the characteristics by which *Gadus esmarkii* can be distinguished from its British congeners are:—The lower jaw, which projects beyond the upper; the dentition, the teeth of the outer series in the upper jaw being a little larger than the inner ones; the length of the snout, which is almost equal to the length of the diameter of the eye, which is a little less than one-third the length of the head; the slender barbel, which is about half as long as the eye; and, finally the fin formula—it being D 15–16, 23–25, 22–25; A 27–29, 23–25" (H.B., p. 203). *Gadus esmarkii* is, in some respects, not unlike *Gadus minutus*, and may have occasionally been mistaken for that species. It is occasionally taken in the shrimp trawl-net of the "Garland."

Gadus merlangus, Linné. The Whiting.

This is one of the more common and generally distributed of the *Gadi*; but though extending into Upper Loch Fyne it is described as "not abundant" there. The whiting appears to be more frequent in the seaward portion of the Clyde estuary than it is in the more inland parts.

Gadus poutassou, Risso. Couch's Whiting.

This is readily distinguished from other British *Gadi* by the position of the dorsal fins, and especially by the distance between the second and third dorsals being greater than the distance between the same fins in the whiting, which it somewhat resembles. Three specimens of *Gadus poutassou* were captured in the shrimp-trawl of the "Garland" at the mouth of the Clyde estuary, in 54 fathoms, on September 22nd 1897. These specimens are now amongst the collection of fishes in the Fishery Board's Laboratory at Bay of Nigg.

Gadus virens, Linné. The Coal-fish or Saithe.

Moderately common and generally distributed, but mostly of small size. Full grown coal-fish do not appear to be very plentiful in the Clyde, but the young "podlies" sometimes occur in great numbers in inshore localities, as at East Loch Tarbert harbour and wharf.

Gadus pollachius, Linné. The Pollack or Lythe.

More or less frequent, but usually of small size; large specimens are occasionally brought to East Tarbert, Loch Fyne (B. & S.). The "Garland" also has records of lythe from Loch Fyne as well as off Sanda Island. The specimens from Sanda measured from 23 to 35 inches in length. *Gadus pollachius* has no barbel on the lower jaw.

Merluccius vulgaris, Cuvier. The Hake.

The hake is frequently captured in the Clyde by the "Garland" at all the Stations, as many as 108 having been caught in a single haul of the net; most of the specimens are more or less immature, but sometimes range from 30 to 40 inches.

Phycis blennioides (Brun.). The Greater Fork-beard.

The late Dr. Robertson of Millport, Cumbrae, recorded this species as having been taken near Cumbrae in April 1890.* Mr. Alex. Gray, of the Millport Marine Station, informs me that "the palate and forked fins of a specimen of *Phycis* are in the Robertson collections," and are probably portions of the fish referred to by Dr. Robertson, as they agree with the description he gave of the specimen which he recorded. Several specimens of the greater fork-beard have occurred on the coasts of the Solway Firth†, but it seems to be rare in the Clyde.

**Proc. Nat. Hist. Soc. Glasgow*, Vol. III. (N.S.), p. 276 (1892). This specimen measured 24 inches in length.

†Day, *British Fishes*, Vol. I., p. 304.

Molua molva, Linné. The Ling.

The ling, though not uncommon in the Clyde, is not very often captured by the "Garland," and rarely more than one or two specimens are obtained in any single haul made by the beam-trawl.

Onos mustela, Linné. The Five-bearded Rockling.

Taken between tide marks in East Loch Tarbert; not common (B. & S.).

Onos cimbrius, Linné. The Four-bearded Rockling.

"Very common, and generally distributed in the Clyde area at depths varying from 6 to 65 fathoms in April, to 70 and 90 fathoms in July and August, to 100 fathoms in November at Upper Loch Fyne and Kilbrennan Sound, at 37 to 46 fathoms in December," &c. (Günther). *Motella cimbria* is frequently captured in the shrimp-trawl of the Fishery steamer "Garland," but rarely in quantities, usually only one or a very few specimens being taken at one time.

Onos tricirratus, Bloch. The Three-bearded Rockling.

The three-bearded rockling has been taken in Rothesay Bay and other parts of the Clyde area, but appears to be rare. Part III. of the *Sixteenth Annual Report of the Fishery Board for Scotland* contains records of the capture of a few specimens in Upper Loch Fyne.

Onos maculatus, Risso. The Spotted Rockling.

"Loch Fyne, 40 fathoms; Mull of Cantyre, 65 fathoms" (Günther). This species somewhat resembles the last, but the front teeth are large. If *Onos tricirratus* and *maculatus* be really distinct species, the Clyde specimens should perhaps be all included under the latter name.

Raniceps raninus, Collet. The Lesser Fork-Beard, Tadpole Hake.

A specimen of the lesser fork-beard was recorded from Loch Fyne by the late Dr. Scoular.*

Fam. Ophidiidæ, Müller.

Ammodytes lanceolatus, Le Sauvage. Greater Sand Launce or Sand Eel.

Taken occasionally in the neighbourhood of East Loch Tarbert (B. & S.). "Taken in the vicinity of Sanda Island, Sound of Sanda, Cantyre. The young numerous about the end of March" (Günther).

Fam. Pleuronectidæ, Risso.

Hippoglossus vulgaris (Fleming). The Halibut.

The halibut is occasionally taken in Loch Fyne (B. & S.), but it is usually of small size.

Mr. Duthie, Fishery Officer at Girvan, states *in lit.* :—"Halibut are frequently got here in spring, though they cannot be called plentiful. On the 25th of March this year (1899) one boat landed four cwts., caught between Ailsa Craig and the Mull of Cantyre; the fish were of all sizes up to 112 lbs. or more—just what would have been a fair sample of Shetland-caught fish. I believe they are more plentiful in the neighbourhood of the 'Mull' than here, but an occasional fish is got all round this part of the Firth in the spring months when great-lines are

**Proc. Nat. Hist. Soc. Glasgow*, Vol. I., p. 8 (1868).

being used. Halibut are occasionally recorded at Ballantrae caught by cod or turbot nets. I have no doubt a stray specimen is also got between Arran and Ayr, although I do not at present remember of more than one cwt. being landed at Ayr this year."

Drepanopsetta plattessoides, Fabr. The Long Rough Dab.

"Many adults and young (2 inches in length) were obtained in 26 to 46 fathoms in Kilbrennan Sound in December. Many adults and young were also taken between Cumbrae and Wemyss Point in 30 to 40 fathoms in February 1888" (Günther). The long rough dab is very common and generally distributed throughout the Clyde area, especially off shore and in moderately deep water.

Bothus maximus (Linné). The Turbot.

"One captured in the Clyde area, August 28th, 1888; formerly numerous there" (Günther). Turbots have been taken in the trawl-net of the Fishery steamer "Garland" in the vicinity of Ailsa Craig, in the vicinity of Sanda Island, and in Kilbrennan Sound. Occasionally taken in Loch Fyne (B. & S.). There is a regular turbot fishery carried on off Girvan, a special net called the "turbot net" being used for the capture of the fish.

Bothus rhombus (Linné). The Brill.

The brill is rather more frequently recorded amongst the lists of fishes captured by the Fishery steamer "Garland" than the turbot, but mention is not often made either of the one or the other. The largest specimen of the brill referred to by Day is one recorded by Thompson, which measured 24 inches in length. The "Garland" has, however, obtained even larger specimens than that; one 25 inches was captured after nightfall at Station VII. on May 21st, 1897. A few measuring 21 and 23 inches have also been taken at different times.

Zeugopterus unimaculatus, Risso. One-Spotted Topknot.

"One specimen in 10 fathoms off Ardrossan, Clyde area, in April 1888" (Günther). Several specimens were captured in a shallow sandy bay at Barmore, Loch Fyne, in 1885 (B. & S.). Two of these specimens are still in the collection of fishes at the Fishery Board Laboratory, Bay of Nigg, Aberdeen.

Zeugopterus punctatus (Blainville). Müller's Topknot.

"Clyde area, 60 fathoms" (Günther). Upper Loch Fyne in 10 to 25 fathoms (M.). *Zeugopterus punctatus* has been taken in the trawl-net of the "Garland" in the vicinity of Ailsa Craig and in Kilbrennan Sound.

Rhombus norvegicus, Günther. The Norway Topknot.

Dr. Günther records the following specimens from the Clyde:—One dredged in Lamlash Bay at a depth of 6 to 18 fathoms, measuring 3½ inches in length, and in excellent condition; one smaller than the last, caught off the Cloch Lighthouse in 43 fathoms; and one 3½ inches long, caught in Kilbrennan Sound in 45 fathoms. (*See* also Dr. Günther's description of the larger of these specimens.*) The Norway topknot is occasionally taken in the shrimp-trawl of the "Garland," but it appears to be a rare species in the Clyde.

**Proc. Roy. Soc. Edin.*, Vol. XV., p. 47 (1888).

Lepidorhombus megastoma, Donovan. The Sail Fluke or Whiff.

The sail-fluke is recorded for the Clyde area by Dr. Günther (1886). It is a species that does not appear to be very rare in the Clyde area, especially in the seaward portion of it, and is more or less frequently mentioned amongst the captures of fishes made by the "Garland"; it is especially frequent at Stations VIII., IX., and X.

Platophrys laterna, Walbaum. The Scald Fish.

Recorded for the Clyde area by Dr. Günther (1888). Taken in the trawl-net of the "Garland" between Sanda Island and Bennan Head. This species appears to be a comparatively rare one in the Clyde estuary; a few specimens were taken last year (1899) at Stations II., V., VI., VII., VIII., and X.

Pleuronectes platessa, Linné. The Plaice.

This is a moderately common and generally distributed species from the head of Loch Fyne to the seaward limits of the Clyde estuary.

Pleuronectes microcephalus, Donovan. The Lemon Dab; also called Lemon Sole and Smooth Dab.

Clyde area, feeding on annelids and *solens* (Günther). The lemon sole is more or less frequent and generally distributed throughout the estuary of the Clyde, especially off shore. Annelids appear to constitute the principal food of the lemon sole, at least in Scottish waters, as shown by the investigations that have been made concerning fish-food on board the Fishery steamer "Garland."

Pleuronectes cynoglossus, Linné. The Witch Sole, Craig Fluke, Pole Dab.

This appears to be the most common of the flat fishes in the Firth of Clyde, especially in the deep water. Dr. Günther records its occurrence at a depth of 80 to 100 fathoms in Loch Fyne. It is most abundant at Stations III., VII., VIII., IX., XI., XII., XV., and XVII.; nearly 400 have been got in a single haul in Loch Fyne. Its food, like that of the lemon sole, consists chiefly of annelids, and it is probably on this account that the species is usually more common on a muddy bottom.

Pleuronectes limanda, Linné. The Common Dab.

Pleuronectes limanda is also one of the more common of the Clyde fishes, and seems to be distributed all over the estuary to the head of Loch Fyne, and probably also throughout the other sea-lochs within the Clyde area (Günther). It is got at all the "Garland" Stations.

Pleuronectes flesus, Linné. The Flounder or Fluke.

Common in Tarbert Harbour, Lower Loch Fyne (B. & S.). Occasionally obtained in Upper Loch Fyne (G.). One was captured off Largymore, Upper Loch Fyne, on April 28th, 1896, and a few have been captured in other parts of the loch with the push-net; but it seems to be a rare fish in the more seaward portion of the Clyde.

Solea vulgaris, Quensel. The Sole or Black Sole.

The black sole is occasionally taken in the trawl-net of the "Garland" at all the Stations, except in Loch Fyne; there are seldom more than one or two specimens, but occasionally ten or twelve, in a haul. It is more difficult to capture black soles during daylight than after darkness sets in. The food of the black sole appears to consist largely of annelids.

Solea variegata, Donovan. The Variegated Sole or Thickback.

"Two immature specimens were obtained in the vicinity of the Mull of Cantyre in 65 fathoms on March 21st, 1888" (Günther, p. 220). Two specimens, one about 3½ inches long, the other slightly less, were captured near the mouth of the Clyde estuary at Station VI., on June 15th, 1899. They were taken with the shrimp-trawl of the "Garland," and are now in the collection in the Laboratory at Bay of Nigg.

Solea lutea, Risso. The Solenette or Little Sole.

The solenette has been recorded amongst the fishes captured by the "Garland," but appears to be rare in the Clyde.

Order PHYSOSTOMI, Müller.

Fam. SALMONIDÆ, Müller.

Salmo trutta (Fleming). The Sea Trout.

The sea trout is regularly taken in small quantities just outside East Loch Tarbert (B. & S.). A fine specimen, which, I understand, had been captured in the Clyde, was kept in one of the tanks in Rothesay Aquarium when I was there in 1886-87.

Salmo salar, Linné. The Salmon.

There are regular fisheries for salmon at various parts of the Clyde estuary, including the several sea lochs. The salmon is taken occasionally in herring-nets between Tarbert and Barmore, and probably also in other parts of the Clyde.

Osmerus eperlanus, Linné. The Smelt.

"One was taken with mussel-bait at Brodick, Arran, October 1888. Not uncommon" (H.B., p. 218).

Argentina sphyræna, Linné. The Hebridean Smelt.

"Three specimens were obtained in 32 fathoms between Little Cumbrae and Brigaird Point on February 7th, and five obtained in 37 fathoms in Loch Striven on February 15th, 1888" (Günther). The Hebridean smelt is not very rare in the Clyde estuary, when sought for with suitable apparatus; it is frequently taken with the shrimp trawl-net of the Fishery steamer "Garland," as many as seven specimens having been captured in a single haul; usually, however, only one or a few are obtained at one time.

Fam. SCOMBRESOCIDÆ.

Rhamphostoma belone. The Garfish.

A specimen of the garfish, 28 inches in length, was taken off Dunoon on May 25th, 1877 (Dr. F. P. Fleming).* It is taken in the Clyde area occasionally in shoals (H.B., p. 212). A young specimen was captured in the surface tow-net of the "Garland" in Loch Fyne.

Scombresox saurus, Walbaum. The Saury Pike.

Taken in the Clyde area (H.B., p. 212). We have not yet had the good fortune to capture this species, either in the immature or adult stages.

* This record is referred to in Dr. Day's *British Fishes*, Vol. II., p. 150.

[(?) *Exocetus volitans*, Linné. The Flying-fish.

The Rev. David Landsborough, in his *Natural History of Arran*, p. 386, states that the flying-fish has been seen in Ayr Harbour. Two or three kinds of fishes are spoken of as "flying-fish," but probably it is the species named above that he refers to.]

Fam. CLUPEIDÆ, Cuvier.

Clupea harengus, Linné. The Herring.

Common in the Clyde and Loch Fyne, where a great herring fishing is carried on. The movements and habits of the Clyde and Loch Fyne herring have been for a long time subjects of much interest to naturalists, and even yet are not very clearly understood.

Clupea sprattus, Linné. The Sprat.

Sprats are not uncommon in the Clyde, but owing to their having been frequently mistaken for young herring, there is some uncertainty as to their numbers and distribution.

Clupea alosa, Linné. The Allis Shad.

Very large specimens were taken in Loch Fyne in 1888 (H.B., p. 221). Mr. Gray, of the Millport Marine Station, says *in lit.*:—"A fine specimen of this fish was taken in a seine-net off Isle of Ross in the winter of 1894, and was put in spirits by me and left in the old museum in Kirk Street, Campbeltown, and is probably still preserved in the new museum there."

Fam. MURÆNIDÆ, Müller.

Anguilla vulgaris, Cuvier. The Common Eel.

The Common Eel affords a small but regular fishery in Tarbert harbour, Loch Fyne (B. & S.). It was also taken in the shrimp trawl-net of the "Garland" off Inveraray in May 1896.

Conger vulgaris, Cuvier. The Conger.

Moderately large specimens of conger are at times captured in the "Garland's" beam trawl-net, one 50 inches in length was taken near the head of Loch Fyne on May 5th, 1896; another of the same length was secured in the vicinity of Ailsa Craig on April 28th, 1897. A specimen 45 inches long is recorded from Whiting Bay, and others of somewhat smaller size from various parts of the Clyde area. I have taken a fairly big specimen between tide marks at Lunderston Bay after the tide had ebbed.

Order LOPHOBRANCHII, Cuvier.

Fam. SYNGNATHIDÆ.

Siphonostoma typhle (Linné). The Deep-nosed or Broad-nosed Pipe-fish.

A specimen of this species was captured amongst *zostera* in East Loch Tarbert (B. & S.). A specimen, which I believe to be the one now recorded here, is in the collection of fishes in the Fishery Board's Laboratory at Bay of Nigg.

Syngnathus acus (Linné). The Great Pipe-fish.

This species is not uncommon in the Clyde and Loch Fyne, especially inshore where the water is shallow.

Nerophis æquoreus (Linné). The Straight-Nosed Pipe-fish.

East Loch Tarbert, amongst *zostera* (B. & S.). A fine specimen is in the Robertson collection in the Marine Station at Millport, which was captured at Cumbrae.

Nerophis lumbriciformis (Linné). The Worm Pipe-fish.

Taken in East Loch Tarbert amongst *zostera* (B. & S.). I have taken this little fish amongst weed between tide marks in Lunderston Bay, near Inverkip, and it has also been taken by the "Garland" in Campbeltown Loch, Cantyre.

Hippocampus antiquorum, Leach. The Sea-horse.

Mr. Gray, of the Marine Station at Millport, writes to me concerning this species as follows :—"I picked up a specimen of *Hippocampus* on the Kinloch Park, Campbeltown, in the autumn of 1894, from a spot where herring seine-nets had been spread out to dry, and from the fresh condition of the fish I had no doubt whatever that it had been caught in the nets in the Sound of Kilbrennan, and been shaken out on the spot where I found it. Still I did not see it alive, so there is room for the element of doubt to creep in ; though this evidence, therefore, may not be quite conclusive, I have very little doubt in my own mind of the little fish having been caught in the Kilbrennan Sound. Moreover, I may mention, by way of confirming what has just been said, that during the past summer a gentleman visitor to the Marine Station told me that many years ago his own children caught two live *Hippocampus* in a pool on the Fairlie sands, and kept them alive for about a week in a vessel of sea-water. I took the gentleman to Mrs. Robertson of Fernbank, who happened at the time to be in the museum connected with the station, and to her he repeated the story also. Since then I feel more firmly convinced that the Campbeltown specimen was a genuinely local one."

Hippocampus has been recorded from Belfast Lough, which is not very far distant from the mouth of the Clyde ; and the same species is also recorded for the West Coast of Scotland in Harvey-Brown and Buckley's work on the *Vertebrate Fauna of Argyle and the Inner Hebrides.*

Order PLECTOGNATHI.

Fam. GYMNODONTES.

Orthagoriscus mola, Linné. The Short Sun-fish.

A specimen of the short sun-fish was captured off the Esplanade at Greenock on September 10th, 1881 (J. M. Campbell).* This specimen was said to weigh about a ton; it measured 7 feet 9 inches in length and 3 feet 9 inches in height. Mr. Campbell states that "the liver was absolutely crammed with a scolecid worm, *Tetrarhynchus reptans.*"

SUB-CLASS CHONDROPTERYGII.

Order GANOIDEI.

Fam. ACIPENSERIDÆ.

Acipenser sturio, Linné. The Sturgeon.

Fine specimens are often noticed in Loch Fyne during the herring fishery, but are seldom captured (B. & S.). Mr. Alexander Gray, of the

* *Proc. Nat. Hist. Soc., Glasgow*, Vol. V., pt. II., p. 177 (1883).

Marine Station, Millport, in a letter to me concerning some Clyde fishes, says that "a sturgeon was caught near Carradale in 10 to 12 fathoms of water; it was about 7 or 8 feet long, but in poor condition, and was sold in the Glasgow market by Mr. Lagan of Paisley for £1 15s. So far as I can recollect, this was in the late autumn of 1895. A few years previous to this I remember seeing another sturgeon, perhaps 5 or 6 feet long, that was caught in a salmon-net at Penimore Bay; I had no opportunity to examine this specimen, as it was shipped on the steamer ready for conveyance to the Glasgow market when I saw it."

Order ELASMOBRANCHII.

Fam. Carchariidæ.

Carcharias glaucus, Linné. The Blue Shark.

This shark has been taken in Loch Fyne (H.B., p. 177). Mr. A. B. Watt of Glasgow saw a specimen of *Carcharias* which had come ashore at Ayr Bay on the 11th or 12th September last year (1899).

Galeus canis, Rondel. The Tope or Toper.

Several specimens of this species were landed at Girvan in December last. They were at the time mistaken for another species, but were subsequently correctly identified as the tope. I am not aware of this species having been previously recorded for the Clyde; probably it is only an occasional visitor to the estuary, and may on former occasions have been passed over as one of the more common species. A fine specimen of toper was brought to Girvan by a local fisherman on December 28th. It was examined by Mr. Duthie, the Fishery Officer at that place, who was able to identify the species; the specimen measured 5 feet in length and 24 inches in circumference at the thickest part. Mr. Duthie was kind enough to secure the specimen and forward it to the Laboratory at Bay of Nigg, and I was thus enabled to verify Mr. Duthie's identification. The specimen was a female.

Fam. Lamnidæ.

[*Alopias vulpes* (Gmel.). The Thrasher or Fox Shark.

Captain Campbell, of the Fishery steamer "Garland," informs me that a year or two ago he was proceeding down Loch Fyne, and, having reached a point somewhere between Crarae and Castle Lachlan, but rather nearer the former place, he saw a thrasher making an attack on what was probably a cetacean of some kind; the thrasher was leaping clear out of the water in its usual way when engaged at this kind of work, and was coming down with a slap, the sound of which could be heard distinctly on board the vessel. Captain Campbell knows the thrasher quite well, and has frequently, when voyaging across the Atlantic, been an eye-witness of its tactics, so that there is little likelihood of his having been mistaken about the fish he saw in Loch Fyne.

My friend Mr. Gray of Millport tells me that in July 1895 a thrasher shark got into shallow water in Machrihanish Bay, and that some men there put off in a boat and, with ropes, managed to entangle it and haul it ashore close to the Pans Hotel. This specimen, which measured 15½ feet in length, was seen by Mr. Gray soon after it was captured. Machrihanish, though not within the Clyde area, is only a few miles west from Campbeltown, and comparatively near the mouth of the Clyde, and tends to show that the *Alopias* may occasionally find its way into the Clyde estuary.]

Selache maxima (Gunner). The Basking Shark.

A young specimen measuring 8 feet in length was captured in Maidens Bay, near Turnberry, Ayrshire (*Scotsman* newspaper, September 26th, 1898). This record was confirmed by the Fishery Officer at Girvan. Dr. Landsborough, in his *Natural History of Arran*, refers to the occurrence of this fish in the Clyde, and says (pp. 95, 96):—"A century ago . . . it was a frequent visitor to the Clyde, and was taken at Ballantrae, in Ayrshire, as well as in Arran. It made its appearance in the first or second week in June, and generally remained only for three or four weeks, though occasionally seen considerably later. . . . Now it is seldom seen." Dr. Landsborough also describes the means by which the fishermen of Arran usually captured these sharks.

Fam. Scylliidæ.

Scyllium canicula (Linné). The Lesser Spotted Dog-fish, Rough Hound.

"A very young specimen, 8 inches long, was obtained in the Sound of Sanda, at a depth of 20 fathoms" (Günther). Two specimens, each about 25 inches in length, were captured by the "Garland" at Station I, Firth of Clyde, on May 25th, 1897, and three specimens, measuring respectively 25, 28, and 29 inches in length, were captured on the same day in the vicinity of Sanda Island. In a male specimen 12¾ inches long taken in 60 fathoms between the Mull of Cantyre and Corsewall Point on May 15th, the spots are distinctly larger than they are on the adult specimens, especially on the anterior portion of the body. This specimen is now in the collection of fishes in the Fishery Board's Laboratory, Bay of Nigg, Aberdeen.

[*Scyllium catulus*, Cuvier. The Larger Spotted Dog-fish, Nurse Hound.

The following notice appeared in the *North British Daily Mail* of December 11th, 1899:—

"One of the Girvan great-line boats on Saturday, the 9th inst., had an unusual catch of dog or hound sharks. No fewer than seven were caught in the great-lines, set in Lendal Bay, south of Girvan. Some of them measured about 5 feet in length and 24 inches in girth. The species is known as *S. catulus*, or rock shark. The females were full of well-developed eggs. Where they abound they are most destructive to the fishermen by taking their bait and hooks off the lines. The fish were cut up for bait for the crab and lobster creels."]*

Pristiurus melanostomus (Bonaparte). The Black-Mouthed Dog-fish.

"Two adult males in Upper Loch Fyne, 37 fathoms" (Günther). One captured by a Cumbrae fisherman was exhibited at a meeting of the Natural History Society of Glasgow on January 26th, 1869. The black-mouthed dog-fish is occasionally brought into East Tarbert amongst the *Acanthii* in the winter fishing (B. & S.). Upper Loch Fyne, in 10 to 20 fathoms (M.). Captured by the "Garland" in the deep water between Arran and Turnberry Point.

Fam. Spinacidæ.

Acanthias vulgaris, Risso. Picked Dog-fish.

Sometimes of common occurrence in the Clyde and Loch Fyne,

*There appears to have been some mistake on the part of the writer of the above note concerning the name of the fish landed at Girvan on December 9th. I am able to state conclusively that the fish landed were Tope or Topers, *Galeus canis*, and not *Scyllium catulus* as stated (see page 289). I have been unable hitherto to obtain any satisfactory information as to the occurrence of the Larger Spotted Dog-fish within the Clyde estuary.

especially during the herring fishing. Few of those taken by the "Garland" are of large size; they seldom reach beyond 2 feet in length; whereas the picked dog-fish is stated by Day to attain a length of at least 4 feet off our shores; but such large specimens are probably of exceptional occurrence.

Fam. RHINIDÆ.

Rhina squatina (Linné). The Angel-fish or Monk-fish.

"In the Firth of Clyde it is by no means uncommon, and is frequently found there after gales; one was harpooned while asleep, but broke away."* This appears to be the only Clyde record for the angel-fish hitherto published. In the *Vertebrate Fauna of Argyle and the Inner Hebrides* it is stated that two specimens of the angel-fish in the Hunterian Museum, Glasgow, are from the West Coast, but no locality is given for them.

Mr. Wright, the chief Fishery Officer for the Barrow-in-Furness district of the Lancashire Sea Fisheries, states that he trawled in the Clyde for about eighteen winters previous to the closing of the estuary to that mode of fishing, and that during that time he occasionally captured angel-fish on the Ballantrae Bank. He knows the fish very well, and has brought specimens from Morecambe Bay to the Sea Fish Hatchery at Piel. The name he uses for the angel-fish is the "abbot."

Fam. RAIIDÆ.

Raia batis, Linné. The Skate, the Grey Skate or Blue Skate.

Moderately common and generally distributed, especially off-shore. Those captured by the "Garland" are seldom of large size, being usually mere pigmies when compared with the immense specimens sometimes landed at the fish market at Aberdeen. The largest taken by the "Garland" in the Clyde rarely exceed three feet in width.

Raia intermedia, Parnell. The Flapper Skate.

"A female with a disk 19 inches wide was obtained between Sanda Island and Ailsa Craig in 24 fathoms, March 6th, 1888" (Günther). The flapper skate has been taken by the "Garland" in the deep water to the east of Arran, and also in the vicinity of Ailsa Craig. (This is the *Raia macrorhynchus* of Day's *British Fishes.*)

Raia oxyrhynchus, Linné. Long or Sharp-nosed Skate.

Two specimens were captured by the "Garland" in the deep water to the east of Arran; both were comparatively small, one being only 21 inches and the other 29 inches across the pectoral fins.

Mr. Duthie, Fishery Officer, Girvan, informs me that on February 1st (1900) he saw a fine specimen of the long-nosed skate which had just been sent to Girvan from Maidens Village—a village not far from Girvan. The following measurements were taken by Mr. Duthie—Extreme length, 51 inches; extreme breadth, 34 inches; length from tip of snout to centre of closed mouth, 13 inches; length of tail, 18 inches; while from the tip of the tail to the vent was 21 inches.

Raia fullonica, Linné. Shagreen Ray, Fuller's Ray.

"A female example, 24 inches across the disk, from Loch Fyne, off Skate Island, was obtained in 100 fathoms. An adult male, 19 inches across the disk, was caught in Kilbrennan Sound in 20 fathoms"

*A. Norman, *Zoologist*, Vol. XV. (1857), p. 5366.

(Günther). The shagreen ray is occasionally captured by the "Garland," but is apparently not very common in the Clyde.

Raia clavata, Linné. Thornback Ray or Thorny.

"One adult female was obtained in 26 fathoms in Kilbrennan Sound, and an immature male 17 inches wide in 24 fathoms between Sanda Island and Ailsa Craig. The contents of the stomach of the latter specimen consisted of small fish and crustaceans" (Günther). The Thorny is one of the more common of the fishes captured in the Clyde by the Fishery steamer "Garland," but the specimens are mostly of small size, and very few of them extend beyond 25 or 30 inches across the disk.

Raia maculata, Montagu. The Spotted Ray, or Homelyn Ray.

"An immature female was captured between Cumbrae and Wemyss Point in 30 to 40 fathoms. Another from the Sound of Sanda from 20 fathoms. One or two very young specimens from $2\frac{1}{2}$ to $4\frac{1}{2}$ inches across the disk were obtained off Ardrossan and off Whiting Bay" (Günther). The spotted ray is occasionally captured by the "Garland," but the specimens are usually of small size. One measuring 18 inches across the disk was taken in the vicinity of Ailsa Craig on April 27th, and one 10 inches across the disk at Station VI. on May 25th, 1897. A small specimen a little over 7 inches across the disk is in the collection of fishes in the Laboratory at Bay of Nigg.

Raia circularis, Couch. The Cuckoo Ray, Sandy Ray.

"An adult male, 14 inches across the disk, and a very young female, $3\frac{2}{3}$ inches broad, were obtained in the Sound of Sanda at a depth of 20 fathoms on March 10th; another adult male, also from the Sound of Sanda, was obtained at 49 fathoms on March 17th, 1888" (Günther). The cuckoo ray has been taken by the "Garland" in Whiting Bay, in the vicinity of Sanda Island, in the vicinity of Ailsa Craig, and in various parts of Upper Loch Fyne. It does not appear to be a very rare fish in the Clyde area.

SUB-CLASS CYCLOSTOMATA.

Fam. Myxinidæ.

Myxine glutinosa, Linné. The Hag-fish.

The hag-fish has been taken at Rothesay in the Clyde area. It is said to be numerous and most destructive to the line fishes off Girvan (H.B., p. 225). I do not remember having seen *Myxine* in the Clyde.

SUB-CLASS LEPTOCARDII.

Fam. Cirrhostomi.

Branchiostoma lanceolata, Pallas. The Lancelet.

"Amphioxus" is "taken plentifully in suitable ground in the Clyde area" (H.B., p. 225). Mr. Gray, of the Millport Marine Station, states, in a letter to me, that "over a dozen specimens of this little fish were taken on a bank between Little Cumbrae and Hunterston, locally known as the *Dogger Bank.*" Dr. James Bryce, in his *Geology of Arran and Clydesdale* (1865), p. 250, remarks that the *Amphioxus* has been dredged at the north end of Holy Island, and has been obtained in Lamlash Bay, as well as near Millport. Dr. Landsborough also speaks of having found it when dredging near Cumbrae.

VII.—ON THE MACKEREL OF THE EAST AND WEST COASTS OF SCOTLAND.

By H. Chas. Williamson, M.A., B.Sc.

The present research was undertaken with a view of determining whether or not racial differences existed between the mackerel of the West and East Coasts of Scotland. The method employed is that of separating local forms by the averages of the size, or numbers of certain characters. This method, first employed by anthropologists in the examination of the races of man, has been applied by Heincke* to the division of the herring into local forms.

The principles upon which the division of a species into races is carried out, and certain of the theories bearing upon the formation of the local form or race, will be found detailed in Heincke's work.

All the characters of an individual are variable. If, then, we find that the mean of the variations of a certain character in one group differs from their mean in a second group, we are entitled to regard this as a racial distinction between the two. It is necessary to select a number of characters, *e.g.*, the number of the vertebræ, the numbers of fin-rays, measurements on the body, etc., as tests by which the groups may be compared. The greater the number of individuals in each group, the more nearly correct will be the mean (or average). Since, however, we cannot examine all the members of a race we cannot get the true mean directly. By experiment and observation we get a mean which is more or less approximate. From this observed mean we may get two values between which the true mean lies. This is obtained from the Probability curve. One of these two values is obtained by subtracting and the other by adding the probable error of the mean to the observed mean. The two values are represented by the formulæ $M—r$, and $M+r$, where M is the observed mean and r is the probable error. In order to get a result which is almost absolutely correct, in place of r, five times r is subtracted and added, viz., $M—5r$, and $M+5r$. According to Heincke there are 999 chances to 1 that the true mean lies between these limits. The interval between these values is known as the fluctuation of the mean. If now we find that the fluctuations of the means of a character in two groups do not overlap, we are entitled to conclude that the true means are different from one another, and therefore so far as this character is concerned the two groups are of distinct races.

The Mean, the Probable Error of the Mean, the Standard Deviation are obtained from the following formulæ, which have been taken from Davenport's "Statistical Methods," Chapman & Hall, 1899.

The Standard Deviation, $\sigma = \frac{1}{n}\sqrt{n\Sigma(d^2 f)—(\Sigma d)^2}$

The Probable Error of the Mean, $r = \cdot 6745 \cdot \frac{\sigma}{n}$

n = number of variants; d = deviation from the mode:

The Standard Deviation σ is a measure of the range of Variation.

As bases of comparison between the mackerel of the East and West Coasts, the following characters were selected:—

* "Naturgeschichte des Herings," Berlin Otto Salle, 1898, text, 1 Hälfte.

I. Girth of Body at three points—(1) pectoral region, close to the hind border of the operculum (*G.* Pect.*), (2) at the beginning of the second dorsal fin (*G.* 2nd D.), (3) at the narrowest part of the root of the tail (*G.* T.). The measurements were made by means of a thread.

II. The length of the Dorsal Groove (*l* D. groove), which encloses the base of the first dorsal fin.

III. The length of the Pectoral Fin (*l* Pf.), measured from the proximal end of the first or superior ray to the tip of the fin.

The following are measurements made on the lateral axis ("principal axis" of Heincke). The lateral axis is a line drawn from the tip of the mandible, when the mouth is closed, to the middle of the fork of the tail. From certain points on the body of the mackerel (*vide* diagram), perpendiculars were drawn to the lateral axis, 0a. The distances from zero (the tip of the snout) to the points where the perpendiculars cut the axis were measured. These dimensions are as follows:—

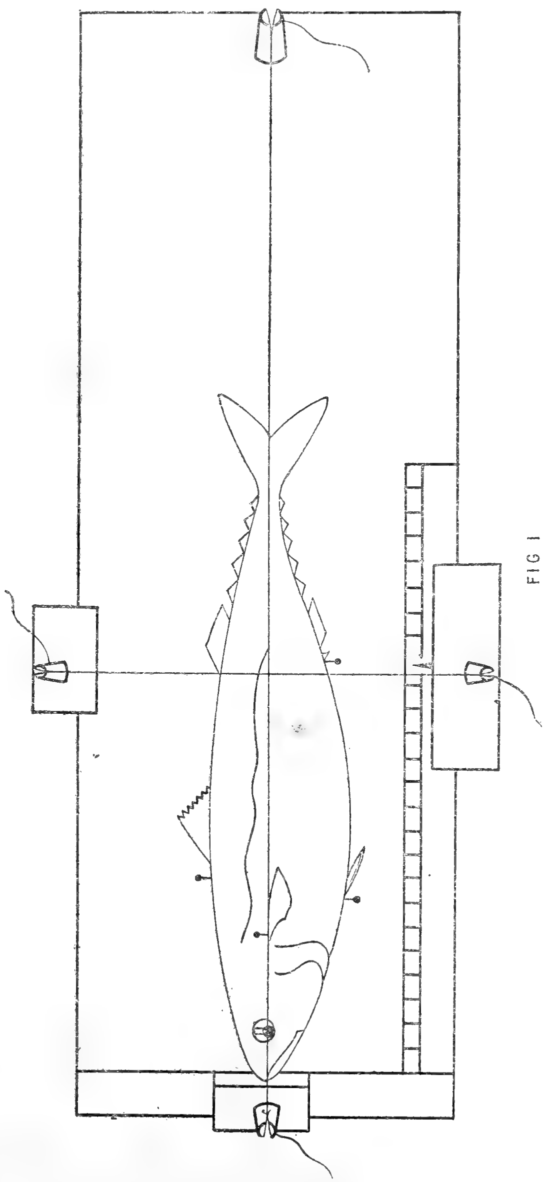


FIG I

* These symbols refer to the headings in the Tables appended.

IV. Length of Snout; from zero to the point where the perpendicular from centre of the eye cuts the axis, *l* Sn.

V. Lateral Length of Head; from zero to the point where the perpendicular from the hind edge of the operculum cuts the axis, *ll* H.

VI. Distance of Pectoral Fin; from zero to the point where the perpendicular through the proximal end of the first ray of the fin cuts the axis, *d* Pf.

VII. Distance of Ventral Fin; from zero to the point where the perpendicular through the proximal end of the first or outer ray of the ventral fin cuts the axis, *d* Vf.

VIII. Distance of First Dorsal Fin; from zero to the point where the perpendicular from the anterior edge of the base of the first dorsal cuts the axis, *d* 1 D.

IX. Distance of Second Dorsal Fin; from zero to perpendicular from the anterior edge of the base of the second dorsal, *d* 2 D.

X. Distance of the Anus; from zero to perpendicular from the hind edge of the anus, *d* A.

XI. Distance of Anal Spine; from zero to the perpendicular from the anal spine, *d* As.

XII. Length of Skull; from the edge of the occipital foramen to the tip of the ethmo-palatine boss, *l* Sk.

XIII. Length of Mandible; from the extremity of the articular to the tip of the mandible, *l* M.

XIV. Length of Dentary; the length of the ossified portion of the dentary, *l* De.

XV. Length of the Tail; measured from the anterior edge of the 31st vertebra to the tips of the shortest rays in the fork of the tail, *l* T.

XVI. Length of Superior Lobe of the Caudal Fin; measured from the superior hind edge of the 29th vertebra to the extreme tip of the lobe of the fin, *l* Cr.

In addition to the preceding, the following characters which admit of enumeration were chosen:—

XIX. The Number of Vertebræ.

XX. The Number of Rays in the First Dorsal Fin.

XXI. ,, ,, ,, Second ,, ,,

XXII. ,, ,, ,, Anal Fin.

XXIII. ,, Dorsal Finlets.

XXIV. ,, Anal ,,

XXV. Weight.

The Length of the fish was taken as the distance from the tip of the snout to the middle of the fork of the tail. This standard was adopted by Garstang.*

Mode of Measurement.

Since there are not on the mackerel external marks by which the origin of any of the fins may be sharply defined, it was necessary to select certain artificial points which would enable the measurements to be made all through with some degree of uniformity. The distances on the body were measured from the one origin—viz., the tip of the snout. To mark the beginning of the pectoral fin a pin was inserted at the angle between the base of the first ray and the scapula (3, fig. 3); the same point was used in the measurement of the length of the pectoral fin, the other limit being the extreme tip of the same; for the beginning of the ventral fin a pin was inserted at the angle between the first or outer ray of the ventral fin and the ventral surface of the body (4, *ib.*); the beginning

* Garstang, "On the Variation, Races, and Migrations of the Mackerel (*Scomber scombrus*)," *Journal Marine Biological Association*, N.S., Vol. V., No. 3.

of the first dorsal fin was indicated by a pin which was introduced immediately in front of the first dorsal ray, between it and the anterior border of the dorsal groove (5, *ib.*); a slight cut made with a scalpel, close in front of the first ray, was taken as the commencement of the second dorsal (6, *ib.*). The anus was located by means of a pin inserted into, or as near as possible to, the genital aperture (7, *ib.*). The length of the snout was obtained by measuring the distance from the tip of the snout to the point where the perpendicular from the anterior edge of the pupil cut the lateral axis, and adding thereto half the diameter of the pupil (1, *ib.*). Since the eye is kept in place by two adipose lids which partly overlap, it was almost without exception found to be fixed in a uniform manner.

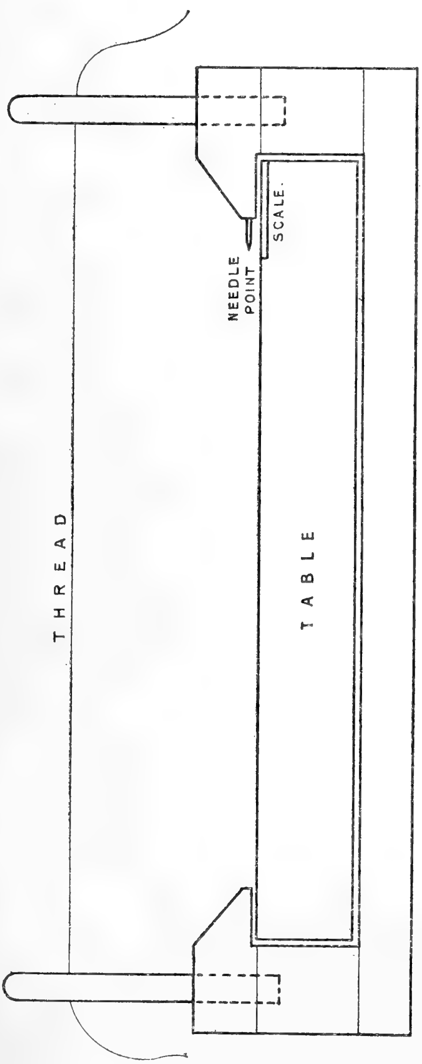


FIG 2

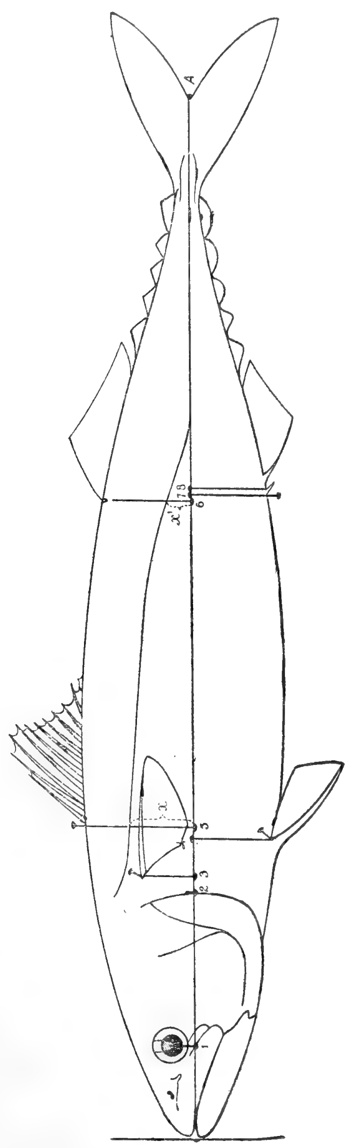


FIG.3

Measuring Board.

In order to readily obtain the points at which the perpendiculars from the different points cut the lateral axis, a board (*vide* figs. 1 and 2), which served this purpose with a considerable amount of accuracy, was constructed. The apparatus was furnished with a movable frame, carrying a thread which cut the lateral axis at right angles. This frame could be moved from one end of the board to the other, and could thus be brought exactly over each selected point in succession. The two supports which received the ends of the thread were connected together by a wooden cross-piece that held them firmly united. The near support was shaped as the base of a T square, so that when it was pushed up against the edge of the board the thread crossed the same at right angles. The edge of this support moved over a millimetre scale. A needle point was inserted in this edge, immediately below the thread. The frame was moved along until the pin that marked the point on the fish, the thread, and the needle point were in the same plane. The distance was, with the aid of the needle point, then read off on the scale. The thread could be raised or lowered to suit the varying thickness of the fish. At either end of the board there was a support which received one end of a thread which traversed the board longitudinally. This represented the lateral axis of the fish, and was drawn parallel to the edge of the board. The lateral axis was also represented by a groove cut in the board itself. The fish, when ready for measurement, was placed on the board with the anterior tip of the mandible and the middle of the fork of the tail exactly on the lateral axis, so far as could be judged by the eye. The tip of the mandible was in contact with the upright at the zero point of the scale. The distances were accurately measured to half a millimetre. The measurements of the skull, mandible, and dentary were made by means of callipers, the fish having been first boiled. Other dimensions—*e.g.*, length of tail, etc.—were got by the aid of dividers. It has been necessary to go into a minute description of the modes of measurement, for it is very evident that unless there is uniformity in taking the dimensions no comparison of any value can be made between their Means.

The mackerel were sent from the West Coast to Aberdeen in ice, and, with the exception of a few which were examined immediately, were put into the cold-storage room of a local ice-factory. There they were kept until they were required. The Aberdeen fish were similarly stored.

Shortcomings in respect to the Measurements.

It was not possible to measure every one of the characters which appear in the list given above on each fish. Some of the fishes, through damage or contortion, were unsuitable for certain measurements, and, as will be seen from the Tables appended, the number of fishes in which each character was noted varies considerably. In the case where the fish is damaged, or is much contorted, the measurements which would be affected thereby can be neglected, but where the fish does not show any sign of damage there may, however, be a certain amount of contortion, which will affect the accuracy of the measurements. This slight contortion, which is not apparent, and which usually occurs at the neck or in the anterior part of the trunk, may have a considerable effect on the disposition of the soft parts, and consequently on such characters as the distance of the fins from the tip of the snout. The contortion has the effect of shortening these distances. The true distance of any of these characters is to be got only when the dorsal fins, tail fin, and centre of the tip of the snout are in the same plane, which, when the fish is swimming, is vertical. Any flexure of the body to the right or left shortens the distances taken—namely, the projections of the distances on the lateral axis. A certain amount of evidence bearing upon the extent to which contortion may give rise to error is afforded by six mackerel, which were used to test the effect of freezing on the dimensions of the body. The following Table gives a comparison between the measurements taken in the fresh state, and the measurements found for the same characters after the fishes had been in the cold-storage-room for twenty-five days:—

TABLE I.—MEASUREMENTS IN CENTIMETRES.

		Length, cm.	Girth.			Dorsal Groove.	*l* Pf.	*l* Sn.	*ll* H.	*d* Pf.	*d* Vf.	*d* 1 D.	*d* 2 D.	*d* A.	*d* As.	Sex.	Weight, Gmme.
			Pect.	2nd D.	T.												
1	Before . . .	36·4	15·5	15·7	3·5	6·1	3·9	3.02	7·7	7·95	9·75	10·6	23·4	23·25	23·5	♀	598
	After . . .	36·05	15·5	15·4	3·1	.	3·9	3·07	7·75	8	9·65	10·6	23·3	23·15	23·5		580
2	Before . . .	35	14·6	14·6	3·3	5·3	3·8	3	7·65	8·1	9·4	10·55	22·4	22·6	22·9	♀	482
	After . . .	34·65	14·4	14·5	3	5·45	3·75	3·05	7·55	7·9	9·3	10·45	22·2	22·3	22·55		471
3	Before . . .	33·8	15	14·2	3	6	3·65	3·15	7·75	8·05	9·7	10·6	21·7	22	22·3	♂	478
	After . . .	33·55	14·8	14·2	2·85	5·8	3·65	3·12	7·7	8·05	9·5	10·7	21·5	22	22·2		470
4	Before . . .	34·2	14·3	13·8	3	4·8	3·6	3·22	7·95	8·3	9·6	10·55	21·7	21·8	22·1	♀	432
	After . . .	33·95	14·3	13·4	2·8	4·95	3·6	3·27	7·95	8·35	9·5	10·6	21·7	21·9	22·1		422
5	Before . . .	35·4	15·3	14·9	3·2	5·9	4	3·02	7·9	8·1	9·7	10·65	22·45	22·6	23	♂	520
	After . . .	35	15·1	14·1	3	5·75	3·9	2·9	7·6	7·85	9·5	10·4	22·15	22·2	22·55		504
6	Before . . .	34·1	14	14·2	3·1	5·4	3·6	3·02	7·55	8	9·5	10·4	21·65	21·8	22·1	♂(?)	439
	After . . .	33·75	.	.	.	5·5	3·65	2·92	7·45	7·8	9·55	10·05	21·4	21·25	21·55		428

When the mackerel were sent to the store the pins which had been used in marking the limits of the dimensions were left in the fish. It was thus possible on re-examination to measure to exactly the same points. Any change found in the dimensions was due then to alteration in the fish. It was found that a shrinkage had taken place in length, in amount about 1 per cent. The fishes had lost in weight, in amount, 1·7, 2·3, 2·5, 2·5, 3, and 3 per cent. respectively. It might have been inferred that, in consequence of the shrinkage in length, a proportional decrease would have been found in the various measurements. But this was not so; for while in certain cases exactly the same measurement was obtained, in others the alteration in the dimension was greater than the total shrinkage in length of the fish. In the case of the girth, that in the pectoral region showed a decrease of 2mm. in some cases; at the second dorsal a decrease of as much as 8mm. was found in the case of No. 5—in no example was this exceeded; and in the girth at the root of the tail a shrinkage of as much as 4mm. took place. With the exception of the preceding, and the distances of the dorsal fins, anus, and anal spine from the snout—viz., *d* 1 D, *d* 2 D, *d* A, and *d* As—none of the differences exceed 2·5mm. In the case of *d* 1 D and *d* 2 D, the greatest differences are 3·5 and 3mm. respectively. In *d* A the difference is as large as 5·5mm., and so with *d* As. The latter is the greatest dimension measured on the fish. Those fishes which show the extreme differences—*e.g.*, Nos. 2, 5, and 6—in this character, also show considerable differences in other characters. Again, it is remarkable that, even although the fish itself has shrunk in length 1 per cent.—*e.g.*, No. 1—the measurement *d* As. remains at 23·5cm., which it was found to be before freezing. If that measurement had decreased in the same proportion as the total length had lessened, its size should have been 23·3. The fish was no doubt contorted when it was in a fresh condition; and the disarrangement of its parts may, through its being frozen, have been lessened or increased. It is at least evident that in the varied treatment which a fish may receive in capture, or in packing, an amount of contortion may occur which it is quite impossible to measure or eliminate. This, then, militates against the accuracy of the body-measurements, and must be kept in view in the discussion of the results. The error due to the personal equation of the observer is eliminated in a large series of measurements, when the characters themselves permit of accurate measurement. In the case of enumeration of vertebræ and fin-rays, where the numbers are small, as in the mackerel, the personal error may be left out of consideration.

It was further found that very often the measurements of certain characters were of different values for the two sides of the fish. Thus, for example, in 14 mackerel, measuring from 31–36cm., the greatest difference between the lengths of the mandibles of the right and left sides was 1mm. The most common difference was ·5mm. In the case of the dentary, measured on both sides in 15 specimens, in nine cases equality was found, in one case the difference was 1mm., while in the others it was ·5mm. The length of the pectoral fin was found to be the same on both sides in three out of six fish measuring from 34–36cm.; in two there was a difference of 1mm., and in the sixth a difference of ·5mm. As regards the length of snout, the greatest difference was 1mm.; this occurred in two specimens. In the lateral length of the head, a difference of 1mm. was found; but this was not exceeded. The distance of the pectoral fin from the snout varied as much as 2·5mm. on the two sides; while in the distance of the ventral fin differences of ·5mm. (three specimens), 1mm. (one specimen), 1·5mm. (one specimen), 4mm. (one specimen).

In this research all the measurements have been made on the left side of the fish.

Vertebræ and Fin-rays.

In the enumeration of the vertebræ no difficulty presents itself; the same is true of the fin-rays, with the exception of those of the first dorsal fin. The posterior rays of this fin are, as Garstang has pointed out, very small, and often do not appear above the skin. It is necessary to dissect the floor of the dorsal groove in every fish ere one can be sure that all the fin-rays have been noticed. In many cases only the base is found as the representative of the ray. This, however, has been included in the number of rays.

The Mackerel Investigated.

The mackerel were obtained from three localities :—

I.	Clyde—Lower Loch Fyne,	June and July 1899—	171 fishes	}	183
	,, Kilbrennan Sound,	October 9th ,,	12 ,,		
II.	Barra	June ,, ,,	65 ,,	}	88
	Stornoway	August 13th ,,	23 ,,		
III.	Aberdeen	August and September,			207

The mackerel from Lower Loch Fyne were taken in mackerel nets; those procured from the other districts were captured in herring drift-nets.

The following Table (II.) shows the sizes and numbers of the fish examined. They have been arranged in centimetre divisions. All the fishes, for example, measuring from 30 to 30·9cm. are entered in the 30cm. group, and similarly with the others.

Table II.—Sizes and Sex of the Mackerel Examined.

Size.		Aberdeen.		Clyde.			Barra and Stornoway.		
Inches (approximate).	Cm.	♂	♀	♂	♀	?	♂	♀	?
10	26	.	.	.	.	.		1	.
	27	.	.	.	1	.	1	.	2
11	28	.	.	3	3	2	1	.	1
	29	1	1	5	3	.	1	1	1
12	30	3	.	5	.	.	6	3	3
	31	11	5	3	5	.	3	4	.
	32	21	15	9	12	.	11	10	3
13	33	32	32	10	6	.	2	4	1
	34	31	19	22	16	.	1	2	.
14	35	8	20	17	25	.	1	.	.
	36	2	2	11	12	.		.	.
	37	3	1	4	1	.	1	2	.
15	38	.	.	2	4	.	2	2	.
	39	.	.	.	2	.	1	4	.
16	40	.	.	.	.	.	1	4	.
	41	.	.	.	.	.	2	1	.
	42	.	.	.	.	.	1	2	.
17	43	.	.	.	.	.	.	2	.
Total, -	-	112	95	91	90	2	35	42	11

TABLE IIA.—AVERAGE SIZES OF THE MACKEREL OF THE THREE DISTRICTS.

	Sex.	No.	Average Size. Cm.	♂ ♀		Total.	
				No.	Average Size. Cm.	No.	Average Size. Cm.
Aberdeen,	♂	112	33	207	33·2	478	33.4
	♀	95	33·4				
Clyde, -	♂	91	33·5	183*	33·6		
	♀	90	34				
Barra and	♂	35	33	88*	33·6		
Stornoway,	♀	42	35				

* Mackerel of undetermined sex included.

It will be noticed that the fishes are grouped mainly about the sizes 32-35cm., the numbers tapering off above and below these limits. On reference to Table IIA., which gives the average size of the fishes from each district, it will be seen that their averages range from 33-35cm., a space of less than one inch. In instituting a comparison between the characters of two or more groups of fishes, it is necessary that they be as near as possible of the same stage, which is conveniently determined by their size. This is important in order to eliminate variations which may be due to growth. All the mackerel here recorded, with three exceptions, are of mature size; that is to say, their sizes do not fall below the sizes of the smallest mature forms. The smallest mackerel was an unripe female of a length of 26·8cm. The smallest ripe male was 27·7cm. Two unripe specimens of 27 and 27·5 were obtained from Barra. Their sex was not determined. The smallest ripe female was 28·9cm.; a male of this size was also ripe. The smallest ripe female observed by Cunningham* was 29·5cm., while the smallet ripe male was 30·3cm. He considered a mackerel of that size to be two years old.

In a total of 236 mackerel obtained from Loch Fyne and Barra, measuring from 26-43cm., only 13 examples were not ripe; four females, measuring 26·8, 28·4, 30, and 32·3cm., were unripe; four specimens of 27, 27·5, 28·5, and 28·6cm. (sex undetermined) were unripe; five males of from 32-37cm. were not ripe, but may have been spent. It is thus evident that the mackerel examined were of mature size. None of the Aberdeen mackerel were less than 29·4cm., and the fish at this size, a female, was spent. One specimen from Kilbrennan Sound was 27·6cm., and the ovary had the appearance of being spent. It is, then, obvious that a fair comparison may be drawn between the groups, so far as the stage of development is concerned.

There is still sex-variability, which Heincke, however, found to be of very little moment in the herring. I have, however, kept the averages of the males and the females separate. When combining them to get the average for the group I have included those mackerel which appear in the Tables as of undetermined sex.

* *Journal Marine Biological Association*, N.S. Vol. II., p. 232.

Conversion of Measurements into Percentages.

In order to admit of a comparison between the measurements made upon mackerel of different sizes, it is necessary to convert them into percentages of some standard length. The total length of the fish is a convenient standard, in percentages of which the measurements may be expressed. I have adopted that standard. Heincke, however, employed for the herring more than one standard. For measurements made upon the head he took for his standard the length of the head, and so on. This may, or may not, be an advantage, but for the sake of simplicity I have employed only one standard.

Means of Averages.

The averages of all the characters were then calculated for all the individuals in each of the one-centimetre divisions. The averages for the males and females are to be found in Table VII. (Aberdeen), IX. (Clyde), and VIII. (Barra), (pp. 315 *et seq.*). The figure within brackets, alongside each average, indicates the number of individuals from which the average was calculated. The averages of all the males and all the females in respect to each character were then found (Table III.), and this was finally done for the males and females together (*vide* Tables IV. and IVA). The figures in the vertical columns marked (No.) give the number of individuals from which the average was made. The Standard Deviation (σ) and Fluctuation of the Mean ($M \pm 5r$) is given for several characters in Table VIIA. In the calculation of these quantities I am indebted to Mr. H. M. Kyle for much assistance.

[Table.

TABLE III.

Average Percentages (M) for the Male and Female Mackerel of each Locality.

	Sex.	G. Pect.		G. 2nd D.		G. Tail.		D. Groove.		l Pf.		l Sn.		ll H.		d Pf.		d Vf.	
		No.	M.	No.	M.	No.	M.	No.	M.	No.	M.	No.	M.	No.	M.	No.	M.	No.	M.
Aberdeen.	♂	*43*	41·9	*41*	40·07	*45*	8·73	*104*	15·05	*100*	11·01	*79*	9·09	*82*	22·57	*89*	23·99	*28*	27·67
	♀	*33*	41·07	*29*	39·18	*31*	8·49	*74*	15·06	*76*	10·98	*59*	9·07	*59*	22·59	*60*	23·88	*28*	27·67
Clyde.	♂	*49*	41·25	*72*	39·92	*71*	8·75	*57*	15·44	*66*	11·26	*67*	9·07	*77*	22·04	*81*	23·37	*58*	26·89
	♀	*37*	41·75	*50*	40·15	*50*	8·72	*46*	15·59	*53*	11·25	*51*	9·03	*69*	22·13	*70*	23·48	*46*	26·93
Barra and Stornoway.	♂	*28*	40·68	*27*	38·75	*28*	8·89	*27*	15·18	*28*	11·03	*28*	9·02	*27*	22·14	*28*	23·49	*25*	27·02
	♀	*37*	40·18	*37*	37·77	*37*	8·74	*38*	15·14	*38*	11·04	*37*	8·97	*38*	22·11	*38*	23·33	*35*	27·19
	?	*6*	39·86	*6*	38·98	*6*	8·56	*6*	14·93	*6*	10·65	*6*	9·51	*6*	23·03	*6*	24·38	*3*	26·4

TABLE III.—*continued.*

	Sex.	*d* 1 D.		*d* 2 D.		*d* A.		*d* As.		*l* Sk.		*l* M.		*l* De.		*l* T.		*l* Cr.	
		No.	M.	No.	M.	No.	M.	No.	M.	No.	M.	No.	M.	No.	M.	No.	M.	No.	M.
Aberdeen.	♂	*90*	30·56	*68*	63·25	*32*	63·62	*74*	64·41	*103*	16·42	*108*	12·68	*109*	7·61	*105*	7·67	*91*	18·61
	♀	*66*	30·59	*64*	63·43	*31*	63·72	*58*	64·49	*91*	16·38	*87*	12·60	*94*	7·59	*88*	7·55	*83*	18·54
Clyde.	♂	*82*	30·23	*82*	62·92	*67*	63·48	*81*	64·38	*77*	16·25	*68*	12·58	*69*	7·55	*56*	7·60	*45*	18·46
	♀	*71*	30·30	*70*	62·92	*53*	63·68	*69*	64·59	*79*	16·14	*61*	12·53	*65*	7·51	*47*	7·64	*44*	18·22
Barra and Stornoway.	♂	*28*	30·23	*28*	63·59	*26*	64·18	*28*	64·92	*30*	16·12	*32*	12·55	*32*	7·61	*35*	7·61	*35*	18·27
	♀	*38*	30·31	*38*	63·47	*37*	64·24	*38*	65·02	*39*	16·11	*39*	12·44	*39*	7·52	*38*	7·48	*39*	18·29
	?	*6*	30·51	*6*	63·20	*3*	65·23	*6*	65·31	*7*	16·38	*8*	12·80	*8*	7·71	*7*	7·61	*7*	17·95

TABLE IV.

Average Percentages for the Two Sexes combined.

	Both Sexes.	*G.* Pect.		*G.* 2nd D.		*G.* Tail.		D. Groove.		*d* Pf.		*d* Vf.		*d* A.		*l* Cr.	
		No.	M.	No.	M.	No.	M.	No.	M.	No.	M.	No.	M.	No.	M.	No.	M.
Aberdeen.	,,	*76*	41·68	*70*	39·7	*76*	8·63	*178*	15·06	*149*	23·94	*56*	27·67	*63*	63·67	*174*	18·57
Clyde.	,,	*88*	41·42	*124*	40	*123*	8·72	*105*	15·49	*153*	23·43	*106*	26·9	*122*	63·56	*91*	18·34
Barra and Stornoway.	,,	*71*	40·35	*70*	38·2	*71*	8·78	*71*	15·14	*72*	23·47	*63*	27·05	*66*	64·26	*81*	18·26

TABLE IVA.

Means, Standard Deviations, Fluctuations of the Means of certain Characters for the Two Sexes combined.

	l Pf.				*l* Sn.				*ll* H.				*d* 1 D.				*d* 2 D.			
	No.	M	σ	M ± 5r.	No.	M	σ	M ± 5r.	No.	M	σ	M ± 5r.	No.	M	σ	M ± 5r.	No.	M	σ	M ± 5r.
Aberdeen.	*176*	10·99	·14	10·94 – 11·07	*138*	9·08	·107	9·05 – 9·11	*141*	22·57	·2	22·51 – 22·62	*156*	30·57	·21	30·51 – 30·62	*152*	63·31	·29	63·23 – 63·39
Clyde.	*120*	11·26	·21	11·19 – 11·32	*120*	9·06	·19	9·00 – 9·12	*148*	22·08	·6	21·91 – 22·24	*155*	30·25	·29	30·17 – 30·33	*154*	62·91	·49	62·78 – 63·04
Barra & Stornoway.	*72*	11·00	·32	10·87 – 11·12	*71*	9·03	·31	8·91 – 9·16	*71*	22·18	·58	21·95 – 22·41	*72*	30·30	·42	30·13 – 30·47	*72*	63·48	·5	63·27 – 63·69

	d As.				*l* Sk.				*l* M.				*l* De.				T.			
	No.	M	σ	M ± 5r.	No.	M	σ	M ± 5r.	No.	M	σ	M ± 5r.	No.	M	σ	M ± 5r.	No.	M	σ	M ± 5r
Aberdeen.	*132*	64·44	·22	64·37 – 64·50	*194*	16·40	·109	16·37 – 16·42	*195*	12·64	·11	12·61 – 15·66	*203*	7·60	·06	7·58 – 7·61	*193*	7·62	·12	7·59 – 7·65
Clyde.	*152*	64·47	·3	64·38 – 64·55	*157*	16·20	·26	16·13 – 16·27	*131*	12·56	·19	12·50 – 12·61	*136*	7·54	·13	7·50 – 7·56	*106*	7·62	·13	7·57 – 7·65
Barra & Stornoway.	*72*	65·01	58	64·77 – 65·24	*76*	16·13	·32	16·01 – 16·26	*79*	12·52	·28	12·42 – 12·62	*79*	7·56	·167	7·50 – 7·62	*80*	7·54	·2	7·47 – 7·62

TABLE V.

The Mean Number of Rays in the First and Second Dorsal and Anal Fins, and of the Dorsal and Anal Finlets.

District.	Sex.	First Dorsal.		Second Dorsal.		Dorsal Finlets.		Anal Fin.		Anal Finlets.	
		No.	M.	No.	M.	No.	M.	No.	M.	No.	M.
Aberdeen.	♂	*111*	13·54	*112*	11·99	*111*	5	*112*	11·92	*112*	5
	♀	*93*	13·45	*95*	11·91	*95*	4·99	*95*	11·92	*95*	5·01
Clyde.	♂	*90*	13·4	*91*	11·92	*91*	4·99	*90*	11·90	*91*	5
	♀	*89*	13·37	*89*	11·95	*90*	5·01	*89*	11·81	*90*	5·01
Barra and Stornoway.	♂	*34*	13·77	*33*	11·94	*35*	4·94	*35*	11·94	*35*	4·97
	♀	*42*	13·72	*42*	11·89	*42*	5	*42*	11·95	*42*	5·02
	?	*11*	13·36	*11*	11·91	*11*	4·91	*11*	12·09	*11*	5

TABLE VA.

The Means, Standard Deviations, and Fluctuations of the Means of the Numbers of Fin-rays and Finlets.

	Sex.	First Dorsal.				Second Dorsal.				Dorsal Finlets.				Anal.				Anal Finlets.			
		No.	M	σ	M ± 5r.	No.	M.	σ	M ± 5r.	No.	M	σ	M ± 5r.	No.	M	σ	M ± 5r.	No.	M	σ	M ± 5r.
Aberdeen.	♂+♀	*204*	13·50	1·01	13·27 – 13·73	*207*	11·95	·4	11·86 – 12·04	*206*	4·996	·18	4·95 – 5·03	*207*	11·92	·44	11·82 – 12·02	*207*	5·004	·18	4·96 – 5·04
Clyde.	♂+♀	*181*	13·40	1·06	13·14 – 13·66	*182*	11·92	·43	11·82 – 12·02	*183*	5	·14	4·96 – 5·03	*181*	11·86	·43	11·76 – 11·96	*183*	5·005	·22	4·95 – 5·05
Barra, &c.	♂÷♀	*87*	13·76	·97	13·41 – 14·11	*86*	11·91	·32	11·80 – 12·02	*88*	4·96	·18	4·90 – 5·03	*88*	11·96	·38	11·8 – 12·07	*88*	5	·15	4·95 – 5·05

TABLE VI.

Dimensions (in centimetres) of a Theoretical Mackerel, 33cm. (13 inches) in length, deduced from the Average Percentages for each District.

	Girth.			D. Groove.	*l* Pf.	*l* Sn.	*ll* H.	*d* Pf.	*d* Vf.	*d* 1 D.	*d* 2 D.	*d* A.	*d* As.	*l* Sk.	*l* M.	*l* De.	*l* T.	*l* Cr.
	Pect.	2nd D.	T.															
Aberdeen.	13·76	13·1	2·84	4·98	3·63	2·99	7·45	7·88	9·14	10·09	20·89	21·02	21·25	5·41	4·16	2·50	2·51	6·14
Clyde.	13·66	13·2	2·87	5·11	3·72	2·98	7·29	7·72	8·87	9·96	20·75	20·98	21·28	5·34	4·16	2·48	2·51	6·03
Barra and Stornoway.	13·3	12·6	2·89	4·98	3·63	2·97	7·32	7·75	8·91	9·99	20·95	21·18	21·45	5·31	4·12	2·49	2·48	6·03

Fin-rays and Finlets.

The variations in the numbers of fin-rays and finlets are given in Table IXa. (p. 319). The average number of fin-rays in the first and second dorsal and anal fins was calculated for males and females separately (Table V.), and for the two sexes combined (Table Va). The same was done for the dorsal and anal finlets, and the results are given with the former. Owing to the fact that the majority of the mackerel from each locality are of nearly one size, it is impossible to satisfactorily break them up into groups by which any change in the number of fin-rays due to growth might be proved to be present or not. So far as sexual differences are concerned, Table V. does not give any proof of their existence. The only difference between the averages of the males and females is to be found in the second place of decimals. This holds good for each fin, and for the finlets in the mackerel from the three localities. Eleven of the Stornoway specimens, of undetermined sex, give a slightly different average for the rays of the first dorsal, but in so variable a character eleven specimens are too few upon which to place any importance. If, now, the males and females are taken together, and a comparison made between the Means for the three localities, a little divergence is seen in the case of the first dorsal fin. In respect to this character the Means for Aberdeen, the Clyde, and Barra and Stornoway are respectively 13·5, 13·4, and 13·76. In place of comparing the observed averages, it is necessary to compare the fluctuations of the Means (Table Va.). In the case of the first dorsal the fluctuation is 13·27–13·73 for Aberdeen, that for the Clyde 13·14–13·66, and that for Barra and Stornoway 13·41–14·11. In order that the Means may be regarded as differing from one another, their fluctuations must not overlap. But in this case all three do so, so that the probability is that as regards this character there is no racial distinction between the mackerel of the three districts. On reference to the Table it is seen that the fluctuations of the Means overlap in the case of the rays of the second dorsal and anal fins and the finlets. So far, then, as these characters are concerned, no racial differences exist between the three groups.

Vertebræ.

The number of vertebræ was found to be very constant, viz., 31. One mackerel alone, 31·3cm. in length, from the Clyde, had a greater number, viz., 32. No example was found with less than 31 vertebræ.

The Question of Sexual Differences.

So far as this research goes, none of the characters examined can be claimed to have any sexual variability. On reference to Table III. it may be seen that the relation between the male and female averages is comparatively irregular. While in one group of mackerel (Aberdeen) the male average for the distance of the origin of the pectoral fin from the snout (*d* Pf.) is greater than the female average, in the Clyde the reverse is the case, and in the Barra fishes the male average is again the greater. In three characters only—the distance of the first dorsal (*d* 1 D), the distance of the anus (*d* A), and the distance of the anal spine (*d* As) from the snout respectively—is the female average greater than that of the male in the mackerel from all three localities. The male average, on the other hand, exceeds the female in three characters—viz., the length of the skull (*l* Sk), the length of the mandible (*l* M), and the length of the dentary (*l* De). These six characters are alone those in which any sexual distinction appears. In the distance of the first dorsal from the snout (*d* 1 D) the female average exceeds the male in the Aberdeen lot by ·03, in the Clyde group by ·07, and in those from Barra and Stornoway by ·08. In the distance of the anus from the snout (*d* A) the female exceeds the male average by ·1 for Aberdeen, ·2 for the Clyde, and by ·06 for Barra; and in the distance of the anal spine from the snout (*d* As) the differences are—Aberdeen ·08, Clyde ·18, Barra ·06. The greatest difference between the averages is in the case of the distance of the anus from the snout (*d* A) in the Clyde fish, in which case it is ·2. It is, however, necessary to apply to these differences the test of probability. The averages are not really different unless their fluctuations fail to overlap. Now, in the case where there is the largest difference (·2) just cited, the averages are—female 63·68, male 63·48. The male average has a fluctuation of from 63·3–63·64, which approaches the female average so closely that its fluctuation must necessarily overlap that of the former. So with the other differences; none of them are sufficiently large to warrant the averages being regarded as indicating sexual differences. Again, the male average exceeds that of the female in the length of the skull (*l* Sk), length of the mandible (*l* M), and length of the dentary (*l* De). The greatest difference does not exceed ·15—a difference which is not sufficient to prevent the overlapping of their fluctuations. The conclusion is, then, warranted that of the characters treated none are of sexual variability.

Comparison of the Mackerel from the Three Districts.

The group average by which the three lots of mackerel are to be compared is the average of the males and females combined. This combined average is given for each character in Tables IV. and IVa. The fluctuation of the average has been calculated for certain of the characters which were capable of more exact measurement than the others (Table IVa). So far as the characters in Table IV. are concerned, the averages of the three groups approach each other very closely, and, allowing for the fact that the dimensions are not capable of very exact measurement, they may be regarded as practically coinciding. In the following characters—then, girth at three points,, viz., in pectoral region, at beginning of second dorsal fin, and at the root of the tail, the lengths of the dorsal groove and of the superior ramus of the tail fin, the positions of the pectoral and ventral fins and of the anus—the mackerel from Aberdeen, the Clyde, and Barra and Stornoway show no appreciable difference.

On examination of Table IVa. a very close agreement is seen to exist between the three localities in respect to the characters there entered. In this case the greater or less resemblance will be tested by the fluctuations of the Means of the dimensions. In these characters, the means of which for the three localities overlap through their fluctuations, viz., the length of the snout (*l* Sn), the length of the mandible (l M), the length of the dentary (*l* De), and the length of the tail (*l* T), complete agreement is demonstrated. They do not, so far as the evidence in this paper goes, afford any indication of racial differences between the mackerel of the three localities. In the remaining characters, viz., the length of the pectoral fin (*l* Pf), the distance of the first dorsal fin (*d* 1 D), the distance of the second dorsal fin (*d* 2 D), distance of the anal spine (*d* As) from the snout respectively, the length of the skull (*l* Sk), the three Means do not overlap, but in each character the Means for two localities do so. Thus, for example, the Clyde and

Barra mackerel overlap in respect to the fluctuations of the Means of the characters, lateral length of the head (*ll* H), distance of the first dorsal fin (*d* 1 D), and length of the skull (*l* Sk); while the Aberdeen and Barra specimens overlap in the length of the pectoral fin (*l* Pf) and distance of the second dorsal fin (*d* 2 D).

The liability of the distances of the first and second dorsal fins (*d* 1 D and *d* 2 D) to alteration through the contortion of the fish has been already referred to, and it may be well not to press the agreements and differences in these characters. Leaving these characters aside, the evidence points to the conclusion that in the lateral length of the head and the length of the skull it is probable that the mackerel of the Clyde and those of Barra and Stornoway resemble each other more closely than they do those of Aberdeen; while, as regards the length of the pectoral fin, Aberdeen and Barra and Stornoway mackerel would appear to be more closely allied to one another than they are to the mackerel of the Clyde. The nature of the relationship consists in the Clyde and Barra mackerel having a slightly shorter skull and lateral length of head than the Aberdeen forms; the means of these dimensions in the case of the fishes of the former districts lie between 16·01 and 16·27, and between 21·91 and 22·41, while the fluctuations of the means for the Aberdeen district are 16·37–16·42, and 22·51–22·62 respectively. In the Clyde specimens the pectoral fin is found to be slightly longer than in the Barra and Aberdeen examples. The means for this character lie between 10·87 and 11·07 in the Aberdeen and Barra specimens, and between 11·19 and 11·32 in the Clyde fishes.

In order to show how great the differences between the groups are in respect to the dimensions of the selected characters, and to the number of fin-rays and finlets, a typical mackerel has been constructed for each district from the average percentages given above. The averages for the males and females combined are used. The average length of all the mackerel is 33·4cm. The dimensions of a theoretical mackerel of a length of 33cm. (13 inches) are given in Table VI. All the dimensions are in centimetres, and it is therefore possible to see exactly by how much the averages are separated from one another.

Conclusion.

Of the varied characters which have been considered, there are, with the three exceptions referred to above, probably none which differ in the three groups to an extent that would permit stress to be laid upon them, when the shortcomings of the dimensions in respect to accurate measurement are taken into account. In the case of the fin-rays, finlets, and vertebræ, no differences which would on Heincke's method admit of their separation into races were found. Between the mackerel, then, which were caught at the times recorded in the Clyde, at Barra and Stornoway, and off Aberdeen, the differences in the lengths of the head, skull, and pectoral fin may with some probability be granted racial distinction. The shorter length of head and skull, in which the Clyde and Barra and Stornoway lots more closely resemble one another, separate them slightly from the Aberdeen collection. And in respect to a shorter pectoral fin the Aberdeen and Barra and Stornoway fish are separated by a small interval from the Clyde individuals. With regard to the remaining characters I consider that the evidence does not prove them of racial distinction.

[Table.

TABLE VII.—ABERDEEN.

Average Dimensions in Percentage of Total Length of Mackerel.

Length—cm.	Sex.	Girth. Pect.	Girth. 2nd D.	Girth. Tail.	Dorsal Groove.	*l* Pf.	*l* Sn.	*ll* H.	*d* Pf.	*d* Vf.	*d* 1 D.	*d* 2 D.	*d* A.	*d* As.	*l* Sk.	*l* M.	*l* De.	*l* T.	*l* Cr.
29—29·9 . .	♂	.	.	.	15·0 (1)	11·7 (1)	.	.	24·7 (1)	.	31·4 (1)	63·8 (2)	.	64·1 (1)	16·7 (1)	13·0 (1)	7·8 (1)	8·0 (1)	18·4 (1)
,, . .	♀	.	.	.	.	.	.	.	.	.	.	.	.	.	16·4 (1)	12·3 (1)	7·3 (1)	.	.
30—30·9 . .	♂	41·9 (2)	40·3 (2)	8·8 (2)	14·4 (3)	11·3 (3)	9·2 (3)	23·0 (3)	24·3 (3)	27·6 (2)	30·8 (3)	63·2 (2)	64·2 (2)	64·8 (2)	16·8 (2)	12·9 (3)	7·7 (3)	7·8 (3)	18·7 (3)
31—31·9 . .	♂	41·0 (3)	39·5 (3)	8·8 (3)	14·6 (11)	10·9 (11)	9·0 (6)	22·0 (5)	23·5 (7)	27·7 (2)	30·4 (7)	62·9 (7)	63·1 (2)	64·0 (5)	16·5 (10)	12·8 (1)	7·6 (11)	7·7 (11)	18·3 (9)
,, . .	♀	41·5 (2)	39·4 (1)	8·3 (2)	14·3 (3)	11·4 (4)	9·3 (4)	22·9 (4)	24·2 (4)	28·3 (1)	30·6 (4)	63·4 (4)	62·6 (1)	64·0 (3)	16·6 (3)	12·9 (4)	7·8 (5)	7·7 (5)	18·5 (4)
32—32·9 . .	♂	41·7 (7)	39·7 (7)	8·6 (7)	15·0 (19)	11·0 (17)	9·2 (13)	22·7 (14)	24·6 (14)	27·9 (3)	30·4 (14)	62·8 (13)	63·0 (4)	64·1 (13)	16·5 (20)	12·7 (20)	7·6 (21)	7·7 (19)	18·7 (18)
,, . .	♀	40·1 (1)	38·0 (1)	8·5 (1)	15·1 (9)	10·0 (7)	9·2 (4)	22·4 (5)	24·6 (5)	28·6 (1)	30·6 (6)	63·3 (4)	62·6 (1)	63·9 (4)	16·5 (14)	12·8 (14)	7·7 (14)	7·7 (12)	18·7 (11)
33—33·9 . .	♂	42·5 (16)	40·3 (16)	8·7 (16)	15·1 (28)	11·1 (28)	9·1 (26)	22·5 (25)	23·8 (27)	27·9 (7)	30·6 (27)	63·1 (27)	63·8 (11)	64·4 (22)	16·4 (30)	12·6 (29)	7·6 (31)	7·7 (31)	18·6 (27)
,, . .	♀	41·8 (10)	39·4 (10)	8·6 (9)	15·3 (25)	11·1 (26)	9·1 (23)	22·7 (20)	23·9 (22)	27·8 (8)	30·6 (24)	63·3 (24)	63·4 (10)	64·3 (21)	16·4 (32)	12·6 (30)	7·6 (32)	7·6 (30)	18·6 (28)
34—34·9 . .	♂	41·6 (8)	39·3 (7)	8·8 (10)	15·3 (30)	11·1 (28)	9·1 (22)	22·7 (25)	24·0 (25)	27·6 (9)	30·6 (26)	63·5 (26)	63·6 (7)	64·4 (21)	16·4 (28)	12·7 (31)	·6 (30)	7·6 (29)	18·6 (26)
,, . .	♀	40·7 (7)	37·5 (6)	8·4 (7)	15·0 (16)	10·9 (17)	9·1 (12)	22·5 (12)	24·0 (11)	27·6 (5)	30·7 (14)	63·8 (14)	64·1 (6)	64·9 (14)	16·3 (19)	12·5 (18)	7·6 (19)	7·3 (18)	18·4 (17)
35—35·9 . .	♂	41·9 (2)	40·3 (2)	8·5 (2)	15·0 (7)	10·9 (7)	8·9 (4)	22·3 (5)	23·9 (7)	26·8 (1)	30·4 (7)	63·2 (7)	63·7 (2)	64·1 (5)	16·2 (7)	12·6 (8)	7·6 (7)	7·7 (6)	19·0 (4)
,, . .	♀	41·4 (12)	39·8 (10)	8·5 (1)	15·0 (19)	10·9 (19)	8·9 (15)	22·5 (16)	23·6 (16)	27·6 (11)	30·5 (16)	63·3 (16)	64 (11)	64·6 (14)	16·3 (19)	12·5 (17)	7·5 (20)	7·6 (20)	18·5 (20)
36—36·9 . .	♂	41·7 (2)	38·4 (1)	8·9 (2)	15·0 (2)	10·4 (2)	9·0 (2)	22·6 (2)	24·2 (2)	27·0 (2)	31·4 (2)	64·1 (2)	65·4 (1)	65·6 (2)	16·6 (2)	12·6 (2)	7·7 (2)	7·6 (2)	18·8 (2)
,, . .	♀	42·8 (1)	42·5 (1)	8·5 (1)	13·8 (1)	10·9 (2)	8·5 (1)	21·4 (1)	22·1 (1)	26·6 (1)	29·2 (1)	64·3 (1)	63·7 (1)	64·9 (1)	15·9 (2)	12·5 (2)	7·5 (2)	7·4 (2)	18·5 (2)
37—37·9 . .	♂	42·6 (3)	42·5 (3)	9·0 (3)	15·4 (3)	11·1 (3)	8·9 (3)	22·5 (3)	23·5 (3)	28·1 (2)	30·2 (3)	63·7 (2)	63·2 (3)	64·0 (3)	16·2 (3)	12·7 (3)	7·8 (3)	7·7 (3)	18·5 (1)
,, . .	♀	.	.	.	15·0 (1)	10·6 (1)	9·1 (1)	23·0 (1)	23·9 (1)	27·4 (1)	31·7 (1)	63·6 (1)	64·1 (1)	64·9 (1)	16·5 (11)	12·7 (1)	7·6 (1)	7·5 (1)	18·6 (1)

TABLE VIII.—CLYDE.

Average Dimensions in Percentage of Total Length of Mackerel.

Length—cm.	Sex.	Girth. Pect.	Girth. 2nd D.	Girth. Tail.	Dorsal Groove.	*l* Pf.	*l* Sn.	*ll* H.	*d* Pf.	*d* Vf.	*d* 1 D.	*d* 2 D.	*d* A.	*d* As.	*l* Sk.	*l* M.	*l* De	*l* T.	*l* Cr.
27—27·9 . .	♀	41·6 (1)	42·0 (1)	8·3 (1)	14·8 (1)	10·9 (1)	8·7 (1)	22·1 (1)	23·2 (1)	27·7 (1)	29·5 (1)	63·3 (1)	62·6 (1)	63·7 (1)	16·5 (1)	12·5 (1)	7·4 (1)	.	18·5 (1)
28—28·9 . .	♂	**41·8** (3)	**40·8** (3)	**8·7** (3)	**15·2** (3)	**11·1** (3)	**8·6** (3)	**22·4** (2)	**23·8** (3)	**27·6** (2)	**29·6** (3)	**62·6** (3)	**63·0** (3)	**64·2** (3)	**16·1** (1)	**12·9** (3)	**7·8** (3)	**7·8** (3)	**18·5** (2)
„ . .	♀	40·6 (3)	41·2 (3)	8·4 (3)	15·8 (2)	10·9 (3)	9·0 (3)	22·3 (3)	23·6 (3)	26·9 (3)	30·0 (2)	61·9 (3)	63·8 (3)	64·5 (3)	16·5 (3)	12·7 (3)	7·6 (2)	7·6 (3)	18·3 (2)
	?	*40·9* (2)	*39·1* (2)	*8·3* (2)	*14·7* (2)	*11·1* (1)	*9·6* (2)	*22·9* (2)	*24·2* (2)	*27·0* (2)	*30·0* (2)	*62·6* (2)	*62·7* (2)	*63·7* (2)	*16·7* (1)	*12·8* (2)	*7·6* (2)	*7·6* (2)	*17·6* (2)
29—29·9 . .	♂	**41·0** (4)	**40·3** (5)	**8·8** (5)	**14·5** (5)	**11·2** (5)	**9·2** (5)	**22·2** (5)	**23·4** (5)	**26·4** (4)	**30·4** (5)	**62·1** (5)	**62·8** (5)	**63·8** (5)	**16·6** (4)	**12·9** (5)	**7·7** (5)	**7·6** (4)	**17·8** (4)
„ . .	♀	41·8 (3)	40·2 (3)	8·6 (3)	15·3 (3)	11·1 (3)	9·1 (3)	22·8 (3)	24·2 (2)	28·2 (2)	30·0 (3)	62·9 (3)	62·6 (3)	63·6 (3)	16·8 (3)	13·0 (3)	7·8 (3)	7·7 (3)	18·1 (3)
30—30·9 . .	♂	**41·8** (2)	**40·7** (5)	**8·6** (4)	**15·3** (2)	**11·4** (4)	**9·3** (5)	**22·3** (4)	**23·5** (5)	**27·3** (3)	**30·4** (5)	**63·0** (5)	**63·3** (4)	**64·5** (4)	**16·3** (4)	**12·4** (3)	**7·6** (2)	**7·8** (2)	**17·9** (2)
31—31·9 . .	♂	**41·0** (1)	**40·0** (2)	**8·7** (2)	**14·9** (1)	**11·8** (2)	**9·6** (2)	**22·1** (3)	**23·3** (3)	**27·5** (2)	**31·0** (3)	**62·8** (3)	**63·2** (2)	**64·6** (3)	**16·2** (3)	**12·6** (2)	**7·8** (1)	**7·1** (1)	**17·6** (1)
„ . .	♀	43·2 (2)	39·8 (3)	8·7 (3)	14·5 (3)	11·0 (3)	9·2 (3)	22·2 (4)	23·5 (4)	26·7 (3)	30·2 (4)	62·7 (4)	63·4 (3)	64·9 (4)	16·4 (5)	12·8 (4)	7·7 (4)	7·3 (3)	17·5 (2)
32—32·9 . .	♂	**39·7** (5)	**39·0** (7)	**8·7** (7)	**14·8** (5)	**11·4** (5)	**9·2** (5)	**22·1** (7)	**23·6** (8)	**27·3** (5)	**30·3** (8)	**62·7** (8)	**63·0** (5)	**64·0** (8)	**16·8** (8)	**12·8** (7)	**7·7** (7)	**7·5** (5)	**18·7** (5)
„ . .	♀	41·5 (4)	40·2 (7)	8·9 (7)	15·4)	11·5 (8)	9·3 (8)	22·2 (11)	23·7 (10)	26·9 (6)	30·2 (11)	62·6 (10)	63·5 (7)	64·2 (10)	16·2 (11)	12·6 (9)	7·5 (8)	7·7 (7)	18·2 (7)
33—33·9 . .	♂	**41·8** (5)	**40·7** (9)	**9·0** (9)	**15·9** (7)	**11·6** (8)	**9·0** (8)	**21·9** (9)	**23·1** (9)	**26·8** (7)	**30·1** (9)	**62·3** (9)	**63·3** (8)	**64·1** (9)	**16·1** (9)	**12·6** (9)	**7·6** (9)	**7·6** (6)	**18·8** (6)
„ . .	♀	42·2 (3)	40·2 (3)	8·8 (3)	17·1 (4)	11·1 (5)	9·1 (3)	23·4 (4)	24·2 (5)	27·2 (1)	30·4 (5)	62·6 (5)	65·0 (3)	65·4 (5)	16·5 (5)	12·5 (5)	7·7 (4)	7·9 (3)	19·1 (3)
34—34·9 . .	♂	**41·0** (11)	**38·8** (14)	**8·6** (14)	**15·7** (14)	**11·1** (14)	**9·2** (14)	**22·4** (17)	**23·5** (19)	**26·9** (10)	**30·3** (19)	**63·6** (19)	**63·6** (14)	**64·5** (19)	**16·3** (20)	**12·7** (14)	**7·5** (17)	**7·7** (14)	**18·7** (5)
„ . .	♀	41·7 (7)	40·5 (10)	8·8 (10)	15·9 (9)	11·6 (11)	9·0 (11)	22·3 (13)	23·5 (14)	26·8 (10)	30·4 (14)	63·2 (14)	63·8 (11)	64·7 (14)	16·1 (16)	12·5 (12)	7·5 (13)	7·7 (11)	18·7 (9)
35—35·9 . .	♂	**41·2** (10)	**39·5** (13)	**8·7** (13)	**15·1** (10)	**11·2** (11)	**8·9** (11)	**22·4** (14)	**23·5** (14)	**27·1** (11)	**30·4** (14)	**63·4** (14)	**63·9** (12)	**64·7** (14)	**16·2** (14)	**12·4** (14)	**7·5** (13)	**7·5** (11)	**18·5** (11)
„ . .	♀	42·0 (9)	39·8 (10)	8·5 (10)	15·6 (9)	11·1 (10)	9·0 (9)	22·3 (15)	23·5 (16)	26·9 (10)	30·7 (16)	63·5 (16)	64·0 (11)	64·9 (14)	16·1 (18)	12·5 (14)	7·5 (16)	7·7 (8)	18·8 (8)
36—36·9 . .	♂	**41·3** (5)	**40·6** (9)	**8·7** (9)	**15·9** (6)	**11·2** (9)	**9·0** (9)	**20·9** (11)	**23·1** (10)	**26·4** (9)	**29·8** (11)	**63·2** (11)	**63·4** (9)	**64·3** (11)	**15·9** (11)	**12·3** (6)	**7·4** (7)	**7·6** (6)	**18·5** (5)
„ . .	♀	42·6 (2)	40·2 (6)	8·9 (6)	15·4 (5)	11·2 (6)	8·7 (6)	20·5 (9)	22·8 (9)	26·6 (6)	29·8 (9)	62·8 (8)	63·4 (7)	64·2 (9)	15·8 (11)	12·2 (6)	7·3 (9)	7·4 (5)	16·5 (5)
37—37·9 . .	♂	**42·4** (2)	**40·6** (3)	**9·1** (3)	**16·7** (3)	**11·1** (3)	**8·9** (3)	**21·6** (3)	**22·6** (3)	**25·9** (3)	**29·9** (3)	**63·0** (3)	**64·3** (3)	**64·9** (3)	**15·8** (2)	**12·2** (4)	**7·4** (4)	**7·7** (3)	**18·2** (3)
„ . .	♀	.	.	.	.	.	.	22·3 (1)	23·8 (1)	.	30·5 (1)	63·4 (1)	.	65·1 (1)	16·2 (1)	.	7·4 (1)	.	.
38—38·9 . .	♂	**45·5** (1)	**42·1** (2)	**9·3** (2)	**15·3** (1)	**11·1** (2)	**8·9** (2)	**22·5** (2)	**23·4** (2)	**27·8** (2)	**30·3** (2)	**63·3** (2)	**64·5** (2)	**65·0** (2)	**16·4** (1)	**12·7** (1)	**7·8** (1)	**7·7** (1)	**19·2** (1)
„ . .	♀	41·6 (1)	40·5 (2)	9·1 (2)	14·8 (1)	11·3 (1)	9·3 (2)	22·2 (3)	23·3 (3)	27·8 (2)	30·4 (3)	64·6 3)	63·8 (2)	65·1 (3)	16·1 (3)	12·7 (2)	8·0 (2)	7·6 (2)	17·8 (2)
39—39·9 . .	♀	40· (2)	37·5 (2)	8·7 (2)	15·0 (2	10·9 (2)	8·9 (2)	22·2 (2)	22·7 (2)	26·6 (2)	30·1 (2)	63·0 (2)	63·2 (2)	63·9 (2)	15·4 (2)	12·1 (2)	7·2 (2)	7·6 (2)	17·9 (2)

TABLE IX.—BARRA AND STORNOWAY.

Average Dimensions in Percentage of Total Length of Mackerel.

Length—cm.	Sex.	Girth.			Dorsal Groove.	*l* Pf.	*l* Sn.	*ll* H.	*d* Pf.	*d* Vf.	*d* 1 D.	*d* 2 D.	*d* A.	*d* As.	*l* Sk.	*l* M.	*l* De.	*l* T.	*l* Cr.
		Pect.	2nd D.	Tail.															
26—26·9 . .	♀	40·2 (1)	39·1 (1)	8·5 (1)	15·8 (1)	11·5 (1)	9·9 (1)	23·8 (1)	24·5 (1)	27·7 (1)	31·2 (1)	63·2 (1)	64·0 (1)	64·7 (1)	17·3 (1)	13·2 (1)	7·8 (1)	8·2 (1)	18·2 (1)
27—27·9 . .	♂	39·4 (1)	40·8 (1)	9·1 (1)	14·1 (1)	10·7 (1)	10·0 (1)	22 (1)	23·1 (1)	26·1 (1)	29·7 (1)	61·9 (1)	63·4 (1)	63·4 (1)	16·5 (1)	12·9 (1)	7·9 (1)	8·0 (1)	18·2 (1)
,, . .	?	36·8 (2)	38·3 (2)	8·5 (2)	14·1 (2)	10·2 (2)	9·4 (2)	23·0 (2)	24·5 (2)	26·3 (2)	30·7 (2)	62·8 (2)	64·6 (2)	65·3 (2)	16·5 (2)	.	.	7·7 (2)	17·6 (2)
28—28·9 . .	♂	.	.	.	.	.	.	.	.	.	.	.	.	.	.	12·2 (1)	7·3 (1)	8·0 (1)	17·5 (1)
,, . .	?	41·6 (1)	41·6 (1)	8·4 (1)	15·0 (1)	10·7 (1)	9·8 (1)	24·1 (1)	25·2 (1)	26·6 (1)	31·1 (1)	63·3 (1)	66·5 (1)	67·2 (1)	16·8 (1)	12·8 (1)	7·9 (1)	7·3 (1)	17·5 (1)
29—29·9 . .	♂	40·3 (1)	.	8·9 (1)	14·3 (1)	11·6 (1)	9·5 (1)	21·8 (1)	23·7 (1)	.	30·2 (1)	64·8 (1)	63·8 (1)	65·5 (1)	16·5 (1)	12·6 (1)	7·9 (1)	8·1 (1)	18·5 (1)
,, . .	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8·0 (1)	18·4 (1)
30—30·9 . .	♂	40·6 (2)	38·9 (2)	9·1 (2)	15·4 (2)	11·5 (2)	9·0 (2)	22·3 (2)	23·8 (2)	27·0 (3)	30·1 (2)	63·4 (2)	63·8 (2)	64·8 (2)	16·4 (4)	12·9 (4)	7·5 (5)	7·8 (6)	18·5 (6)
. .	♀	39·4 (1)	38·4 (1)	8·7 (1)	14·9 (1)	11·3 (1)	9·5 (1)	23·5 (1)	25·0 (1)	27·7 (1)	31·4 (1)	64·5 (1)	63·8 (1)	64·8 (1)	16·5 (1)	13·0 (1)	7·5 (1)	7·7 (2)	17·6 (2)
,, . .	?	40·9 (2)	38·8 (2)	8·5 (2)	16·3 (2)	10·8 (2)	9·5 (2)	22·6 (2)	23·8 (2)	.	29·8 (2)	63·2 (2)	.	63·9 (2)	16·0 (1)	12·6 (3)	7·4 (3)	7·6 (2)	18·2 (2)
31—31·9 . .	♂	41·3 (2)	37·4 (2)	9·0 (2)	15·0 (2)	11·3 (2)	9·1 (2)	22·2 (2)	23·4 (2)	26·7 (2)	30·6 (2)	64 (2)	64·6 (2)	65·4 (2)	16·4 (3)	12·7 (3)	7·7 (3)	7·6 (3)	18·9 (3)
. .	♀	40 (4)	37·7 (4)	8·7 (4)	14·5 (4)	11·2 (4)	9·1 (4)	22·6 (4)	23·8 (4)	27·0 (4)	30·7 (4)	63·1 (4)	63·4 (4)	64·4 (4)	16·5 (4)	12·9 (4)	7·6 (4)	7·5 (3)	18·7 (4)
32—32·9 . .	♂	40·3 (10)	38·5 (10)	8·8 (10)	15·4 (9)	11·1 (10)	9·1 (10)	22·5 (9)	23·7 (10)	27·3 (9)	30·1 (10)	63·6 (10)	63·8 (9)	64·5 (10)	16·1 (10)	12·6 (10)	7·6 (10)	7·6 (11)	17·9 (11)
,, . .	♀	39·0 (8)	35·4 (8)	8·6 (8)	14·3 (9)	11·3 (9)	9·2 (8)	22·4 (9)	23·7 (9)	27·3 (8)	30·5 (9)	63·4 (9)	63·9 (8)	64·9 (9)	16·3 (10)	12·7 (10)	7·6 (10)	7·4 (9)	18·3 (9)
,, . .	?	42·2 (1)	38·1 (1)	9·0 (1)	13·8 (1)	11·2 (1)	9·5 (1)	22·9 (1)	24·5 (1)	.	31·0 (1)	63·9 (1)	.	66·3 (1)	16·3 (3)	13·0 (3)	7·9 (3)	.	.
33—33·9 . .	♂	39·1 (2)	35·4 (2)	9·1 (2)	15·9 (2)	11·6 (2)	9·0 (2)	22·4 (2)	23·2 (2)	27·7 (2)	30·8 (2)	64·0 (2)	64·6 (2)	65·5 (2)	16·2 (2)	12·7 (2)	7·7 (2)	7·5 (2)	19·1 (2)
,, . .	♀	38·9 (4)	37·0 (4)	8·6 (4)	15·1 (4)	10·9 (4)	9·0 (4)	22·2 (4)	23·6 (4)	27·0 (4)	30·1 (4)	63·1 (4)	63·8 (4)	64·8 (4)	16·2 (4)	12·4 (4)	7·4 (4)	7·5 (4)	18·2 (4)
,, . .	?	.	.	.	.	.	.	.	.	.	.	.	.	.	16·2 (1)	12·8 (1)	7·9 (1)	7·4 (1)	18·2 (1)

TABLE IX.—BARRA AND STORNOWAY—*continued.*

Length—cm.	Sex.	Girth. Pect.	Girth. 2nd D.	Girth. Tail.	Dorsal Groove.	*l* Pf.	*l* Sn.	*ll* H.	*d* Pf.	*d* Vf.	*d* 1 D.	*d* 2 D.	*d* A.	*d* As.	*l* Sk.	*l* M.	*l* De.	*l* T.	*l* Cr.
34—34·9	♂	41·2 (1)	38·8 (1)	8·8 (1)	14·6 (1)	10·5 (1)	8·9 (1)	22·2 (1)	23·9 (1)	.	30·1 (1)	61·9 (1)	.	63·6 (1)	.	12·5 (1)	7·7 (1)	7·7 (1)	18·7 (1)
,	♀	40·6 (2)	38·1 (2)	8·5 (2)	15·3 (2)	11·2 (2)	9·0 (2)	23·0 (2)	24·4 (2)	28·1 (2)	30·9 (2)	63·1 (2)	64·5 (2)	65·1 (2)	16·6 (2)	12·6 (2)	7·7 (2)	7·6 (2)	18·4 (2)
35—35·9	♂	39·2 (1)	40·3 (1)	8·2 (1)	14·3 (1)	10·7 (1)	8·7 (1)	22·0 (1)	23·3 (1)	27·5 (1)	30·3 (1)	62·3 (1)	65·3 (1)	65·9 (1)	15·8 (1)	12·2 (1)	7·5 (1)	7·6 (1)	17·9 (1)
37—37·9	♂	43·1 (1)	41·8 (1)	8·7 (1)	16·5 (1)	11·0 (1)	8·8 (1)	21·0 (1)	22·1 (1)	25·5 (1)	29·2 (1)	63·5 (1)	65·4 (1)	65·9 (1)	15·8 (1)	12·2 (1)	7·2 (1)	7·9 (1)	18·8 (1)
,,	♀	39·5 (2)	37·9 (2)	8·6 (2)	15·2 (2)	10·8 (2)	9·1 (2)	21·7 (2)	23·3 (2)	26·2 (2)	30·0 (2)	63·4 (2)	64·0 (2)	64·6 (2)	15·9 (2)	11·8 (1)	7·3 (2)	7·6 (2)	19·0 (2)
38—38·9	♂	40·8 (2)	38·7 (2)	8·6 (2)	15·4 (2)	10·3 (2)	8·9 (2)	21·6 (2)	24·1 (2)	27·3 (2)	30·5 (2)	63·7 (2)	64·1 (2)	64·3 (2)	15·7 (2)	12·5 (2)	7·8 (2)	7·2 (2)	17·3 (2)
,,	♀	39·7 (2)	37·9 (2)	8·8 (2)	15·4 (2)	10·8 (2)	8·8 (2)	21·7 (2)	23·4 (2)	28·1 (2)	30·7 (2)	64·4 (2)	65·0 (2)	65·6 (2)	15·8 (2)	12·3 (2)	7·6 (2)	7·4 (2)	17·8 (2)
39—39·9	♂	41·0 (1)	40·5 (1)	8·7 (1)	14·4 (1)	10·7 (1)	8·7 (1)	22·5 (1)	24 (1)	28·5 (1)	30·5 (1)	64·2 (1)	65·2 (1)	66·5 (1)	15·7 (1)	12·4 (1)	7·7 (1)	7·5 (1)	17·5 (1)
,,	♀	41·3 (4)	39·0 (4)	8·8 4)	16·2 (4)	11·0 (4)	8·7 (1)	21·6 (4)	22·1 (4)	27·0 (2)	30·0 (4)	64·3 (4)	65·1 (4)	65·6 (4)	15·8 (4)	12·2 (4)	7·5 (4)	7·5 (4)	18·2 (4)
40—40·9	♂	41·3 (1)	39·4 (1)	8·8 (1)	15·0 (1)	10·3 (1)	8·2 (1)	21·6 (1)	22·5 (1)	26·8 (1)	29·8 (1)	64·2 (1)	65·2 (1)	65·9 (1)	15·5 (1)	11·8 (1)	7·2 (1)	7·0 (1)	18·7 (1)
,,	♀	41·1 (4)	39·5 (4)	9·1 (4)	16·1 (4)	11·1 (4)	8·9 (4)	21·6 (4)	22·9 (4)	27·3 (4)	29·9 (4)	63·3 (4)	64·6 (4)	65·1 (4)	15·9 (4)	12·1 (4)	7·4 (4)	7·5 (4)	18·4 (4)
41—41·9	♂	41·7 (2)	39·6 (2)	9·4 (2)	15·5 (2)	11·0 (2)	8·9 (2)	21·9 (2)	23·3 (2)	25·7 (2)	30·6 (2)	63·5 (2)	64·3 (2)	65·4 (2)	15·9 (2)	12·3 (2)	7·7 (2)	7·4 (2)	18·8 (2)
,,	♀	40·8 (1)	38·4 (1)	9·0 (1)	15·0 (1)	10·8 (1)	8·5 (1)	21·6 (1)	23·2 (1)	27·8 (1)	29·0 (1)	64·1 (1)	63·6 (1)	64·3 (1)	15·8 (1)	12 (1)	7·7 (1)	7·7 (1)	18·4 (1)
42—42·9	♂	43·7 (1)	39·8 (1)	9·4 (1)	13·0 (1)	11·1 (1)	9·9 (1)	21·6 (1)	22·7 (1)	26·7 (1)	30·6 (1)	63·6 (1)	64·8 (1)	65·3 (1)	16·4 (1)	12·6 (1)	7·8 (1)	7·5 (1)	18·7 (1)
,,	♀	43·4 (2)	40·2 (2)	8·9 (2)	13·8 (2)	10·5 (2)	8·7 (2)	21·3 (2)	21·9 (2)	25·3 (2)	30·1 (2)	62·7 (2)	65·4 (2)	66·0 (2)	15·5 (2)	11·9 (2)	7·2 (2)	7·1 (2)	17·8 (2)
43—43·9	♀	41·4 (2)	38·8 (2)	9·1 (2)	15·0 (2)	10·5 (2)	8·3 (2)	21·2 (2)	22·5 (2)	26·2 (2)	29·8 (2)	63·7 (2)	64·6 (2)	65·5 (2)	15·3 (2)	11·8 (2)	7·5 (2)	7·3 (2)	18·4 (2)

TABLE IXA.

Analysis of the Variations in the Number of Fin-rays in the Mackerel from each Locality.

Locality.	Sex.	First Dorsal								Second Dorsal.					Dorsal Finlets.				Anal.							Anal Finlets.			
		No.	10	11	12	13	14	15	16	No.	11	12	13	14	No.	4	5	6	No.	9	10	11	12	13	14	No.	4	5	6
Aberdeen.	♂	*111*	..	1	16	36	41	14	3	*112*	9	96	7	..	*111*	1	109	1	*112*	..	..	13	96	2	1	*112*	2	108	2
	♀	*93*	..	2	14	32	32	11	2	*95*	14	76	5	..	*95*	3	90		*95*	1	1	7	82	4	..	*95*	1	92	2
	♂+♀	*204*	..	3	30	68	73	25	5	*207*	23	172	12	..	*206*	4	199	3	*207*	1	1	20	178	6	1	*207*	3	200	4
Loch Fyne and Kilbrennan Sound.	♂	*90*	1	..	14	35	25	15	..	*91*	12	75	4	..	*91*	2	88	1	*90*	..	1	10	76	3	..	*91*	2	87	2
	♀	*89*	1	1	17	32	23	13	2	*89*	11	73	4	1	*90*	..	89	1	*89*	..	2	15	70	2	..	*90*	2	85	3
	♂+♀	*181*	2	1	31	68	48	29	2	*182*	24	149	8	1	*183*	2	179	2	*181*	..	3	25	148	5	..	*183*	4	174	5
Barra and Stornoway.	♂	*34*	..	..	3	10	14	6	1	*33*	3	29	1	..	*35*	2	33	..	*35*	..	..	4	29	2	..	*35*	1	34	..
	♀	*42*	..	1	..	18	11	9	3	*42*	5	37	..	..	*42*	..	42	..	*42*	..	..	4	36	2	..	*42*	..	41	1
	?	*11*	..	..	3	3	3	2	..	*11*	1	10	..	..	*11*	1	10	..	*11*	..	..	..	10	1	..	*11*	..	11	..
	♂+♀	*87*	..	1	6	31	28	17	4	*86*	9	76	1	..	*88*	3	85	..	*88*	..	..	8	75	5	..	*88*	1	86	1

Previous Work on the Races of Mackerel.

The mackerel caught off the southern coasts of Ireland and England have been investigated by Garstang. Owing to the fact that the present research has been conducted on different lines from his work, it is not possible to institute a very close comparison. It may not, however, be unprofitable to review the results obtained by that author, more especially with regard to the correlation of the variations of the numbers of finlets and dorsal fin-rays.

Garstang established among the European mackerel which he examined, two races, viz., the Irish (Kerry and Kinsale) mackerel and the North Sea and English Channel variety. The characters upon which he founded his comparison were—(1) the number of transverse bars; (2) the number of transverse bars which cross the lateral line; (3) the number of dorsolateral intermediate spots; (4) and (5) the number of fin-rays in the first and second dorsal fins; (6) the number of dorsal finlets. With regard to the first of these characters the author says:—"The bars are not always distinct and parallel, but are frequently branched and anastomosed with one another, broken or otherwise irregular, rendering the task of enumeration not always easy, and so introducing a certain subjective element into the records." In the case of the second character, viz., the number of bars that cross the lateral line, another interfering factor is present, namely, the irregularity of the lateral line in its course. By means of the third character—the "spottiness" of the fish—he was enabled to separate the American examples from the European specimens. I have not adopted these characters for the present research, because in such a case, where the colour-markings are so irregularly disposed, that the two sides of the one fish generally differ in the arrangement of the bars, too much will depend upon the observer, and too little upon any rule which can be enunciated for guidance. Owing to this a comparison between the results of different workers would be difficult, if not impossible. As regards the number of rays in the first dorsal fin, I have found a considerably higher average than was found by Garstang in his specimens. The highest average which he found was 12·5 rays (in the Scilly mackerel), while for Plymouth the average was 12·18. The lowest average which I obtained was 13·4 (for the Clyde fish), while the Aberdeen specimens gave 13·5, and the Barra and Stornoway, 13·76. Moreover, the evidence accumulated by his investigation of this character indicated that a reduction in the number of recognisable fin-rays accompanied the increase in length of the fish. This reduction, he is inclined to believe, is due to the concealment of the minute posterior rays by the encroachment of the surrounding tissues on the lower part of the fin. Their concealment is not a sufficient description of the reduction in number of the recognisable rays. The mackerel which I have examined do certainly afford a slight indication of a reduction due to growth, as the following Table shows; but the evidence here furnished is not conclusive. I have arranged all the mackerel of which I have noted the number of first dorsal rays into two-centimetre groups. The number of specimens in each, and the average for each group, are given alongside.

[Table.

Cm.	No.	Average.	Cm.	No.	Average.
26–28	15	13·6	—	—	—
29–31	63	13·4	—	—	—
32–34	256	13·7	26–33	245	13·55
35–37	108	13·2	35–43	227	13·47
38–40	22	13·59	—	—	—
41–43	8	14·1	—	—	—

But since the groups are so irregular as regards the numbers of mackerel in each I have divided the whole number into two groups of from 26–33 and 34–43cms. By this arrangement a slight reduction in the number of rays is indicated in the group of larger fish; the averages being 13·55 for the less, and 13·47 for the larger. Two groups of mackerel which Garstang compares with the object of showing this decrease give more indication of the reduction; *e.g.*, 129 mackerel of from $5\frac{1}{2}$–$10\frac{1}{2}$ inches gave an average of 12·49 rays, while 127 of from $12\frac{1}{2}$–$15\frac{3}{4}$ gave an average of 12·02. The discrepancy between the average numbers of rays obtained by Garstang and by myself can only be due to a difference in the interpretation of the term recognisable. And herein lies the difficulty of counting the rays of this fin. In almost every fish one ray at least was completely sunk beneath the skin, and, notwithstanding its minute size, if its articular base was made out, it was counted as a ray.

Second Dorsal Fin and Dorsal Finlets.

The average number of rays found by Garstang for this fin, viz. North Sea and English Channel 11·946, Brest and Scilly 11·948, and for Ireland, S. and W., 11·933, agree very closely with what I found in the Scottish fish, viz., 11·95 for Aberdeen, 11·92 for the Clyde, and 11·91 for Barra and Stornoway. The average for the dorsal finlets of the same southern localities were 5·009, 4·994, 5·011, while those for the Scottish districts were 4·996, 5, and 4·96. Here, again, a close agreement is seen.

The Correlation between the Variations in the Numbers of the Rays of the Second Dorsal and Anal Fins, and the Dorsal and Anal Finlets.

Garstang draws attention to the correlation between the variations of the second dorsal fin and the number of dorsal finlets, and from an analysis of the variation of these organs in a number of American mackerel makes the following generalisations:—(1) "That the normal or modal number of fin-rays (12) is constantly associated with the normal or modal number of finlets (5); (2) that when the number of fin-rays is below 12, the variation in the number of finlets is confined to deviations above the mode (5); (3) that when the number of fin-rays is above 12, the deviations from the modal number of finlets are exclusively below the mode; (4) that the normal number of finlets (5) is associated with a wide range of variation in regard to the number of rays in the second dorsal fin (from 10–14); (5) that when the number of finlets is above five, the number of rays is constantly below 12; and (6) that when the number of finlets is below 5, the number of rays is constantly above 12." Nos. 1, 5, and 6 do not hold good for Scottish mackerel, as the following Table will show.

Table to show the numbers of second dorsal fin-rays which have been found associated with each number of finlets, and the observed frequency of each combination in 474 mackerel:—

Dorsal Finlets.	Second Dorsal Fin-rays.			
	11	12	13	14
4	—	5	4	—
5	52	392	16	1
6	1	3	—	—

It is thus evident that the normal or modal number of fin-rays of the second dorsal (12) is associated with the two variations (4 and 6) of the finlets, and in the present instance that association occurs more frequently than what might be called the compensating association of a higher number of fin-rays, *e.g.*, 13, with a lower number of finlets, *e.g.* 4. The following Table gives an analysis of 476 Scottish mackerel in respect to the variation in the number of anal finlets and their association with variations in the number of the anal fin-rays :—

Anal Finlets.	Anal Fin-rays.					
	9	10	11	12	13	14
4	—	—	—	2	6	1
5	1	2	44	396	12	—
6	—	1	6	3	—	—

It is here seen that in this case also a similar relation is found, viz., that the normal or modal number of fin-rays (12) is associated with both variations from the modal number of finlets. The following generalisation is then warranted, viz., that the modal number of rays of the second dorsal and anal fins (12) is to be found associated with the two variations (4 and 6) of the dorsal and anal finlets ; and, further, that with a variation in the number of finlets either above or below 5, if the modal number of the rays of the related fin is not found associated therewith, the rays will be found to vary in number from 12 inversely as the finlets vary from 5.

It is, again, apparent from these two Tables that, as Garstang records in his fourth generalisation, the normal number of finlets (5) is associated with a wide range of variation in the number of fin-rays. A converse of the generalisation made above with regard to the variations in the finlets holds good also for variations in the fin-rays, viz., that the modal number of finlets is found associated with most of the variations in the number of rays ; and, further, that with a variation in the number of finlets either above or below 12, if the modal number of finlets be not associated therewith, the finlets will be found to vary in number from 5 inversely as fin-rays vary from 12. This applies to both dorsal and anal couples (fin-rays and finlets). These two propositions may be stated more briefly :—

(1) When the number of finlets varies, the number of fin-rays remains normal, or *varies in the opposite sense.*

(2) When the number of fin-rays varies, the number of finlets remains normal, or *varies in the opposite sense.*

The variation of the finlets in the opposite sense to the fin-rays is more apparent than real. So long as a distinction is made between the fin-rays and the finlets, the compensating variation seems to occur. But the finlets are really detached rays of the second dorsal fin. Very often a finlet remains attached to the fin, and occasionally a fin-ray becomes detached from the fin, in which cases we get such compensating variations as 13 fin-rays and 4 finlets and 11 fin-rays and 6 finlets, which of course together give the normal total 12 + 5 (17). In these compensating variations there is no real variation in number, simply a slight variation in location. The rearrangement (in brackets) of the figures in Table X. eliminates this compensating variation. The generalisation may therefore be, with great probability, simplified thus—(1) that with variations in the number of finlets there are associated the normal number of fin-rays; (2) that with variations in the number of fin-rays there are associated the normal number of finlets.

TABLE X.

Combination of Variations in One Couple with the Normal in the other.

Variations in Dorsal Couple.					Variations in Anal Couple.				
2nd Dorsal Fin-rays.	Dorsal Finlets.	Anal Fin-rays.	Anal Finlets.	Frequency.	Anal Fin-rays.	Anal Finlets.	2nd Dorsal Fin-rays.	Dorsal Finlets.	Frequency.
13 (12)	4 (5)	12	5	4	13 (12)	4 (5)	12	5	5
12	4	12	5	4	12	4	12	5	2
12	4	11 (12)	6 (5)	1	14 (13)	4 (5)	12	5	1
11 (12)	6 (5)	10 (11)	6 (5)	1	13 (12)	4 (5)	11	5	1
12	6	12	6	3	13 (12)	4 (5)	13	5	1
–	–	–	–	–	11 (12)	6 (5)	12	5	5

TABLE XI.

Variations in the Number of 2nd Dorsal Fin-rays, accompanied by Normal Number of Dorsal and Anal Finlets.					Variations in the Number of Anal Fin-rays, accompanied by Normal Number of Dorsal and Anal Finlets.				
2nd Dorsal Fin-rays.	Dorsal Finlets.	Anal Fin-rays.	Anal Finlets.	Frequency.	Anal Fin-rays.	Anal Finlets.	Dorsal Fin-rays.	Dorsal Finlets.	Frequency.
11	5	12	5	35	11	5	12	5	34
12	5	12	5	337	13	5	12	5	6
13	5	12	5	12	11	5	11	5	8
14	5	12	5	1	13	5	11	5	3
–	–	–	–	–	11	5	13	5	1
–	–	–	–	–	9	5	11	5	1

TABLE XII.

A. Variations in Dorsal Combination.			B. Variations in Anal Combination.			C. Additional Variations in Dorsal and Anal Combinations.		
2nd Dorsal Fin-rays and Finlets.	Anal Fin-rays and Finlets.	Frequency.	Anal Fin-rays and Finlets.	Dorsal Fin-rays and Finlets.	Frequency.	Dorsal Fin-rays and Finlets.	Anal Fin-rays and Finlets.	Frequency.
–	–	–	16	17	38	16	14	1
14	17	1	18	17	7	16	16	8
16	17	41	–	–	–	16	18	3
18	17	13	17	17	351	18	16	1
19	17	1	–	–	–	18	18	3

Correlation between the Dorsal Couple (2nd Dorsal Fin-rays and Dorsal Finlets) and the Anal Couple (Anal Fin-rays and Anal Finlets).

For the purpose of this comparison, each set of fin-rays and finlets is added together. The normal number is 17 in each case. The correlation which is found to exist is as follows :—That a variation from the normal number in the dorsal couple is accompanied by the normal number in the anal couple, and *vice versa.* This proposition will be modified later, when the exceptions to this rule are considered. In Tables X. and XI. are set forth the various combinations of fin-rays and finlets which were present in 468 mackerel (♂ and ♀); and in Table XII. the number of fin-rays and finlets are added for each couple. In the divisions A and B all the variations which agree with the above generalisation are entered. In division C are the exceptions. They are 16 in number. One variation, which occurred eight times, is a decrease in the dorsal couple, accompanied by a similar decrease in the anal—viz., 16 in each; while a second variation, in which both couples were equally increased—viz., 18 in each—occurred three times. In these two cases, then, we have accompanying a decrease or an increase in one couple an equal decrease or increase in the other. There remain five cases, in four of which a decrease in one couple was accompanied by an increase to the same amount in the other couple—viz., 16 and 18 and 18 and 16. The last exception—viz., dorsal 16, anal 14—is one in which an abnormally low number of anal fin-rays—viz., nine—was found. This reduction is possibly due to injury. Two other cases in which abnormally low numbers were found—*e.g.*, in one, two dorsal finlets and in the other eight dorsal fin-rays—have been left out, since they were evidently due to injury. A generalisation which would include all the cases (with the exception of the three supposed abnormal cases) is as follows :—A variation in one couple is accompanied by the normal number, or by an *equal* deviation in the same or opposite sense in the other. It is very possible and probable that the variations in the dorsal and anal couples may be sometimes correlated with variations in the number of caudal rays, and such a relation may be present in the case of those exceptions which required a widening of the proposition. I have, however, no data bearing on the number of caudal rays.

An attempt was made to find what correlation, if any, existed between the number of rays of the first dorsal fin and the various combinations of the dorsal and anal couples. These are set out in Table XIII. No connection was very apparent. It would not unnaturally be expected that the first dorsal fin would vary quite independently of the dorsal couple, and this is probably the case.

[TABLE.

Table XIII.

Combination of Fin-rays of First Dorsal Fin with the Second Dorsal and Anal Fins and the Dorsal and Anal Finlets.

Nature of Variations.	Frequency.	2nd Dorsal and Anal Fin-rays. Dorsal and Anal Finlets.				First Dorsal Fin-rays.						
		2nd Dorsal Fin-rays	Dorsal Finlets.	Anal Fin-rays	Anal Finlets.	10	11	12	13	14	15	16
Dorsal and Anal Combinations: Normal.	338	12	5	12	5	1	5	50	108	109	57	8
Decrease in Dorsal Combination: . .	41	11	5	12	5	–	–	3	19	8	4	2
Anal Normal.		12	4	12	5	1	–	1	2	1	–	–
Decrease in Anal Combination: . .	38	12	5	11	5	–	–	4	17	10	4	–
Dorsal Normal.		12	5	12	4	–	–	1	–	1	–	–
		12	5	10	6	–	–	–	–	1	–	–
Increase in Dorsal Combination: . .	16	13	5	12	5	–	–	1	8	5	1	–
Anal Normal.		14	5	12	5	–	–	1	–	–	–	–
Increase in Anal Combination: . .	10	12	5	13	5	–	–	1	3	4	1	–
Dorsal Normal.		12	5	14	4	–	–	1	–	–	–	–
Decrease in both Dorsal and Anal . .	14	11	5	11	5	–	–	2	5	2	2	–
Combinations.		11	5	10	5	–	–	1	–	1	–	–
		11	5	9	5	–	–	–	–	1	–	–
Increase in both Dorsal and Anal . .	3	12	6	12	6	–	–	–	1	2	–	–
Combinations.		–	–	–	–	–	–	–	–	–	–	–
		–	–	–	–	–	–	–	–	–	–	–
Decrease in Dorsal: Increase in Anal .	3	11	5	13	5	–	–	–	1	1	1	–
Combination.		–	–	–	–	–	–	–	–	–	–	–
Increase in Dorsal: Decrease in Anal .	1	13	5	11	5	–	–	1	–	–	–	–
Combination.		–	–	–	–	–	–	–	–	–	–	–

TABLE XIV.

Ripe and Unripe Spent Mackerel.

	Clyde and Barra. (June and July).					Stornoway (August).				Aberdeen (Aug. and Sept.).		Kilbrennan Sound (October).	
	Ripe.		Unripe.			Ripe.	Unripe and Spent.			Unripe and Spent.		Unripe and Spent.	
Length—cm.	♂	♀	♂	♀	?	♀	♂	♀	?	♂	♀	♂	♀
26	–	–	–	1	–	–	–	–	–	–	–	–	–
27	1	–	–	–	2	–	–	–	–	–	–	–	1
28	1	1	–	1	2	–	1	–	1	–	–	3	1
29		1	–	–	–	1	–	–	1	1	1	2	2
30	5	–	–	1	–	–	4	2	3	3	5	2	–
31	5	8	–	–	–	–	1	–	–	11	15	–	1
32	16	19	2	1	–	–	2	2	3	21	32	–	–
33	12	10	–	–	–	–	–	–	1	32	19	–	–
34	21	18	1	–	–	–	1	–	–	31	20	–	–
35	17	25	1	–	–	–	–	–	–	8	2	–	–
36	10	12	–	–	–	–	–	–	–	2	1	–	–
37	4	3	1	–	–	–	–	–	–	3	–	–	–
38	4	6	–	–	–	–	–	–	–	–	–	–	–
39	1	6	–	–	–	–	–	–	–	–	–	–	–
40	1	4	–	–	–	–	–	–	–	–	–	–	–
41	2	1	–	–	–	–	–	–	–	–	–	–	–
42	1	2	–	–	–	–	–	–	–	–	–	–	–
43	–	2	–	–	–	–	–	–	–	–	–	–	–
Totals,	105	118	5	4	4	1	9	4	9	112	95	7	5

The Spawning of the Mackerel.

A certain amount of evidence bearing on the spawning season of the mackerel has been afforded by the fishes examined during this research. Among the mackerel got in Loch Fyne and at Barra in June and July 105 males and 118 females were ripe; four females were unripe, and five males ripe or spent; four specimens of undetermined sex were unripe (*vide* Table XIV.). The total of ripe females included seven spent fish. Twenty-three mackerel were obtained from Stornoway on August 13th; of these, one female was ripe and three females were spent, while the remainder were unripe (or, in the case of the males, possibly spent). Of the 207 specimens caught off Aberdeen in the latter half of August and first half of September 95 were females, and of these 84 were spent; nine were ripe. The males were either unripe or spent. In October, 12 fish were sent from Kilbrennan Sound; of these, five were spent females. It is to be inferred, then, that on the West Coast spawning takes place in July and part of August. The lower and upper limits of the spawning season it is so far not possible to fix. The mackerel caught off Aberdeen had ceased spawning by the middle of August. The smallest ripe male was 27·7cm. in length; the smallest ripe female was 28·9cm. long. The smallest ripe male and ripe female mackerel recorded by Cunningham* were 30·3 and 29·5cm. long respectively. He considered that this form had a short spawning period in the vicinity of Plymouth—viz., from the middle of May to the end of July.

Weights of Ripe and Unripe Mackerel.

The accompanying Table (XV.) gives some particulars of the weight of ripe and unripe mackerel at various sizes. The average weight is given for all the mackerel at each size, the number of specimens from which the average is made being indicated by a number within brackets. In most instances the average weight of the unripe male exceeds that of the ripe male. In two cases—viz., at 32 and 35cm.—the ripe male exceeds the unripe by 10 and 7 grammes respectively. At 33cm. the unripe male exceeds the ripe by 39 grammes. There is much greater variation in the relation of the ripe and unripe females to one another. Cunningham records a ripe male of 42·5cm. length weighing 524 grammes; the only ripe male of this size which I have weighed was 837 grammes in weight. The numbers, which are given in Table XV., are not sufficient to permit of any detailed discussion. It is, however, very evident that, so far as they go, they point out, in several cases, that the ripe and unripe males are of very similar weight, and so with the ripe and unripe females, while in other instances they diverge considerably.

* *Loc. cit.*

[TABLE.

TABLE XV.

Weights (in Grammes) of Ripe and Unripe ♂ and ♀ Mackerel at Different Sizes.

	Length—cm.	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
♂	Ripe	-	201 (1)	225 (1)	259 (4)	275 (4)	311 (4)	337 (12)	381 (10)	415 (13)	471 (11)	507 (8)	562 (4)	587 (3)	605 (3)	712 (1)	721 (2)	837 (1)	-
	Unripe . . .	-	-	242 (3)	278 (2)	302 (2)	344 (4)	327 (4)	420 (6)	417 (5)	464 (3)	-	604 (3)	-	-	-	-	-	-
♀	Ripe	-	-	269 (1)	261 (1)	-	304 (6)	330 (10)	372 (6)	432 (10)	494 (8)	503 (5)	486 (2)	579 (4)	648 (4)	655 (4)	707 (1)	844 (2)	825 (2)
	Unripe . . .	194 (1)	230 (1)	231 (2)	276 (2)	300 (2)	327 (1)	317 (6)	401 (6)	426 (4)	452 (8)	580 (1)	-	-	-	-	-	-	-

VIII.—REPORT ON THE OPERATIONS AT DUNBAR MARINE HATCHERY DURING THE SPRING SEASON 1899.

By Harold C. Dannevig.

As mentioned in last year's Report, the transference of the Dunbar Hatchery to the same site as the Marine Laboratory, Bay of Nigg, Aberdeen, had to be postponed owing to delay in the completion of the large tidal pond, and it was found necessary to continue the hatching operations at Dunbar for another season. Owing to this and to the stormy weather which prevailed during the early part of the year, the collection of spawners was begun in the third week of February. The fish were procured by the "Garland" from steam trawlers as in previous years, and from February 25th to April 1st a total number of 419 male and female plaice were landed and placed in the spawning pond. The collection of the spawners was sometimes a matter of difficulty owing to the stormy weather, and the "Garland" on several occasions found it impossible to land the fish at Dunbar, and had to keep them on board, in tubs, in Granton harbour until the weather moderated, a constant circulation of water being maintained. On two or three occasions it was found desirable to remove the ripe spawn from the fishes at Granton, to fertilise the eggs, and take them on to the hatchery. It has been found that, though in ripe condition at the time of capture, the plaice does not spawn immediately upon being put into confinement. Several days, or even more than a week, may elapse before the regular spawning commences. But, as has been stated in previous Reports, this regular spawning, or a daily production of fecundated eggs, is preceded by the extrusion of non-fertilised eggs—eggs that have been retained in the ovaries or oviduct so long that they are incapable of fecundation. This retention of ripe eggs appears, in the first instance, to be due to fright, discomfort, or bodily injury to the fish; and if it is not continued for a sufficiently long time to allow any quantity of ripe eggs to accumulate has not serious consequences. Once the overdue eggs have been got rid of a normal spawning follows; but if a large number of eggs are retained in the ovaries and oviduct the latter becomes congested, and serious consequences for the fish may be apprehended. The as yet healthy ovary continues to swell by the development of new eggs, and if the outlet is closed it is easily seen how the ovaries may reach such a distended condition as to be dangerous not only to this organ but to the fish itself. The immediate consequences are that a fish in such a condition becomes inactive, and does not take any food. If the capture has inflicted any superficial injury in the region of the ovary, inflammation soon sets in, and the tenacity of the abdomen becomes reduced. The constantly increasing pressure in the ovary may gradually force a portion of this organ through the inflamed tissue and leave it exposed. If, however, the abdomen is healthy and able to withstand the ovarian pressure, the intestines become pushed forward and partly out through the anus; while the foremost part of the oviduct is often also pushed out externally. As in all these cases the fish is rendered useless for breeding purposes, and almost invariably will die in the course of the season, I have found it expedient at once to kill such specimens. In other cases, when the ovarian pressure is not sufficiently great to cause such injury as that described, the eggs will gradually begin to disintegrate, and the once very hard ovary becomes softer, while the pressure is gradually diminished. In the course of the summer the disintegration leaves the contents of the ovary in a semi-fluid condition, containing fragments of the broken-up egg—capsules. While pressure is still present part of this fluid may escape through the oviduct, and if a fish in such a condition is placed upon a table some of this fluid generally flows out. But I have observed that once the ovary of the plaice has been excessively distended for any length of time it does not again contract freely, and it is not therefore able to expel the entire contents, and a certain portion of it must consequently become absorbed before a normal state is established. From observations made during the months of December and January upon plaice that had been egg-bound during the previous season, it appears that this absorption is not always completed at that time of the year, although I always found small eggs, with more or less yolk, developing from the walls of the ovary.

The above-mentioned difficulties have a great effect upon the success of the hatching work as regards the number of fertilised eggs that may be obtained from fish that have been captured immediately before or during the course of the spawning season; and the necessity of having the breeding-stock of plaice collected at some other period of the year by which these difficulties could be avoided, is therefore apparent. While working at Dunbar, where the plaice had to be landed by the "Garland," it was necessary, for the sake of time, to collect the fish when caught in the greatest number—viz., when they gather on the offshore spawning grounds. But as other facilities may be utilised from the port of Aberdeen, it is to be hoped that the necessary supply of adult plaice may be secured at the most suitable time of the year, as it is intended to retain the fish from year to year.

TABLE I.—SHOWING THE DAILY PROGRESS OF THE HATCHING WORK DURING THE SPRING SEASON 1899.

Date.	Number of Eggs Collected.	Number of Eggs Found Dead in Boxes.	Number of Fry put out.	Total Number of Eggs and Fry in Boxes.	Sp. Gravity and Temperature at Noon of the Water in the Hatchery.	
					Sp. Gravity.	Centigr.
March 10th.	65,000	-	-	65,000	1027·3	4·9
,, 11th.	-	-	-	65,000	1027·3	4·8
,, 12th.	60,000	-	-	125,000	1027·2	4·9
,, 13th.	-	-	-	125,000	1027·2	5·0
,, 14th.	75,000	-	-	200,000	1027·0	5·2
,, 15th.	-	-	-	200,000	1027·0	5·1
,, 16th.	90,000	-	-	290,000	1027·1	5·4
,, 17th.	70,000	-	-	360,000	1027·0	5·6
,, 18th.	185,000	20,000	-	525,000	1027·0	5·8
,, 19th.	220,000	-	-	745,000	1027·0	5·7
,, 20th.	250,000	-	-	995,000	1026·9	5·5
,, 21st.	295,000	-	-	1,290,000	1027·0	5·2
,, 22nd.	350,000	-	-	1,640,000	1027·1	5·4
,, 23rd.	535,000	35,000	-	2,140,000	1027·1	5·7
,, 24th.	545,000	-	-	2,685,000	1027·0	5·9
,, 25th.	650,000	-	-	3,335,000	1027·1	6·4
,, 26th.	670,000	-	-	4,005,000	1027·3	6·3
,, 27th.	800,000	155,000	-	4,650,000	1027·4	6·5
,, 28th.	750,000	-	-	5,400,000	1027·3	6·4
,, 29th.	780,000	-	-	6,180,000	1027·1	6·2
,, 30th.	660,000	-	-	6,840,000	1027·0	6·5
,, 31st.	500,000	-	-	7,340,000	1027·3	6·7
April 1st.	640,000	80,000	-	7,900,000	1027·1	6·4
,, 2nd.	680,000	-	-	8,580,000	1026·8	6·2
,, 3rd.	760,000	-	-	9,340,000	1026·9	6·5
,, 4th.	690,000	230,000	-	9,800,000	1026·9	6·7
,, 5th.	750,000	-	-	10,550,000	1027·1	6·3
,, 6th.	760,000	-	-	11,310,000	1027·2	6·6
,, 7th.	790,000	165,000	-	11,935,000	1027·3	6.3
,, 8th.	780,000	-	-	12,715,000	1027·2	6·8
,, 9th.	740,000	-	-	13,455,000	1027·3	6·7
,, 10th.	600,000	215,000	-	13,840,000	1027·2	6·9
,, 11th.	540,000	-	-	14,380,000	1027·3	6·9
,, 12th.	390,000	280,000	775,000	13,715,000	1027·0	7·2
,, 13th.	470,000	-	-	14,185,000	1027·1	7·1
,, 14th.	430,000	290,000	-	14,325,000	1027·0	7·3
,, 15th.	340,000	-	-	14,665,000	1027·2	7·3
,, 16th.	320,000	120,000	-	14,865,000	1027·4	7·5
,, 17th.	300,000	-	1,500,000	13,665,000	1027·2	7·2
,, 18th.	310,000	130,000	-	13,845,000	1027·1	7·4
,, 19th.	270,000	-	-	14,615,000	1026·9	7·0
,, 20th.	180,000	110,000	2,625,000	11,560,000	1027·0	6·8
,, 21st.	130,000	-	-	11,690,000	1027·2	6·9
,, 22nd.	-	-	-	11,690,000	1027·3	6·3
,, 23rd.	150,000	85,000	-	11,755,000	1027·2	7·1
,, 24th.	-	-	-	11,755,000	1027·0	7·3
,, 25th.	60,000	-	800,000	11,015,000	1027·4	7·2
,, 26th.	-	60,000	-	10,955,000	1027·0	7·4
,, 27th.	50,000	-	-	11,005,000	1027·3	7·5
,, 28th.	-	-	1,400,000	9,605,000	1027·1	7·1
,, 29th.	20,000	-	-	9,625,000	1027·0	7·6
,, 30th.	-	-	-	9,625,000	1027·3	7·3
May 1st.	-	85,000	1,400,000	8,140,000	1027·2	7·5
,, 2nd.	-	-	-	8,140,000	1027·4	7·6
,, 3rd.	-	-	1,200,000	6,940,000	1027·5	7·7
,, 4th.	-	55,000	-	6,885,000	1027·3	7·4
,, 5th.	-	-	1,100,000	5,785,000	1027·1	7·7
,, 6th.	-	40,000	-	5,745,000	1027·2	7·5
,, 7th.	-	-	-	5,745,000	1027·1	7·3
,, 8th.	-	-	1,200,000	4,545,000	1027·0	7·9
,, 9th.	-	20,000	-	4,525,000	1027·0	7·8
,, 10th.	-	-	900,000	3,625,000	1027·0	8·2
,, 11th.	-	35,000	-	3,590,000	1027·1	8·1
,, 12th.	-	-	1,200,000	2,390,000	1027·0	8·1
,, 13th.	-	-	-	2,390,000	1027·3	8·4
,, 14th.	-	-	-	2,390,000	1027·4	8·3
,, 15th.	-	20,000	1,100,000	1,270,000	1027·1	8·5
,, 16th.	-	-	-	1,270,000	1027·0	8·7
,, 17th.	-	-	-	1,270,000	1027·0	8·6
,, 18th.	-	-	-	1,270,000	1027·2	8·9
,, 19th.	-	-	1,270,000	-	1027·1	8·8

From the adjoining Table I., which shows the daily progress of the hatching work, it will be seen that the first collection of fecundated eggs was made on March 10th, or thirteen days after the first lot of fish were landed. The total number of eggs collected in the course of the season was 18,700,000, and of these 2,230,000, or not quite 12 per cent., were lost during the process of incubation. The remaining 16,470,000 were successfully hatched, and the larvæ transported to the upper part of Loch Fyne, where they were distributed at various places to the north-east of a line between Inveraray and the Poll Point. After heavy rains the salinity of the surface water in the upper part of the loch is often much reduced, and in such cases the fry were lowered down into water of a density of 1022·5 or more. The particulars in each case are shown in the subjoined Table II. :—

[Table.

TABLE II.

Showing the Physical Conditions under which the Fry were Planted in Loch Fyne.

Date.	Locality.	Surface. Density and Temp.	5 Fthms. Density and Temp.	20 Fthms. Density and Temp.	Tide.	Wind.	Number of Fry Planted.
April 12	Off St. Catherine's, ...	1022·5 / 7·8° C.	1025·6 / 7·7° C.	1026·6 / 7·7° C.	L.W.	Calm.	775,000
„ 17	Under Strone Point, ...	1023·5 / 8·4	1025·9 / 8·1	1026·1	3h. ebb.	N.E., force 1.	1,500,000
„ 20	Do., ...	1020·1 / 8·9	1024·8 / 8·5	1025·2 / 8·4	2h. ebb.	Varying.	2,625,000
„ 25	Off Poll Point, ...	1018·2 / 9·9	1025·2 / 9·0	1025·6 / 8·5	½h. flood.	Calm.	800,000
„ 28	Do., ...	1020·3 / 10·5	1024·3 / 10·0	1025·1 / 9·5	L.W.	E., force 3.	1,400,000
May 1	Off Dunderave Castle, ...	1023·0 / 8·9	1025·7 / 8·9	1025·1 / 9·5	3h. ebb.	N.E., force 1.	1,400,000
„ 3	Do., ...	1025·2 / 9·4	1026·4 / 9·9	1025·1 / 9·5	H.W.	Calm.	1,200,000
„ 5	Off Inveraray, ...	1025·6 / 9·4	1026·3 / 8·9	1026·4 / 8·9	4h. flood.	E., force 1.	1,100,000
„ 8	Between Strona Point and St. Catherine's,	1025·4 / 10·5	1025·5 / 10·5	1025·9 / 9·5	2h. flood.	N.E., force 1.	1,200,000
„ 10	Off Poll Point, ...	1025·6 / 10·5	1025·6 / 10·1	1026·5 / 10·1	1h. flood.	Calm.	900,000
„ 12	Do., ...	1025·8 / 9·0	1026·0 / 9·0	1026·2 / 9·5	L.W.	N., force 2.	1,200,000
„ 15	Off Strona Point, ...	1024·7 / 9·5	1025·9 / 9·3	1026·1 / 9·2	3h. ebb.	Calm.	1,100,000
„ 19	Off Inveraray, ...	1020·2 / 10·1	1024·3 / 10·0	1025·1 / 9·8	H.W.	N.E., force 2.	1,270,000

IX.—THE CLASSIFICATION OF THE FLAT-FISHES (*Heterosomata*). By H. M. Kyle, M.A., B.Sc., Science Scholar, St. Andrews. (Plates XI., XII.).

CONTENTS.

INTRODUCTION.

The present work was begun during the winter of 1898-99 at St. Andrews, was continued as time and opportunity permitted at Heligoland, later at the British Museum of Natural History, and at the Zoological Station at Naples. The opportunities thus afforded for the examination of material—both fresh and in spirit—were exceptional, and a much larger number of specimens and of species have passed through my hands than I had at first thought of or hoped for. I have to thank Prof. M'Intosh, F.R.S., of St. Andrews, and Prof. Heincke and Dr. Ehrenbaum of Heligoland, for the use of the Marine Laboratories at St. Andrews and Heligoland; Mr. Boulenger, F.R.S., especially for the kindness, encouragement, and aid I received whilst working at the British Museum of Natural History; also the British Association for the Advancement of Science, through the secretary, Prof. Howes, F.R.S., for the honour of occupying their Table at the Naples Marine Station; and the staff of the latter for much kindness and courtesy.

The species which have been examined include the majority of the European forms, representatives of the chief genera of the American flat-fishes, and of those of the Indian, China, and Australasian seas. In spite of the large number of species which has been examined, the number unexamined is very much larger, so that the present classification does not profess to be complete, but merely offers a certain outline into which the various groups fit, and displays in a manner easily grasped the gaps in our present knowledge of these forms. The origina aim was to trace out the natural affinities of the various sub families and the changes in their characters with geographical distribution, by the study of their internal structure as well as of their external characteristics. The results that have come to the surface, and perhaps one might say the "cream" of the work which has been done, are here gathered together into the present paper, and it is hoped—if the opportunity is given—to enter more in detail into the anatomy and development of the flat-fishes, and thence be able to eliminate the shortcomings of the present work, and give fuller descriptions of the specific and generic differences within the *Heterosomata*.

External Characters.

The great majority of the external characters—scales, coloration, fin-rays—are only of specific importance in the *Heterosomata*. These are characters which vary greatly and give rise to great difficulties even in the separation of species. Of somewhat greater value are the relative dimensions which are usually given of different parts of the body. These are also subject to great variation, and are in many cases useless and misleading. Yet if those dimensions are chosen which express the "form" of the species, and sufficient examples are measured, one can readily see that they should be of great value. For example, the "form" of the Plaice, Flounder, and Halibut cannot be mistaken for that of a Turbot, and neither for that of a Lemon-dab or a Sole. Apart from the general "form" the dimensions of parts, *e.g.* of the lengths of fins or of the mandible, the breadth of the interorbital space, and so on, are of no more than specific value.

The indefinite nature of the external form of the flat-fish is shared by various other characters which constitute the external appearance of the animal. They seem at first sight to be definite, even generic characters, and thus worthy of being ranked as important in a system of classification, but yet when examined more closely they seem capable of indefinite and indeterminable variation. One of these characters is the position which the eyes occupy, whether on the left or right side of the animal. By some writers (40) this character has been ranked as of generic importance, but most systematists have given it a subordinate rank. A great deal might be said for both sides. When we find that a character varies even within the limits of a species, as this one does for many species both of the European and American fauna, we are apt to regard it as useless for classificatory purposes. And yet if we omit these variable species we find that this character is constant and generic. Further, if we disregard what are evidently abnormalities, such as Turbots with arrested migration of the eye, we find that the variable species are transitional forms of some kind or other. This character is therefore employed as of great importance in the present classification. It aids to bring out the affinities of the different groups, and it will be shown how even the variable forms, when properly classified, serve the same purpose.

Another character of the same description is found in the position of the anterior extremity of the dorsal fin on the head. This was employed as generic by Günther and previous writers, but discarded by more recent systematists. Taken by itself, this character suffers from our inability to give it a clear definition, but when considered in its relation to the position of the nasal organ of the blind side, as will be done later, it is one of the most important characters. The reason for this is not far to seek. It is certain that the flat-fishes are descended from some type of round-fish, and in the latter the dorsal fin does not extend forward over the head. Hence the different degrees we find in the forward extension of this fin should mark the different stages in specialisation of the various groups of flat-fishes. Such, as we pass from the Halibut-group through the Plaice- and Turbot-groups to the Soles, is indeed the case, and the only difficulty in the way of employing this character is our inability to define properly the position of the anterior extremity of the fin. By employing the position of the nasal organ we obtain a character which is more easily expressed, although both characters, as will be shown later, must be taken together in measuring affinities.

The *size of the mouth* was another character considered by Günther as of even greater importance than the position of the anterior extremity of the dorsal fin, and which has also been degraded from this high importance by the American writers. It has, indeed, far less to recommend it than the former character. The Turbots and Halibut, for example, are grouped together by Günther under the wide-mouthed species, and separated from the Plaice and its allies as small-mouthed species. Such a classification very obviously distorts the real affinities, because in all other important characters the Plaice and Halibut groups come together and separate themselves widely from the Turbots. Nevertheless, if we disregarded all consideration of affinities, and endeavoured empirically to find those characteristics which displayed best the general resemblances and differences, this would be one of the characters chosen. It is of the most widespread general nature, and there are very few transitional forms between the wide-mouthed groups with teeth almost equally developed on both sides of the jaws, and the small-mouthed group with teeth more developed on the under sides of the jaws than on the upper. Jordan cites a transitional form (32, p. 285), but none have been seen by myself. Yet this character, for the reason stated above, can only be regarded as of secondary importance in tracing affinities. It is almost certain, for example, that the original primitive form was wide-mouthed, akin to a Gadoid. Shall we say, then, that the Turbot, which has retained this character but has altered in many others, is more nearly allied to the primitive form than the Plaice, which has altered in this character but retained the others? Even if it were a case of balancing the mere number of characters which had altered in these groups, we should decide that the Plaice-group was more akin to the primitive form, but the relative importance of the characters weighs in the same direction. The mouth is not on the same footing as, for example, the structure of the pectoral girdle, the position of the anterior extremity of the dorsal fin, or the structure of the olfactory organ. In the discussion of the various influences that affect the characters, and of the relative importance of characters, it will be shown how the Turbot-group is in reality more specialised and distant than the Plaice-group from the Halibut and thence the primitive stock.

The relative positions of the various bones which form the boundaries of the mouth—premaxilla, maxilla, and mandible—as well as the configuration of the bones which form the palatine and hyomandibular arches, are not exactly the same in the different groups, but how far the differences are generic, how far only specific adaptations, has not yet been determined. This is also the case with the bones forming the gill-covers and the hyoidean arch underneath. There are certain differences present, but they are overbalanced by the general resemblances. Externally, the differences with regard to the opercular bones are most marked in the Sole-group. In this the bones are thin and slender, and their contours are completely hidden by the thick overlying skin, whilst in the other groups the skin is relatively not so thick, and the contours are well marked. This difference, which can be correlated to the more sand-loving habits of the Soles, has been used by Jordan and other American writers to differentiate this group from the others. It is not the sort of character that the morphologist would lay stress upon, but its general nature makes it useful to the systematist. Accompanying it is another important characteristic of the Soles, namely, the almost universal development of a "snout" anterior to the mouth. This was employed by Günther, and the two characters taken together—signifying as they do a definite specialisation in habits—fitly mark the separation and distinctiveness of the Sole-group from the others.

Certain other external differences between the various groups will be considered under separate headings, because they accompany internal differences in organs and structures.

NASAL ORGAN.

The nasal organs show important differences in the various groups under consideration, even superficially. If the animals are regarded from in front, it will be at once remarked that the position of the nasal organ of the blind side relative to the anterior extremity of the dorsal fin is not the same in all the groups. These differences in position are related to the varying amounts of torsion which the organ of the blind side has undergone during the migration of the eye of that side.

In most species of the Halibut- and Citharus-groups the nasal organ of the blind side lies on the ridge of the head, *i.e.* on the median longitudinal line of the body, and directly in front of the anterior extremity of the dorsal fin (Plate XI., Fig. 2, l.n.o. and D). In these forms both sides of the mouth are equally and almost symmetrically developed, and the torsion of the head caused by the migration of the upper eye from the blind side has thus had the effect of turning the nasal organ through a right angle independently of the jaws, which have retained their original positions. The dorsal fin does not come so far forward in these as in the other groups, so that the position of the nasal organ has been determined almost solely by the migration of the upper eye. This conclusion is corroborated by what we find in the Lesser Halibut (*Platysomatichthys hippoglossoides*). In this, the jaws are as in the Halibut, but the left eye does not complete its wandering to the upper side. It rests on the ridge of the head, and associated with this the corresponding or left nasal organ remains on the blind side, although close to the ridge.

In the Plaice-group, the mouth is small, and the lower side is much more developed than the upper. There is thus a torsion of the mouth downward, and hence an apparently greater relative torsion of the left eye and, with it, of the left nasal organ upward, from the blind side towards the right or upper side. In reality, however, the nasal organ of the blind side is in almost exactly the same position as in the groups previously mentioned, *i.e.* it is on the median dorsal longitudinal line of the body (Plate XI., Fig. 1, l.n.o.). But the dorsal fin grows forward and inclines towards the blind side of the head as it approaches and passes alongside the eye of that side. The nasal organ of the blind side may therefore be said to be on the upper or eyed side of the dorsal fin (Fig. 1, D, and l.n.o.). In some cases, *e.g. P. cynoglossus*, the nasal organ in question lies obliquely on the ridge anterior to the dorsal fin.

In the Turbot-group the mouth is symmetrical as in the Halibut- and Citharus-groups. There is consequently no torsional influence from this side on the position of the upper or right nasal organ. Hence it is curious to find that, though the torsion of the eye seems to be more complete here than in the other groups, yet the nasal organ is not twisted round so far. This difference has arisen through the great development anteriorly of the dorsal fin. The early stages in development of several species of this group are fairly well known, and it has been repeatedly shown (19, 26, 45) that the dorsal fin grows forward ere the emigrating eye has had time to pass over the ridge of the head. In some cases the anterior extremity of the fin overhangs the eye as it passes the ridge; in other cases the eye seems to pass through the tissues of the base of the fin which has grown so far forward. It is not astonishing, therefore, that the dorsal fin should prevent the complete torsion of the nasal organ of the blind side, although it was not successful in barring the way to the eye. Hence we find that the nasal organ is on the blind side of the dorsal fin (Fig. 3, r.n.o. and D).

In the Sole-group we find a condition of things which almost seems anomalous. An examination of the skull shows that the distortion of the bones caused by the migration of the eye is quite as complete as in the other forms, yet the parts in connection with the lower nasal organ display no trace of this. Externally we see that the organ of the blind side is in its normal position (Fig. 4, l.n.o.), *i.e.* in a similar position to that of the eye side. It lies a little distance from the extremity of the snout above the maxillary portion of the mouth. This position of the nasal organ of the blind side—which is practically the same in all the species of Soleidæ examined—gives rise to a problem somewhat difficult of solution when we consider that the Soles are descended from one or perhaps two of the preceding groups. If the nasal organ of the blind side in those groups has been carried upward towards the ridge of the head, how has it come about that it remains in its original position in the Soleidæ? The position of the dorsal fin does not afford an explanation, because the development of the fin forwards in the earlier stages of the species whose development is known is just the same as in the Turbot-group. It may be that this organ begins to function very early, and that the underlying structures become disconnected from the parts which are affected by the migration of the eye. This is a problem, however, which can only be solved by a comparative study of the changes in structures that take place during the migration of the eye.

It has thus been shown that the position of the nasal organ of the under or blind side differs in the five groups mentioned. It is probable also that these respective positions will be the same for the species that still remain to be examined.

The position of the nasal organ of the blind side would thus appear to be a character of more than generic importance. In the first four groups its position depends upon the relation between the anterior extremity of the dorsal fin and the migrating eye. The utility of this organ is nevertheless probably equal in all, because the actual position on the head is not very different. And we thus have an example of an important difference arising in one character independently of utility on account of relative alterations in other characters. In the case of the Soleidæ the position of the organ in question is probably connected with its utility. This character is, however, of minor importance in comparison with differences in the internal structure of the nasal organ to be now described. These differences have been already noted by Bateson (6), but as he examined only a few species, it apparently did not occur to him that they were of great importance.

In the Halibut- and Plaice-groups it is found that the olfactory laminæ run parallel to the main axis of the body. The sensory epithelium is simple and comparatively slightly developed, the laminæ being but little raised from the level of the basal supporting membrane (Fig. 5, o.o.). In the Citharus- and Turbot-groups the epithelium is more developed and complex. The laminæ are arranged in the form of a rosette about a median rachis which runs parallel to the main axis of the body. The laminæ are therefore disposed transversely to this axis. In the Sole-group the olfactory organ is similar to that of the Turbot-group, but is not so distinctly rosette-shaped. The laminæ are arranged about a median rachis, but in the form of a leaf in many cases (Fig. 6, o.o.); in other cases the rachis extends the whole length of the underlying membrane, and the laminæ are arranged bilaterally along each side. In the genus *Solea* (Fig. 7) the rachis of the sensory epithelium lies transversely to the main axis of the body, but in other genera *(e.g. Cynoglossus)* the rachis is placed longitudinally, or slightly inclined to the longitudinal axis of the body. In the groups from the Australasian fauna, *Rhombosolea*, etc., and *Brachypleura*, the olfactory organ is similar to that of the Halibut- and Plaice-groups, that is the laminæ are arranged parallel to the longitudinal axis of the body.

These are the main features of the olfactory organ in the various groups of the *Heterosomata*. Sometimes, however, the epithelium is much degenerated and the number of laminæ reduced. In such cases, *e.g. Scophthalmus*, a reason can usually be found in the habits of species which have altered their sand-loving mode of life to some other where the organ of smell is not of such great necessity. The main features are sufficiently obvious, however, to render possible generalisations and thence a classification based upon this character.

With regard to the nasal sacs which have been described in a previous paper (34), it may be said here that they seem to be special adaptations and are of little importance for classificatory purposes. The nasal organ of the eyed side only need be considered, because that of the other side is distorted by its relationship to the dorsal fin, and the presence of one of the nasal sacs is often doubtful. For the former organ, however, the structures are quite clear. In the Turbot-, Plaice-, and Halibut-groups there are generally two nasal sacs attached to this organ (Figs. 5, 6; l.n s., r.n.s.). In the Sole-group only one is usually present (Fig. 7, n.s.). Exceptions occur in some of the groups, however, no sacs occurring in several forms, *e.g. Lepidorhombus, Pardachirus, Rhombosolea,* so that no very great importance can be attached to this character for the purposes of classification.

Pectoral Arch and Ventral Fins.

The arrangement of the bones of the pectoral arch in the *Heterosomata* corresponds to the general Acanthopterygian type. The arch is joined on to the skull by means of the *post-temporal* (p.t.) and the *supraclavicle* (s.c.). The post-temporal has two heads for articulation with the otic region of the skull (a and a_2, Fig. 18, Plate XII.), the upper being joined to the *epiotic*, the lower to the *pterotic*. Sometimes it appears as if this bone were formed from two separate ossifications, since it readily separates into two portions in the adult (Fig. 19, p.t. and p.t.), but this occurs very rarely. The *clavicle* (cl.) begins superiorly as a stout rounded bone, but gradually alters its form as it passes the line of attachment with the scapula and coracoid and becomes three-sided—two sides, external and internal, meeting in a prominent anterior ridge, whilst the third, facing posteriorly, is concave. This concavity is more marked in the Turbot-group than in the Plaice- and Halibut-groups, because it continues to the ventral extremity of the clavicle, whereas in the latter groups it gradually decreases until along the line of junction of the one *clavicle* with the other the bone presents only two surfaces, the one facing anteriorly, the other posteriorly. In the Turbot- and also the Sole-group the pectoral arch is more bent or curved anteriorly than in the Plaice and other groups (see Figs. 18, 19, and 20). This is noticeable externally in the forward curvature of the ventral extremity of the pectoral arch in the Turbot-group, and it is worthy of remark that Citharus (Fig. 21) approaches more nearly in this respect, as in many others, to the Plaice- and Halibut-type than to the Turbot (*cf.* Fig. 23). This curvature of the *clavicle* is connected with the position of the ventral fins.

From the inner face of the *clavicle* superiorly arises the *postclavicle*. This is not definitely fixed to the *clavicle* but lies loose in the dermis between the muscles and the skin. It extends posteriorly within the wall of the abdominal cavity as a whip-like bone (Fig. 19, p.c.), and probably has a similar function with regard to the abdominal wall that the battens in a lateen sail have to the sail. The *postclavicle* is present in the Plaice-, Halibut-, Citharus-, and Turbot-groups, but was not found in any of the species of Soleidæ examined. Cunningham in his "Treatise on the Sole" does not say whether this bone is present or absent.

Along the internal border of the posterior concave aspect of the *clavicle*, the plate of cartilage which gives rise to the *scapula* and *coracoid* is attached. The configuration of these two bones is very similar in all the groups. In the Turbot, only the central portion of the upper plate has become ossified to form the *scapula*. All around it is cartilaginous, even the "brachial ossicles" and the base of the pectoral fin. The degree of ossification is greater on the external surface of these bones, and is greater on the upper or eyed side of the body than on the under. In the Plaice- and Halibut-groups the *scapula* and *coracoid* are firmly ossified and fused together.

The *coracoid* extends downward in a long styliform process which is free and cartilaginous at its lower end. The relation of this process to the *clavicle* is sometimes of great importance in the classification of the Teleostei, but in very few groups of the flat-fishes was any great change noticed. Sometimes the styliform process is broadened out as in Citharus (Fig. 21) and the Soles (Fig. 24), sometimes it seems to be absent, and in a few species of Soles and in *Tephritis* it was found to be attached all along its edge to the *clavicle*.

The bones which have been mentioned do not display any differences that seem of importance for the purposes of classification, though presenting many variations in details. The case is different with the *pubic* bones and position of the ventral fins. The *pubic* arises from the lower posterior surface of the *clavicle*, and may be divided for the purpose of description into two portions. The portion leading down from the clavicle is club-shaped, and of very varying length in different species. It ends inferiorly in a sharp-pointed spine (s., Figs. 18, 19), which is of more frequent occurrence in the Plaice- and Halibut-groups than in the Turbot-group. From the lower third of this club-shaped bone arises anteriorly a thin triangular lamina (l.p.). Sometimes the difference between these two portions of the *pubic* bone is not well marked, as in the Sole-group and individual species of the other groups, but it is convenient to make the distinction. In addition to these two portions there is a third which takes the form of lateral wings near the line where the laminar portion arises. They are prominent in the Turbot (Fig. 19, s.p.), in the Plaice they are compressed alongside the laminar portion (Fig. 18, s.p.), but in many species they are quite absent. These minor differences are, however, insignificant in comparison with the changes in the position of the *pubic* bones relative to one another. In the Plaice- and Halibut-groups the *pubics* run parallel along their whole length. This is also the case in the Sole-group when the ventral fins are symmetrical. In the Turbot-group we find that the club-shaped portion of the *pubic* of the under or blind side tends to lie behind that of the upper or eyed side. In *Arnoglossus* (Fig. 23) the change is not so marked, but in the Megrim, Topknots, and Turbot the former lies completely behind the latter. In *Citharus* we have a transition to what is found in *Arnoglossus*, the club-shaped portion of the *pubic* bone of the eyed side being only slightly anterior to that of the blind side (Figs. 21 and 22).

These differences with regard to the position of the club-shaped portions of the *pubic* bones are accompanied by differences in the structure and position of the laminar portions. In the Plaice- and Halibut-groups these lie wholly behind the base of the *clavicles*, to which they are attached by a strong ligament. The ventral fins are attached to the bases of the laminar portions, and are directed posteriorly (Fig. 18). In the Citharus-group, we find a similar arrangement (Fig. 21), whether the ventral fins are symmetrical—as in *Paralichthys*, or asymmetrical—as in *Citharichthys*. When these fins are asymmetrical, the laminar portion of the *pubic* bone of the upper or eyed side is attached to the base of the *clavicles* (Fig. 21, v.l.). In the Sole-group when the ventral fins are symmetrical, the clavicles are short and do not extend to the ventral edge of the body. In this case the *pubics* are suspended from near their base, and the ventral fins, though posterior to the *clavicles*, have no direct connection thereto (Fig. 24). On the other hand, the Turbot-group, as already noted in the "*Scandinavian Fishes*" (p. 426), shows a remarkable difference from the above groups in this respect. Beginning with *Arnoglossus* (Fig. 23), we find that the laminar portion of the *pubic* bone of the eyed side is continued forward anteriorly beyond the base of the *clavicles* by a cartilaginous plate (V.l.). That of the blind side has no cartilaginous plate, and stops short at the base of the *clavicles* (V.r.) In the Turbots this cartilaginous plate is present on both *pubic* bones. These plates are closely and firmly approximated to one another on their inner surfaces, and both extend beyond the base of the *clavicles* as far as the anterior extremity of the lower prong of the *urohyal* (Fig. 19, u.). According to the description in the work cited, this cartilaginous plate is a part of the triangularly-shaped laminar portion of the *pubic*. This is not exactly the case, however. The cartilage is surrounded by an outer hard layer, but one can readily detect its line of fusion with the osseous *pubic* (Fig. 19, c.V. and l.p.). The rays of the ventral fins arise from the ventral edge of the cartilaginous plates, and are thus morphologically distinct from those of the previous groups. These plates further have no attachment to the clavicles, and depend solely from the pubics and *urohyal*.*

The presence of these plates of cartilage affords a prolonged base of attachment for the fin-rays, and we consequently find that in this case the ventral fin-rays are more spread out and thicker than in the groups where the cartilage is absent.

When only one cartilaginous plate is developed, the ventral fin of that side is prolonged anteriorly much in advance of that of the other side. When both plates are developed, the rays of the one fin alternate with those of the other fin, as in the Turbot. The fin which is anterior is generally that of the upper or eyed side, but according to the American writers the reverse is the case in *Hemirhombus* (*Syacium*).

These differences of internal structure in the various groups show themselves in marked differences externally. In the Plaice- and Halibut-groups, as also in the genus *Solea*, the ventral fins are symmetrical with regard to one another and to the ventral line of the body. In the Turbot-group they are clearly asymmetrical. In *Citharus*, with its allies *Citharichthys* and *Hemirhombus*, the ventral fins are also asymmetrical, but it is necessary to note an important difference between this asymmetry and that of the Turbot. In the former the cartilaginous plate is absent and the fins are both behind the base of the *clavicles* (Fg. 21), in the latter the reverse is the case. The ventral fins in these two groups are therefore morphologically distinct in spite of the asymmetry being present in both, and this important difference gives a means of forming a new sub-family of the flat-fishes with *Citharus* as the type.

* Cunningham (9) has proposed to call this bone *jugular*, because of its remote position from that usually occupied by the *urohyal*. Although its form and position are not the same, yet its relationships are similar—in that it is a median bone in line posteriorly with the *glossohyal*, forming the isthmus between the branchial cavities and connecting the pectoral arch with the hyoid bones. One is therefore justified in calling it the *urohyal*.

The bone in front of the clavicle to which the laminal cartilage of the ventral fins in the Turbot-group is attached requires special mention, as it seems to have a special importance in the flat-fishes. Its form is that of a two-pronged fork, the base of which rests on the *clavicle*, the upper prong passing forward into the substance of the tongue, and the lower shorter fork bending obliquely downward and forward. In the Turbot-group this latter prong is directly connected with the ventral fins, in the other groups mentioned above it has no such connection, but a ligament passes from its end to the end of the *clavicle* and thence to the base of the ventral fin. It would seem to have an important physiological significance, more especially in the Turbot-group, where the bone is larger than in the other groups. It acts as a lever, the clavicle acting as fulcrum, so that any movement of the fins which affects the lower prong will also affect the upper, and thence also the tongue and branchiostegal apparatus, the size of the mouth being thus affected. It is interesting to note further that in the specialised rhomboid-forms, the Topknots, the ventral fins are relatively nearer the mouth than in the other forms, and this is connected with the more anterior position of the *pubic* bone (Fig. 20). The habits of these forms are also specialised, for, as shown by Cunningham and others, these fish swim, or rather hang suspended in a vertical position, amongst the seaweed or rocks, and may use the ventral fins to keep themselves in position.

Vertebral Column and Alimentary Canal.

The formation and arrangement of the vertebræ and vertebral processes furnish important evidence of affinities within the various groups of flat-fishes, much more so than in the round-fishes. The vertebræ are divided into two classes—abdominal and caudal, the differences between which are generally well marked. The former possess certain processes projecting laterally and ventrally on each side, and called *parapophyses* by Günther, to which primary and secondary ribs are attached. In the caudal region the *parapophyses* have joined ventrally to form the *hæmapophyses*, which resemble greatly the *neurapophyses*. According to Günther, the abdominal region ends and the caudal region begins with the first vertebra bearing the hæmapophyses.

This distinction between the vertebræ applies generally amongst the round-fishes, and also in the least specialised of the flat-fishes, *i.e.* in the Halibut- and Plaice-groups. The abdominal vertebra, in addition to the neurapophyses, is provided with ventrally projecting parapophyses, to which are attached the primary (*cf.* Fig. 11, p.r.) and secondary ribs (s.r.). The secondary ribs are short, and arise from the anterior vertebræ. The primary ribs are long, and extend posteriorly and ventrally, those of the posterior abdominal vertebræ reaching as far as the first interhæmal spine. This spine lies along the anterior surface of the first hæmal process, and thus corresponds to the beginning of the caudal vertebræ. These latter have the ordinary structure, and are usually provided with more or less prominent transverse processes.

A similar disposition of the vertebræ is found in the Turbot, but its other characters show this form to be highly specialised, and it is probable that this disposition has arisen secondarily, *i.e.* has reappeared after passing through a certain transitional stage. The reason for this statement is that the forms which stand between the Turbot and the most primitive group of flat-fishes have a different arrangement of the vertebræ. In these, *Citharus*, *Arnoglossus*, and *Rhomboidichthys*, the last three to six abdominal vertebræ bear short hæmapophyses and transverse processes (Fig. 11), which replace the parapophyses and primary ribs. The secondary ribs arise from the transverse processes or the neural arches. Beginning from the second abdominal vertebra—sometimes they appear to be present on the first, they arise from the neural arches, then their points of origin pass on to the centrum, until on the seventh or eighth vertebra they arise from transverse processes which are placed more to the ventral than dorsal surface of the vertebra. In *Citharus*, the secondary ribs are continued on to the caudal vertebræ. This disposition of the vertebræ was remarked by Costa (8) in *Rhomboidichthys*, and he classified them into three—*cervical*, *dorsal*, and *caudal*, by analogy with the terms employed for higher vertebrates. These terms are obviously misleading, because we should then have ribs on the *cervical* vertebræ, and it is better to call the vertebræ which form the dorsal wall of the abdominal cavity abdominal, and to subdivide them when necessary into those with hæmapophyses and those without.

According to Günther's definition (21), the caudal region would begin with the first vertebra which bears the hæmapophyses. According to this the abdominal cavity in the above species would be limited to the first four to six vertebræ from the skull, whereas it is in reality prolonged much further back. A better sign of the delimitation of the abdominal cavity and of the commencement of the caudal vertebræ in the above species, as in the groups previously mentioned, is the first interhæmal spine. This is large, and forms the posterior boundary of the abdominal cavity.

Arnoglossus and *Rhomboidichthys* form a good example of the value of this character for classification. Formerly these were separated from one another, and *Arnoglossus* was considered to be more closely related to *Lepidorhombus* (13). More recently (50) the latter has been placed along with the Topknots, and the two former brought close together under one genus (*Platophrys*), in spite of the great external differences between them. As mentioned above, *Arnoglossus* and *Rhomboidichthys* have a similar arrangement of the vertebræ. *Lepidorhombus*, on the other hand, is like the Turbot and Topknots in this character, and is therefore widely removed from the two former. In another important character, viz. the ventral fins, *Arnoglossus* and *Rhomboidichthys* are also connected and different from the other genera of the Turbot-group, so that their characters are very clear and definite.

The arrangement of the vertebræ which is found exceptionally in the Turbot-group becomes the rule in the Sole-group. Both in the *Cynoglossinæ* and the true Soles, all the species examined showed the *hæmapophyses* in the abdominal vertebræ. These *hæmapophyses* are relatively much shorter than those of the caudal vertebræ, and in *Solea* (Fig. 9) there is a gradual transition from the one to the other.

In addition to the differences in the formation of the abdominal vertebræ in the various groups, there are also important differences in other characters connected with the abdominal cavity. The first interhæmal spine which forms its posterior boundary is large and strong in the Plaice- and Halibut-groups, extending in a groove along the first spine almost to the centrum of the first caudal vertebra. The outer end of this spine is very sharp, and may even project through the skin. This character—the presence of an "anal spine"—is employed by Günther and the American writers as a specific character, but the appearance of the spine externally may depend greatly on the condition of the specimen. Thus Günther declares that there is no anal spine in the Long Rough Dab (*D. platessoides*), whereas the American writers say there is. The latter again declare that *P. cynoglossus* has an anal spine, whilst *P. microcephalus* lacks it, and both they and Günther state that there is no anal spine in the Halibut. As a matter of fact the first interhæmal spine is strong and well developed in all these species, and the appearance of the outer point externally cannot be relied upon.

In the Citharus- and Turbot-groups the first interhæmal spine is also large and well developed (Fig. 8), but in *Rhomboidichthys* it extends only half-way along the hæmal spine, and in *Citharus* but a little further. The outer end of the interhæmal spine, however, lies some distance within the skin, and is continued forward by partly ossified plates of cartilage (Fig. 8, c.), from the ventral edge of which the interspinous rays arise which support the anterior rays of the anal fin. There can be no chance, therefore, of an "anal spine" appearing externally. In the Sole-group (Fig. 9, i.s.) the first interhæmal spine is much reduced, and arises from near the end of the first hæmal spine. In place of the one interhæmal spine of the previous groups, in the Sole-group there are four or five. These are not prominent externally, and thus present no anal spine.

The remaining groups of the flat-fishes, those of the Australasian fauna, have not yet been so carefully examined with regard to these characters. In *Rhombosolea* and *Brachypleura* the arrangement of the various structures is the same as in the Sole-group; the last four to six abdominal vertebræ bear hæmapophyses, and the first interhæmal spine is slender and little developed. It is most probable that this arrangement is the same in the other forms, *Ammotretis* and *Peltorhamphus*, because the external configuration of the abdominal cavity is similar.

It appears, therefore, that the presence of hæmapophyses on the abdominal vertebræ is a valuable character for displaying affinities. These are found universally amongst the Soleidæ, and in certain genera of neighbouring groups. From their presence in the latter we may conclude that these genera have a certain relation to the Soleidæ closer than that possessed by the remaining genera of the same groups.

An example has already been given of the utility of this for purposes of classification. When more genera of the Citharus-group have been examined, this character may again be of use in aiding to subdivide this group. It also aids in differentiating the group of flat-fishes in the Australasian fauna from the Plaice-, Halibut-, and Turbot-groups within which they were formerly placed.

With regard to the *alimentary canal*, the differences found in the various groups are connected with two characters: the intestine—its increase or decrease in length, and the pyloric cæca—their presence or absence. The increase in length of the intestine is chiefly well-marked in the Sole-group and in one or two forms which in some way resemble the Soles, *e.g.* the Lemon-sole *(P. microcephalus)*. In these, two to four coils of the intestine lie along the interhæmal spines of the eyed side, within the secondary body-cavity, which contains also the reproductive organ of that side. This occurs in many other forms, *e.g. Rhomboidichthys*, Plaice, etc., but not to the same extent, the intestine merely projecting into the second body-cavity. It may be that the projection of the intestine into the latter cavity has the advantage of protecting the kidney from injury. In the Sole-group, for example, owing to the presence of *hæmapophyses* on the posterior abdominal vertebræ, the primary abdominal cavity is very small, and some compensation for this is therefore necessary. In the Lemon-sole, although *hæmapophyses* are not present on the abdominal vertebræ, the increase in length of the intestine alone has rendered it necessary apparently to have more room than the primary abdominal cavity can give. On the other hand, this compensation may be obtained by the reduction in length of the intestine. Such is found in *Citharus*, for example, where the posterior abdominal vertebrae bear *hæmapophyses*, but where the intestine is very short.

As an additional protection to the kidney in *Citharus*, we find that the primary ribs of the abdominal vertebræ anterior to those bearing *hæmapophyses* are prolonged greatly posteriorly and ventrally over the *hæmapophyses* and enclose the kidney.

This character very evidently marks a specialisation in structure and habits and cannot be used in classification. Such is the case also with the pyloric cæca. As mentioned by Sagemehl, these vary in a strange and at present unaccounted-for manner even in such as the Clupeidæ and Salmonidæ. In the *Heterosomata* four seems to be the maximum number, but there may be none at all. In the Plaice-group, two, three, or four may be present; four are found in the Halibut, *Rhomboidichthys*, and *Pseudorhombus*; whilst none are found in *Psettodes*, *Rhombosolea*, and possibly many more. *P. cynoglossus*, on the other hand, is similar to the Plaice in this respect. The only group in which this character seems to be constant is that of the Soles, and here there are none at all. As these cæca are in most cases small it is sometimes difficult to say whether slight protuberances or swellings on the intestine are worthy to be called cæca or not, and this occurs in *Citharichthys*, *Parophrys*, *Brachypleura*, and possibly many more. These seem to represent the transition-stages between the presence and absence of the cæca.

Hypural Elements.

The terms by which the bones of the posterior region of the vertebral column are described have been fixed by Huxley (25). The broad fan-shaped bone continuous with the vertebral column is the *hypural* bone (hy.^{1}, Figs. 13-16). Dorsal and ventral to this are two bones which are very similar in appearance, but very dissimilar in their relation to other structures. The dorsal wedge-shaped bone has developed in connection with the *urostyle*, the ossification which supersedes the termination of the notochord, and is dorsal to it, as is shown clearly in the case of the Sole (Fig. 16). Hence this should be called the *epiural*, according to Huxley's terminology. The ventral wedge-shaped bone has no such relations, however, and is not dignified by any other name than *hypural*, but in order to distinguish it from the above it may be called the *second hypural* (hy.^{2}). The relationships of these bones to one another, and to the spines of the second-last vertebra, are not always the same in the various groups of flat-fishes. The fan-shaped hypural bone in the adult is divided into two portions which may be quite separate from one another, but are as a rule joined by a thin connecting layer of bone. The mark of division is not quite in the median line, but inclines slightly downwards, so that the ventral portion is smaller than the dorsal. The distal end is marked by furrows and ridges—the latter being in line with the caudal fin-rays, whilst the furrows pass backward towards the centrum of the last vertebra to a varying extent, some going almost the whole length, others only a little way. The furrows are ossified superficially only, the internal structure being cartilaginous, so that a large amount of flexure is possible. The second hypural and the epiural are similarly furrowed.

The number of ridges and furrows varies, of course, in the different species, but if only the Plaice-, Halibut-, Citharus-, and Turbot-groups be considered, it will be seen that there is no essential difference between them. According to Sauvage (47), three types or three forms of hypural structures were to be found in the flat-fishes—the one, Plaice- or Pleuronectid-type, in which the hypural bones were completely ossified; another, Turbot-type, in which the hypural bones were divided into separate rays to support the caudal fin-rays; and a third type, in the

Soles, in which the rays were only partially united. It was remarked by him also that the appearance of the flat-fishes in the geological records corresponded with these differences. The Turbot-group with free supporting rays appears first in the Tertiary period, the Solea next, whilst the Plaice-group is essentially modern. Such a correspondence would be of great interest, suggesting, as was pointed out by Sauvage, the possible lines of descent; but it does not seem possible to retain the distinctions made. All the species of the Turbot-group which have been examined resembled those of the Plaice- and Halibut-groups in having the hypurals as ossified plates and not composed of separate rays. In some cases, indeed, *e.g.* the Turbot itself (Fig. 14), the hypurals and epiural are fused into one piece, where ordinarily they are divided into three (Fig. 13, ep., $hy.^1$, $hy.^2$). When dried specimens are examined, however, the ossification along the furrows shrinks considerably, because the internal tissue is cartilaginous along these lines, and the ridges become more prominent. The only explanation, therefore, of the facts described by Sauvage is that he has examined dried specimens of the Turbot, and possibly spirit or fresh specimens of the other species. These furrows contract within a few hours, if left to dry, and also in spirit to a certain extent, so that it is advisable to make comparisons with specimens which are under similar conditions.

The bones composing the element supporting the caudal fin-rays are made up chiefly by the three already mentioned, but two or even three others may also take part. The neural and hæmal spines of the second-last vertebra aid invariably in the groups mentioned in supporting the caudal fin-rays. Sometimes they seem to be furrowed like the hypurals, but this has probably arisen from the fusion of a separate and secondary ossification with the true spine, as shown in the drawings of Soles and Turbot (Figs. 14 and 15). Sometimes the hæmal—but not the neural—spine of the third-last vertebra also develops so far posteriorly as to support the first ray of the caudal fin on the ventral side. The extra development of this spine over that of the corresponding dorsal makes up for the greater relative development of the dorsal half of the fan-shaped hypural, and makes the number of fin-rays equal on both sides of the median line.

The basal elements of the caudal fin are thus essentially the same in the Plaice-, Halibut-, Citharus-, and Turbot-groups, and this might have been expected beforehand from a survey of the other parts of the skeleton. In comparison with the Soles, the skull and body-skeleton of these groups are massive, and the movements and habits of the animals consequently require a strong and powerful tail, and thus a strong supporting structure. In the case of the Soles, the skeleton is not so massive, nor do the animals grow to the same size as in the other groups. We thus find in them a transition to a totally different type of structure. In the true Soles (Fig. 15) there is little apparent difference superficially from the Turbot and other groups. The hypurals are marked by furrows and ridges, and the spines of the second and third last vertebræ also take part in supporting the caudal fin-rays. But the urostyle (Fig. 15, u.) remains short and distinguishable from the epiural, whereas in the previous forms it was indistinguishable. This decrease in size of the urostyle becomes greater in the more specialised genera of the Sole-group, and is accompanied by a reduction in the hypural bones, until in the most specialised, as in *Ammopleurops* (Fig. 17) and *Cynoglossus*, we obtain a semblance of the diphycercal tail. How this change has taken place—whether the posterior vertebræ in such as *Ammopleurops* (Fig. 17) are not really homologous to vertebræ, but have arisen from modifications of the hypural elements, or whether the primitive notochord proceeds to the extremity of the caudal region as in the true diphycereal tail—it is impossible to say until the developmental stages are examined. If the former were the case, however, we should expect to find some evidence of the urostyle amongst the posterior vertebræ, but there is no trace of it. Hence we should be inclined to believe that the true form of the diphycercal tail reappears again through convergency. The gradual transformation which is undergone by the urostyle is evidence for this view. Only one stage is here represented, that in Soles (Fig. 15, u.), but an analogous phenomenon is found amongst the eels. Ryder (46), in his treatise on this subject, gives a drawing (Plate IV., Fig. 4) of the caudal region of the Common Eel, which might well represent a further stage in the specialisation of the flat-fishes to that shown here in Soles. The end of the notochord is only slightly bent up, and is almost in line with the other vertebræ. The diphycercal form is obtained further in *Murœna*, which may be compared with *Ammopleurops* and *Cynoglossus* amongst the flat-fishes. It is possible, therefore, that we should call the last degree of specialisation in these fishes the true diphycercal form, and not "pseudodiphycercal" as was formerly suggested.

The development of the caudal region in the flat-fishes has been described by Agassiz (4), M'Intosh and Prince (38), and other writers, but for somewhat earlier stages than those required for the present purpose. It seems clear, however, that Cunningham's view that the hypural bone represents the ventral spines of a number of vertebræ fused together (9, p. 39) is quite erroneous, and that the conclusions of Huxley (28) and Ryder (46) for other forms hold good also for the flat-fishes. In Fig. 16 is shown a drawing of the posterior caudal region of a post-larval Sole 13mm. in length. The hypural elements which later develop into the fan-shaped bone (Fig. 15, hy.[1]) are not yet fused together, but appear as four separate and distinct plates. Their form and position show that they rather correspond to interspinous elements than to hæmal spines. Inasmuch as they fuse later, however, to the base of the urostyle, and support distally the caudal fin-rays, we may accept Huxley's conclusion that they are really composed of both hæmal and interhæmal elements.

From the foregoing description of the caudal region it will be concluded that the diverse forms and changes in structure which are found amongst the flat-fishes may be of use as showing various stages in specialisation, and thus of showing affinities between species in certain groups, but do not aid in the general work of classification, as was imagined by Sauvage. Only with the Soleidœ do they become of such use, because in the other groups the form and structure of the caudal region are essentially the same, and even in the Soleidœ so little is yet known of the intermediate stages between the true Soles and such as Cynoglossus that no classification based on this character could be proposed.

Characters of Most Importance for Classification.

We may once again pass under review briefly the characters which have just been described, in order to consider their respective merits for the purposes of classification. Only those which gave promise of being of importance have been mentioned here, and the choice of characters is therefore not a large one. In a work such as this, further, which endeavours to group the various genera according to their natural affinities, it is self-evident that not one character alone but several must be chosen. So long as the number of species known was relatively small, and classifiers wished to have some external character or characters which would enable them to locate readily any new specimen which came to hand, a classification based on one character was for the most part sufficient and satisfactory. The aim of the classifier was then to find out that external character which most clearly marked off one group consisting of many species and genera from another such group, and it has already been mentioned that no wider-reaching or more general external character could have been found for the separation of the *Heterosomata* into groups than that chosen by Günther, namely, the size and structure of the mouth. Even this, however, shows the weakness of a one-character classification, because the Soles had to be left to one side as an ill-defined heterogeneous group containing both small- and large-mouthed species. Other similar classifications suffer from similar defects. The best classification of the *Heterosomata* hitherto—that, namely, of Jordan and his collaborators—chooses the symmetrical or asymmetrical position of the ventral fins with respect to the median ventral line of the body as the chief character differentiating the Turbot- from the Halibut- and Plaice-groups. But it has already been shown in this paper, and it will be referred to again later when discussing the various groups, how this external difference — viz., symmetry or asymmetry—depends upon certain differences in the arrangement of the underlying structures, and how there are various intermediate stages from the one arrangement to the other ; so that a form, *e.g. Citharus*,* may have the ventral fins slightly asymmetrical and yet be more nearly related to the symmetrical group of flat-fishes. Hence, even with this character, we soon stumble upon difficulties. The Plaice- and Halibut-groups are certainly well marked off from the Turbot- and all three from the Sole-group by its means, but a difficulty arises when we wish to find the limit between the Halibut- and Turbot-groups. All intermediate stages from the symmetrical condition of the Halibut- to the asymmetrical of the Turbot-group are present, and we should be quite at a loss in fixing the limit between them, even though the representative species in the intermediate stages are few in number, if we could not call in the aid of another character. This further character is the form and structure of the olfactory epithelium. By means of this character the Halibut-group is even more sharply divided from the Turbot-group than by the former, and it is found that the intermediate stages between these two groups, though more nearly related to the Halibut than to the Turbot in regard to the structure and position of the ventral fins, have the same type of olfactory organ as the Turbot. The genera possessing the combination of these two characters are consequently separated from both the Halibut- and Turbot-groups and placed in an intermediate sub-family.

It might be thought that the structure of the olfactory organ was a character of greater importance than the position of the ventral fins for the purposes of classification. Such is not the case, however. There are in reality only two types of olfactory organ—the one with the sensory epithelium arranged linearly in longitudinal lamellæ, the other with this epithelium in the form of a rosette. The different forms which are found in the Soleidœ are but varieties of the latter type. Hence, if we choose this as the chief character, we shall he obliged to classify the *Heterosomata* into two sharply-divided groups, each of which contains a number of genera at some distance from their natural allies. This will be displayed in more detail when the characters of the various groups are considered with regard to their distribution. It may be mentioned, further, that the sensory epithelium of the olfactory organ

*Even in *Paralichthys*, which has a close superficial resemblance to the Halibut, the ventral fins are not exactly symmetrical, thus furnishing an additional reason for grouping this genus with *Citharus*, *vide* pp. 354-356.

shows a tendency to degenerate in several species and genera, *e.g.* *Scophthalmus*, so that this character cannot always be relied upon with certainty.

Similar difficulties arise with the other characters which have been described. Each by itself is able to give some sort of classification, but the genera are then arranged merely according to their resemblance with respect to these characters and not necessarily according to their natural affinities. Thus we should obtain different combinations of the *Heterosomata* if we arranged the various genera according to the size and structure of the mouth, or according to the structure of the abdominal or of the last caudal vertebræ, and so on, just as the classifiers of the *Heterosomata* hitherto have done, and one combination would be as good as the others. Each of these characters would divide the *Heterosomata* into two or three large groups, but the lines of division would differ in the different combinations. They are too general, making no allowance for the results of convergency, and do not permit of fine transitional stages being displayed. When, however, they are taken along with the two characters which have been mentioned above, the position of the ventral fins, and the structure of the olfactory organ, they furnish important evidence for the further division of the various groups.

Apart from the particular problems which arise in endeavouring to fix the details of each group, and which will be considered later, there are still a few general questions to be answered. It has been shown repeatedly that what is best for the purposes of classification is not necessarily the best for showing natural affinities, and the question thence arises—Can any classification truly represent the natural affinities of the species classified? In theory the answer is simple, because the classification that will receive the most respect is the one which displays in a simple and natural manner the groupings of the various species as we find them in nature. In practice, however, there are certain unwritten laws according to which a classification should be formed. It should be clear, not cumbered with too many details, and such that any specimen examined may be readily located. Such have been the prevalent notions hitherto, and a conflict thence arises between practical expediency and theoretical correctness. Recent opinion, however, as shown in the work of the American writers, has tended strongly in favour of the latter. The work of Jordan and his collaborators has shown clearly in its various developmental phases that, after all, several different classifications would suit the demands of practical expediency, and the chief value of their last great work (33), for the *Heterosomata* at any rate, is that it has passed beyond this stage and really endeavours to display the natural affinities of the various species, genera, and groups.

The second and more serious question that then arises is whether the characters presented to us—such as have been described here—are really capable of displaying affinities. In these days of the study of variations, when the older notions of the value and fixity of heredity are being rudely shaken, we are not inclined to believe in the permanence, or even comparative permanence, of any character whatsoever. May not, then, the complex condition of things in the environment with the flexible nature of habits have so reacted on the plastic structures that all the lines of genetic relationship are woven round and round inextricably into the form of a net or huge tangle, and any chance of finding a "phylogenetic tree" thereby rendered hopeless? In the case of a large group of animals, such as the Fishes as a whole, or of the *Teleostomi*, one might assent to this, and agree also with Sagemehl that even for a small group, such as the Siluridæ and their nearest allies, only those characters which were out of the common, *e.g.* the Weberian ossicles, or those which were little employed and were thus little acted upon by the strong hand of the environment, such as the bones of the pectoral arch, could be relied upon in the least to show genetic affinities. Nevertheless, there is good reason for believing that the flat-fishes form a favoured group. As a whole they are well marked off from all other groups of the Teleostei, even from the Gadidæ, to which they are supposed to be most nearly related, and this sharp demarcation displays a fact which is very evident throughout—viz., that the group is specialised from the very beginning. The habits and habitat of the species included under it are also peculiar and in certain ways quite uniform throughout the group. We should expect, therefore, that this uniformity will display itself in a certain amount of constancy in the characters, and that if these latter change they will do so in accordance with certain well-marked differences in the surrounding physical conditions, or to greater specialisation of habits and habitat. The former element is shown in the geographical distribution of the characters of the various sub-groups or families; the latter, in these characters also to a certain extent, but more especially in those of the species within the separate sub-groups or families. It follows from this that a classification of the flat-fishes, if it is intended to represent the genetic affinities of the various divisions, should display, along with the characters, their distribution generally and their varying degrees of specialisation. This, in truth, seems possible for the *Heterosomata*, and in the following pages the endeavour is made to show in general outlines how such a classification may be realised. The influence of convergency can also be seen in the various groups, but only the more general and outstanding examples need be mentioned.

Classification of the *Heterosomata*.

Families.

a. Preopercular margin more or less distinct, not hidden by the skin and scales of the head.

Pleuronectidæ.

α. *Hippoglossinæ* (Halibut-tribe).
β. *Pleuronectinæ* (Flounder-tribe).
γ. *Psettinæ* (= *Bothinæ*) (Turbot-tribe).

aa. Preopercular margin aduate, hidden by the skin and scales of the head.

Soleidæ.

α. *Achirinæ* (American Soles).
β. *Soleinæ* (European Soles).
γ. *Cynoglossinæ*.

The above classification, with slight modifications, is taken from the recent work of Jordan and Evermann (33). It is the most convenient at the present time for grouping together the flat-fishes as a whole, but one feels already that it is too definite and cramping to express well the relationships of the various groups to one another. It is premature, for much yet requires to be known, to endeavour to substitute this scheme by another, but it is thought advisable to present the various groups in the following loose arrangement, which has the double advantage of displaying affinities, and at the same time of showing the gaps in our knowledge.

Families.	*Sub-families.*
Pleuronectidæ	*Hippoglossinæ.* *Pleuronectinæ.* *Hippoglosso-rhombinæ.* *Rhombinæ.*
Soleidæ -	*Soleinæ.* *Achirinæ.* *Cynoglossinæ.*

Solei-pleuronectinæ.

Incertæ sedis?

Sub-Fam. *Hippoglossinæ.*

(1) Preopercular margin distinct, not hidden by the skin and scales of the head.
(2) Olfactory laminæ arranged longitudinally with median rachis.
(3) Ventral fins placed symmetrically about ventral line of body, the pubic bones being wholly behind the base of the clavicles and connected thereto by a ligament.
(4) Nasal organ of blind side lies anterior to the anterior extremity of the dorsal fin on the ridge of the head.
(5) Mouth nearly symmetrical, the dentition nearly equally developed on both sides; gape large; lower jaw most prominent.
(6) Eyes on right side, large.

This sub-family, restricted by the above characters, includes the following genera :—

Species Examined.	*Genus.*	*Distribution.*
A. stomias	Atheresthes, Jordan and Gilbert.	Bering Sea to San Francisco.
P. hippoglossoides . .	Platysomatichthys, Bl.	Arctic parts of the Atlantic.
H. vulgaris . . .	Hippoglossus, Fl.	North Atlantic and North Pacific
(?)	Lyopsetta, Jordan & Goss.	California and North Pacific.
(?)	Eopsetta, "	California and North Pacific.
D. elassodon . . *D. platessoides* .	Drepanopsetta, Gill.	North Atlantic and North Pacific
P. melanostictus . .	Psettichthys, Girard.	Pacific coasts of North America.
	Verasper, Jordan & Gilbert.	Japan.
(?)	Hippoglossina, Steindachner	Pacific Coast — California to Mexico.
(?)	Lioglossina, Gilbert.	California
(?)	Xystreurys, Jordan and Gilbert.	South California.

The last three genera are placed as doubtful because they may belong to the family of the Hippoglosso-rhombinæ. They are said by Jordan to be closely related to *Paralichthys*, and this, along with their southerly distribution, their tendency to be either sinistral or dextral—a characteristic of the Hippoglosso-rhombinœ—raises the doubt as to whether they should be grouped with the Hippoglossinæ or with the latter group. It is possible, also, that *Verasper* should accompany the other three genera.

This family includes *Atheresthes* and *Platysomatichthys*, which are generally believed to be more closely related to the primitive ancestors of the *Heterosomata* than any of the other species. The evidence on which this is based rests almost entirely on the position of the left eye, *i.e.* the eye of the blind side, which is on the ridge of the head, looking almost vertically upwards. This position, which appears to be the normal one, recalls the abnormal specimens of other species with arrested migration of the eye of the blind side which are sometimes found, *e.g.* Turbot. Whether these two species are in reality the nearest modern representatives to the primitive ancestors, or whether they are specialisations just as *Cynoglossus* of the Soleinæ is a specialisation at the other extreme, it is impossible to say. In the present paper, however, it is assumed that they are the most primitive forms, and hence the Hippoglossinæ form the earliest or first family of the *Heterosomata.*

The distribution of the various genera here included under the Hippoglossinæ is noteworthy. They all belong to the Arctic and northern portions of the temperate regions.

Sub-Fam. *Pleuronectinæ.*

(1), (2), (3), as in Hippoglossinæ.

(4) The anterior extremity of the dorsal fin is inclined towards the blind side of the head, and lies posterior to the nasal organ of that side, which is (usually) on the ridge of the head.

(5) Mouth unsymmetrical, dentition more developed on blind side; gape small; under jaw more prominent.

(6) Eyes on right side as a rule, large.

The following genera are included under this sub-family :—

Species Examined.	*Genus.*	*Distribution.*
P. cornuta	Parophrys, Gtr.	North America and Japan.
	Pleuronichthys, Girard.	North Pacific.
(?)	Inopsetta, Jordan and Goss.	Pacific coasts of North America.
(?)	Isopsetta, Lockington.	Pacific coasts of North America.
Lepidopsetta bilineata	Lepidopsetta, Gill.	Pacific coasts of North America.
L. limanda, *L. aspera*	Limanda, Gottsche.	North Atlantic and North Pacific.
(?)	Liopsetta, Gill.	North Atlantic and North Pacific (American).
Platichthys stellatus	Platichthys, Girard.	North Pacific.
P, flesus, *P. platessa*, *P. microcephalus*, *P. cynoglossus*	Pleuronectes, L.	North Atlantic and North Pacific.

Various other genera are included by Jordan within this family, but since they are generally classified by other writers as species under the above genera, it is considered advisable to omit them for the present. For example, *Pleuronectes microcephalus* has been relegated to a new genus, *Microstomus*, and *P. cynoglossus* to another, *Glyptocephalus.* Examination of the internal structure of the former species shows that it is very closely allied to the plaice, *P. platessa*, even to the presence of the characteristic tubercles on the otic regions of the skull. *P. cynoglossus* seems the next step to *P. microcephalus* in the specialisation away from the Plaice, and it is a pity to subdivide these species into separate genera when their inclusion within one genus more fitly expresses their affinities.

This sub-family is well marked off from the preceding, to which it is most nearly allied, and from which it has probably been derived, by the peculiar shape and size of the mouth. Amongst the European forms there seem to be no transition stages, but amongst the American Jordan mentions that *Isopsetta* closely resembles *Psettichthys* of the family of Hippoglossinæ.

It is probable, therefore, that the transitional forms existed in the European waters at one time, but have now disappeared. On the other hand, in the peculiar shape of the mouth and in the presence of the "Sole-form" in such as *P. microcephalus* and *P. cynoglossus* we see the close affinities of this family to the Soleinæ—not that these are necessarily the forms which mark the transitional stages, but they indicate how the Soleinæ might have been derived from the Pleuronectinæ.

The distribution of the genera included within this family is more southerly than that of the Hippoglossinæ, but they are for the most part confined to the more northerly portions of the temperate zone.

Sub-Fam. *Hippoglosso-rhombinæ.*

(1) As in Hippoglossinæ.
(2) Olfactory laminæ arranged transversely about a median rachis.
(3) Ventral fins varying from the symmetrical condition of the Hippoglossinæ to a partial form of the asymmetrical condition in the Rhombinæ; in all, the pubic bones are wholly behind the clavicles, to which, when the fins are asymmetrical, the anterior of the pubic bones is sometimes attached.
(4) As in Pleuronectinæ, but the anterior extremity of dorsal fin is continued forward in some genera to nasal organ of blind side.
(5) As in Hippoglossinæ.
(6) Eyes on left side as a rule, but very variable, large.

These are the characters which unite together a number of genera some of which have been hitherto classed with the Halibuts, and others with the Turbots. They are separated from the former group by having the form of olfactory organ which is found in the latter, whilst they are more akin to the Halibut-group in almost all other characters. The genera which have hitherto been included with the Halibut-group are *Paralichthys*, *Pseudorhombus*,* *Psettodes*, and *Tephritis*. These are evidently distinguished from the Halibuts by character (2), in that they have the olfactory laminæ arranged transversely about a median rachis. The most remarkable form is *Psettodes*, which has hitherto been classed with the Halibuts and considered to have affinities to the most primitive, viz. *Atheresthes*. These affinities, displayed in the general form and structure and in teeth, are certainly striking, and lead to the conclusion that *Psettodes* is either a direct offshoot from the Halibut, or, if it has come through any intermediate forms, that it has assumed these characters by specialisation to its peculiar habits of life. The structure of the olfactory organ, however, seems a sufficient reason for removing this genus along with *Paralichthys* from the Halibut group and placing it in this family. In addition to the structure of the olfactory organ, there are other characteristics which separate it from the Halibuts. In the Halibut-group the eyes are almost invariably on the right side. In this genus, as in the other genera of this family, the eyes may be on the left or right side, but generally on the left. Thus, of nine examples mentioned by Günther in his Catalogue (vol. IV., p. 402), five had the eyes on the left side, four on the right. The specimen examined by myself, further, had no pyloric cæca—a characteristic of the Sole-group. Lastly, the distribution of this genus is southerly, where that of the Halibuts is northerly, as already noted.

With regard to *Paralichthys*, there is less objection to removing it from the Halibuts than there is with *Psettodes*. With the exception of

* The American writers include *Pseudorhombus* under *Paralichthys.*

the relatively slight difference in the position of the ventral fins and the form of the lateral line, the description given by the American writers for this genus (33, p. 2624) agrees exactly with that given for *Citharichthys* (*ibid.*, p. 2678), and the similar nature of the olfactory organ renders it imperative to bring these two within the same sub-family.

In *Tephritis*, again, the ventral fins are closely approximated to one another, and the laminar portions of the pubic bones are well developed and reach almost to the clavicles. The ventral fin of the right or blind side further shows a tendency to become reduced to four rays, and it is therefore permissible for these reasons alone to regard this form as transitional.

The genera which have been included hitherto within the Turbot-group are *Hemirhombus*, *Citharichthys*, and *Citharus*. They are separated from that group, however, by the position of the ventral fins. The asymmetry of these is not so great as in the Turbot-group, and the pubic bones of either side never pass beyond the base of the clavicles. As type of this sub-family we may choose the common Mediterranean form, *Citharus linguatula*. This has invariably been classed with the Turbots, and if the reasons advanced here for its separation from them be considered valid, then the necessity of forming a distinct sub-family for it and the allied genera will be admitted.

In the "*Scandinavian Fishes*" it had already been noted that *Citharus* formed an exception to the general rule in the *Heterosomata bothina* in that it had the rays of the ventral fins close together at the base, whereas in other forms they are wide apart. This external difference has been shown to be associated with a more important internal difference in structure (*vide* Fig. 21), and this has been contrasted with the structure of the ventral fins in *Arnoglossus* (Fig. 23), perhaps the nearest ally to *Citharus* within the Turbot-group. Nor is this the only difference from the latter group to be observed in *Citharus*. Although, according to Günther (20), who had not himself examined any specimens of this species, the dorsal fin extends to the snout anteriorly, it does not in reality do so to the same extent as in the other genera of the Turbot-group, and we find consequently in *Citharus* that there is a different relation between the anterior extremity of the dorsal fin and the nasal organ of the blind side from that in the Turbot-group. In *Citharus* the nasal organ in question lies on the ridge of the snout, just as is the case generally in the Hippoglossinæ and Pleuronectinæ, and as in the latter group the anterior extremity of the dorsal fin inclines towards the blind side on passing the upper eye, so that both nasal organs are on the upper or eyed side of the dorsal fin. This position may be again contrasted with that in *Arnoglossus*, where the nasal organ of the blind side lies on the under side of the dorsal fin.

The genera which are included within this sub-family restricted by the above characters are the following :—

[TABLE.

Species Examined.		*Genus.*	*Distribution.*
	(?)	Hippoglossina.	Pacific—California to Mexico.
	(?)	Lioglossina.	California.
	(?)	Xystreurys.	South California.
P. maculosus . . .		Paralichthys, Girard.	Both coasts of America to east and south coasts of Asia.
P. russellii . . .		Pseudorhombus, Gtr.	Sub-temperate zones of both northern and southern hemispheres.
	(?)	Ramuluria, Jordan and Evermann.	California.
	(?)	Ancylopsetta, Gill.	South Atlantic coasts of North America.
	(?)	Notosema, Goode and Bean.	Do.
	(?)	Gastropsetta, Bean.	Do.
	(?)	Trichopsetta, Gill.	Do.
H. aramaca . . .		Hemirhombus, Bl.	Tropical Atlantic coasts of America and Africa, also Pacific.
	(?)	Cyclopsetta, Gill.	Colombia and Gulf of Mexico.
	(?)	Azevia, Jordan.	Pacific coast of Central America.
C. sordidus . . .		Citharichthys, Bleeker.	Tropical and sub-tropical coasts of America.
T. sinensis . . .		Tephritis, Gtr.	China Seas.
P. erumei . . .		Psettodes, Gtr.	Red Sea to China.
C. linguatula . . .		Citharus, Bl.	Mediterranean.
	(?)	Anticitharus, Gtr.	Australasia.

It has to be admitted that this family rests for the present upon somewhat hazardous generalisations. As noted above, only seven* species of the various genera have been examined, whereas, according to Günther's Catalogue of 1862, twenty-one species are included therein, and if the most recent catalogue of the American writers be taken into account this number is almost doubled. It is therefore advisable to point out in detail the extent of the generalisations. In the case of *Paralichthys* and *Pseudorhombus*, it is assumed that the species which have not been examined have the same form of olfactory organ as those examined. In the case of the remaining genera it is also assumed that the ventral fins are placed posterior to the base of the clavicles. The first assumption is based on the fact that all the examined forms, Soleinæ and others, with a similar distribution, viz.—sub-temperate and tropical —have the same type of olfactory organ, in which the olfactory laminæ are arranged about a median rachis. The second assumption is not so well grounded, and unfortunately the descriptions of previous writers are too indefinite to give much aid. All that one can gather from the descriptions of Günther and the American writers is that what is true for the one species holds good also for the remaining species of the genus. In this case the above characters are true for the sub-family as it stands, but more specimens and species require to be examined in order to settle the matter definitely. Some alterations may require to be made, as, for example, in *Hemirhombus* (*Syacium*), whose ventral fins, according to the American writers, are peculiar, but they may not affect the validity of the sub-family as a whole.

The distribution of the various genera included within this family is more southerly than that of the previous family, being tropical and sub-temperate in both the northern and southern hemispheres.

*Through the kindness of Prof. D'Arcy W. Thompson, three more species of this sub-family, viz.:—*Paralichthys arsius*, *Paralichthys dentatus*, and *Citarichthys spilopterus*, have been examined since the above pages were written. These conform to the characters stated, and consequently, enhance the validity of the sub-family.

Sub-fam. *Rhombinæ* *

(1) As in Hippoglossinæ.
(2) As in Hippoglosso-rhombinæ.
(3) Ventral fins asymmetrical, the anterior extends anteriorly beyond the base of the clavicles; the laminar portion of one or both of the pubic bones is continued forward by a plate of cartilage as far as the lower prong of the urohyal.
(4) Nasal organ of the blind side lies entirely on the blind side of the head under the anterior extremity of the dorsal fin.
(5) As in Hippoglossinæ.†
(6) Eyes on left side.

The following genera are now included in this family :—

Species Examined.	*Genus.*	*Distribution.*
R. mancus . . .	Rhomboidichthys, Bl. (Platophrys, Swainson).	Sub-tropical regions of Atlantic and Pacific.
(?)	Perissias, Jordan and Evermann.	Gulf of California.
(?)	Eugyophrys, Jordan and Bollman.	Coast of Panama.
A. grohmanni . .		
A. laterna . . .	Arnoglossus, Ron. (Platophrys, Swainson).	Sub-tropical regions of Pacific and Atlantic.
L. boscii . . *L. whiff* . .	Lepidorhombus, Gtr.	Temperate seas of Europe.
S. unimaculatus . *S. norvegicus* . .	Scopthalmus, Bon.	Do.
Z. punctatus . . .	Zeugopterus, Gottsche.	Do.
R. lævis . . *R. maximus* . . *B. mæoticus* . .	Rhombus,* Kl.	Temperate regions of North Atlantic.
(?)	Etropus, Jordan and Gilbert.	Sub-temperate regions of America.
P. ocellatus . . (?)	Psammodiscus, Gtr.	(?)
(?)	Monolene, Goode.	Tropical and sub-temperate regions of Atlantic.

* This genus has been variously styled by the above mentioned authors, *Psetta*, *Pleuronectus*, *Bothus*. As the reasons for adopting these are somewhat hazy, there is insufficient ground for departing from the now familiar term *Rhombus*.

Under previous classifications this sub-family was more clearly separated from the other families of the Heterosomata than it is under the present. And if the Turbot (*R. maximus*), which was formerly the type of the family, were contrasted directly with the Pleuronectinæ and the Hippoglossinæ, we should be inclined to think that the Heterosomata had had two distinct sources of origin. It has been shown here, however, that *Citharus* and its allied genera form a natural transition from the Hippoglossinæ to the Rhombinæ, and that the latter family has first made its appearance in some form akin to *Arnoglossus*, if not in *Arnoglossus* itself. It is most probable, indeed, that the Rhombinæ had their origin in the sub-temperate or tropical zones, and thence migrated northwards. The Turbot, Whiff, and Topknots are specialisations along certain lines away from the main body of the Heterosomata.

* This sub-family has been variously called *Rhombinæ*, Gill; *Pleuronectinæ*, Jordan and Goss; *Bothinæ*, Smitt; *Psettinæ*, Jordan and Evermann, Gill. Each of these is well supported by weighty reasons, and one has therefore a considerable latitude of choice. In deciding upon *Rhombinæ* for the sub-family as above restricted, I have taken into consideration not only questions of priority, but also the fact that *Rhombus* is now the customary and recognised term for the type of this sub-family, amongst European ichthyologists at least.

† According to Jordan and Evermann (33, p. 2687), *Etropus* is an exception, having a small mouth, as in the *Pleuronectidæ*.

Fam., *Soleidæ*.

(1) " Preopercular margin aduate, hidden by the skin and scales of the head."
(2) Olfactory laminæ arranged about a rachis, which may lie obliquely or even transversely to the longitudinal axis of the body.
(3) Ventral fins symmetrical or asymmetrical; two, one, or absent altogether.
(4) Nasal organ of blind side similarly situated to that of eyed side.
(5) Mouth a symmetrical; dentition (if present) more developed on blind than on eyed side; mouth usually overhung by a definite snout.
(6) Eyes on right or left side.

It has been thought advisable to retain the latest classification of the American writers, and consider the Soleidæ as a family equivalent to the preceding sub-families combined. This has the advantage of dividing the Heterosomata into two main portions with an almost equal number of species in each, and it has the further advantage of a suitable terminology. But it has the great disadvantage of obscuring somewhat the natural affinities of the various groups. For this purpose it would be better if the family Soleidæ were done away with, and a classification similar to that proposed earlier by the American writers (32) established. In the latter, the Heterosomata were arranged in a series of sub-families, two of which—Soleinæ and Cynoglossinæ—represented the present family. It was then possible to arrange the characters of the various groups, so that the Cynoglossinæ were related to the Soleinæ as the Soleinæ were to the Pleuronectinæ and Rhombinæ, and the last two to the Hippoglossinæ. In the more recent classification (33) the Soleidæ are divided into three sub-families, Achirinæ—the American Soles, Soleinæ—the European Soles, and the Cynoglossinæ. Few of the American Soles have been examined by myself, so that the characters (2) and (4) above may not be altogether true for them, although they hold good for both the Soleinæ and Cynoglossinæ.

According to the American writers, the American Soles are allied to the Turbot-group (Rhombinæ) in the form of their ventral fins, whilst, as has been shown here, the European soles are more nearly allied to the Plaice-group. On the other hand, the Cynoglossinæ form an aberrant group whose affinities are by no means clear. They have been derived apparently from the Soleinæ or Achirinæ, but the transitional stages are not yet in evidence. It is to be understood, therefore, that the affinities of the various groups of Heterosomata are displayed by the sub-families, whilst the families are for convenience in classification.

The characters of the sub-families of the Soleidæ are as follows, those stated by the American writers being given in brackets:—

1. *Achirinæ*.

(Eyes on right side; ventral fins developed, one or both of them sometimes obsolete; right ventral with extended base, confluent with the anal fin.)

Species Examined.	*Genera.*	*Distribution.*
	Achirus, Lac.	Tropical and temperate regions of America.
G. fasciatus, . . .	Gymnachirus, Kaup.	Tropical South America (?)
S. unicolor, . . .	Soleotalpa Gtr. (Apionichthys, Kaup.).	Tropical regions of Atlantic.

2. *Soleinæ.*

Eyes on right side; ventral fins developed and free from anal.

Species Examined.	Genera.	Distribution.
S. vulgaris, . . .	Solea, Quen.	Sub-tropical and temperate regions of Europe.
S. lascaris, — *kleinii*, — *impar*, } . . .		
S. ocellata, . . .		
M. variegata, *M. minuta*, } . . .	Microchirus, Bon.	Mediterranean and temperate regions of Europe.
M. hispidus, . . .	Monochirus, Raf.	Mediterranean.
S. pectoralis, . . .	Synaptura, Cantor.	Indian Ocean and Archipelago.
P. pavoninus, . .	Pardachirus, Gtr.	Do. do.
A. cornuta, . . .	Aesopia, Gtr.	Do. do.
L. nitidus, . . .	Liachirus, Gtr.	China Seas.

3. *Cynoglossinæ.*

Eyes on left side; only one ventral (?); dorsal and anal fins confluent with caudal; termination of caudal vertebræ of axial type—diphycercal.

Species Examined.	Genera.	Distribution.
C. semilævis, . . .	Cynoglossus, Gtr.	China Seas.
P. marmorata, . .	Plagusia, Gtr.	East Indies.
A. lacteus, . . .	Ammopleurops, Gtr.	Mediterranean.
A. ornata, . . .	Aphoristia, Kaup.	Atlantic coasts of tropical America.

It may be possible to find further structural characters which differentiate these sub-families from one another, more especially the Achirinæ from the Soleinæ. The Cynoglossinæ are more specialised than either of these, and, in addition to their sinistral form, present stages of specialisation which can be well marked off from the transitional forms of the above sub-families. The confluent nature of the vertical fins occurs but seldom in these sub-families—*e.g.*, in *Soleotalpa* and *Synaptura*. In these, however, the termination of the notochord is slightly bent upwards (*Soleotalpa ?*) as in *Solea*, so that the axial arrangement of the caudal vertebræ, which marks the last degree of specialisation, is distinctive of the Cynoglossinæ. The other characters, the total absence of the pectorals, and the presence of only one ventral, are found also in the other sub-families—*e.g.*, in *Soleotalpa*, *Gymnachirus*, and certain species of *Synaptura*. Between the Soleinæ and the Achirinæ there seems at present only the one differentiating character, and it is of interest to note that it is the same character which forms the chief means of differentiating the Pleuronectinæ and the Rhombinæ, although it has yet to be seen whether the same difference in the internal structure of the pectoral arch and ventral fins is present.

The more specialised forms are found in the tropics, whilst the less specialised range into the temperate regions of the northern hemisphere.

Sub-fam. *Solei-pleuronectinæ.*

(1) and (2) As in *Pleuronectinæ.*
(3) Ventral fins asymmetrical; two or one.
(4) As in *Pleuronectinæ*?
(5) Mouth asymmetrical, as in *Pleuronectinæ.*
(6) Eyes on right side.

This sub-family has already received the name Oncopterinæ from Jordan (32, p. 280), and it might seem as if an unnecessary reduplication of terms was being made. As a matter of priority, however, *Rhombosolea* was the term given by Günther to the genus (21, p. 557), and instead of the name of the last discovered species, *Oncopterus*, being given to the sub-family, Rhombosoleinæ should rather have been employed. The latter term also would have had the additional advantage of declaring certain affinities of the group, whereas Oncopterinæ is an empty term. The doubt, therefore, lay between Solei-pleuronectinæ and Rhombosoleinæ, and it is considered that the weight of the characters decides in favour of the former. The asymmetrical condition of the ventral fins resembles the same character in the Turbot-group certainly, but, as remarked by Jordan, this is also the characteristic of the Achirinæ of the Sole-group. This sub-family, again, has the same disposition of abdominal vertebræ—*i.e.*, the last four to six bear hæmapophyses—as is found in certain of the Turbot-group—*e.g.*, *Rhomboidichthys*; but this has also been shown to be a general characteristic of the Soles. Hence, there is reason for considering that these characters have come from the Soleidæ and not the Bothinæ. This is further shown in the shape of the snout and mouth, which are almost half-way between the types of the Sole- and Plaice-groups. In the remainder of its characters, with the possible exception of the position of the nasal organ of the blind side, which has not yet been determined, this sub-family distinctly resembles the Plaice-group. The eyes are on the right side, and the olfactory organ is the same as in the Pleuronectinæ and Hippoglossinæ.

The genera included under this sub-family are, for the present, three—viz., *Rhombosolea*, *Peltorhamphus*, and *Ammotretis*, all from the waters south of Australia, from Tasmania and New Zealand. These are so distinct in their characters that—as characters are measured amongst the European species—each is entitled to represent a separate genus. As already mentioned, Jordan has classed with these a form from the Patagonian coast of South America, namely *Oncopterus*. This has certain remarkable resemblances to the above, but differs from them in that the ventral fin is not joined to the anal, where in the above it is. The interesting point to determine now is whether *Oncopterus* has the same type of olfactory organ as the others, and a similar disposition of the abdominal vertebræ. If so, then it is very probable that a number of forms intermediate in their geographical distribution between the above may still be found which will fall within this sub-family.

Incertæ Sedis.

Whilst it has been possible to give a certain amount of definiteness to the preceding sub-families, there still remain a few forms—some of which do not fall within the previous groups, and others not examined by myself—which have been given a separate and special importance by the American writers. As it is impossible to say exactly where the latter would fall in the present scheme of classification, it is better to consider them apart until further examination of their structure reveals their affinities.

One of these remarkable forms is *Brachypleura*, which includes several species from the Indo-Pacific Ocean and from New Zealand. This was placed by Günther (20, p. 556) in the Turbot-group, on account of its having a "nearly symmetrical mouth" and because "the dorsal fin commences before the eye." A further character may be added to complete its resemblance to the Turbots, namely that the ventral fins are unsymmetrical. But here the resemblance ceases, and *Brachypleura* has even less affinity to the Turbot-group than the Solei-pleuronectinæ had. The ventral fins though unsymmetrical are only slightly so, and are similar in structure and position to those of the Hippoglosso-bothinæ. Further, as in *Citharus*, *Platophrys*, and the Soleidæ, some of the abdominal vertebræ bear hœmapophyses. As with the Solei-pleuronectinæ, these last two characters are considered to show affinities with the Soleidæ. On the other hand, the structure of the mouth is hippoglossoid, the eyes are on the right side, and the olfactory organ, though little developed apparently, is of the same type as in the Plaice- and Halibut-groups.

Brachypleura has therefore very close affinities to the preceding sub-family, Solei-pleuronectinæ, and differs from it chiefly in the form of the mouth. In order to mark this affinity, and at the same time display the difference, it might be advisable—in the event of further related species coming to hand—to raise this genus to the rank of a sub-family and call it Solei-Hippoglossinæ.

Another genus whose position is uncertain is *Samaris*. This resembles *Brachypleura* in many of its characters, but in its general form as well as the position of the ventral fins shows a greater resemblance to the Turbot-group. The eyes are, however, on the right side. The structure of the olfactory organ is not yet known. Jordan (32, p. 229) has included with this several other genera, *Lophonectes*, *Pœcilopsetta*, *Nematops*, and formed them into a distinct sub-family which he calls Samarinæ. Future research may show, however, that the two latter should be grouped with the Solei-pleuronectinæ. According to Jordan this sub-family lies between the Plaice and Turbot-groups, but one result of the present investigation is to show that these two groups have been and are in no way related to one another. They are both specialisations from the main stock in different directions, and an intermediate group is unlikely—unless it arose through hybridism. The above genera may be transitional stages from the Halibut-or Turbot-groups to the Sole-group or *vice versâ*, or they may be highly specialised members of the Plaice-group.

Another genus of uncertain position is the *Lepidopsetta* of Günther (22), (*Mancopsetta* of Jordan). This comes from the southern end of South America, and seems to display affinities both to the Soles and Turbots.*

* Through the kindness of Prof. D'Arcy W. Thompson, C.B., of the University College, Dundee, and of his assistant, Dr. W. T. Calman, I have been able to examine some additional forms, and had access to additional literature, since the above pages were written. From these observations it seems very probable that the Deep Sea forms of the Indian Ocean described by Alcock (1, 2, 3), connect the flat-fish fauna of the temperate regions of the northern hemisphere with that of the similar regions in the southern hemisphere. Of these forms *Boopsetta* (*Pœcilopsetta*) seems to be one of the Plaice-group, whilst *Lœops* is of the Turbot-group. In the deep sea forms, therefore (*Chascanopsetta* is another), we may perhaps have the transitions from the Plaice- and Turbot-groups of the northern hemisphere to the Solei-pleuronectinæ of the southern. It would be of interest to know whether the forms mentioned had the Plaice or Turbot type of olfactory organ. In this connection, it may be mentioned that a specimen found at University College, which came from New Zealand and seems to be the representative of a hitherto undescribed species, has the external appearance and character of the Turbot group, but the Plaice type of olfactory organ.

Geographical Distribution of the Sub-Families.

It has at times been asked whether the flat-fishes could not be considered as having sprung from more than one stock, that is, as having two or more distinct sources of origin. The doubt concerning this point is centred round the great differences between the Turbot-group and the Plaice-or Halibut-groups. The Sole-group—in the European fauna at any rate—is readily recognised to have close affinities with the Plaice-group, whereas no other groups are so widely separated from one another as the latter and the Turbot-group. Nor are these differences—which have been displayed in the earlier portions of this paper—confined to the adult structures, they are also found in the earliest stages. The eggs of all the species of the Plaice-and Halibut-groups yet known are transparent and without oil-globules like those of the Gadidæ, whereas all the species of the Turbot-group have, without exception up to the present time, an oil-globule which may be coloured or colourless. The larvæ and post-larvæ of the latter group, again, are readily distinguished from those of the former by the very early anterior prolongation of the dorsal fin over the migrating eye, and by the presence, in several species, of spines on some part of the head, in other species of tentacular prolongations of the anterior rays of the dorsal fin.

These great differences throughout might lend countenance, therefore, to the possibility of there being two separate origins for the flat-fishes. But such an hypothesis could only obtain a firm ground in fact if it were shown that no transitional stages existed between the Turbot and Halibut-or Plaice-groups, and is at once disposed of if such transitional stages are found. In the preceding pages it has been shown that the *Citharus*-group intervenes between the Halibut-and Turbot-groups, and that the transitional forms are all present in the existing fauna. It becomes necessary, then, to take a broad survey of the various characters in order to display their gradual transition from the one group to the other, and this can be most readily accomplished by following the geographical distribution of the various sub-families.

Beginning in the northern parts of the northern hemisphere, and restricting attention mostly to the European forms, we find that the Hippoglossinæ are the sole representatives of the flat-fishes in the extreme north. It is there that we find the nearest approximation to the round-fishes in species which have the eye of the blind side on the ridge of the head. Closely allied to these we find other species, *e.g.* the Halibut, which have a broader or deeper body, and both eyes on one side of the head. The chief characters of these, according to the foregoing classification, are the large and nearly symmetrical mouth, the symmetrically-placed ventral fins, the eyes on the right side of the head, and the lamellar type of olfactory organ. As we approach nearer to the coasts of northern Europe we find another form making its appearance, which only differs essentially from the above in the shape of its mouth. This second form—the Plaice-group—differs from the former in having a smaller mouth, which is twisted towards the under side. A further difference, slight in itself but of some significance, is the more anterior position of the anterior extremity of the dorsal fin.

The Halibut and Plaice-groups are found together in the northern portions of the temperate region, the latter extending further south than the former, but as we proceed towards the warmer regions of the temperate zone both groups decrease in number to the vanishing point, and we find their places taken by forms which have undergone some remarkable changes. The asymmetry of the flat-fish, which in the above groups was restricted to the bones round the eyes and mouth, now passes backwards to the body, and both the pectoral and ventral fins begin to degenerate. Those of the eyeless side grow smaller than those of the eyed side, and in the end do not develop at all. As might be imagined from their relative positions, the ventral fins display the various stages in specialisation much better than the pectorals do, although we can trace the specialisation along both lines in separate groups. Following firstly the fate of the ventrals, we find that the ventral fin of the eyed side pushes forward in front of its fellow until it reaches and is joined on to the base of the clavicles. This forms a well-marked stage limiting off the *Citharus* from the Turbot-group, and is accompanied by other characters which display its differentiation from the Halibut-group. Not only is the asymmetry of the *Hippoglossus*-type increased, but the type itself seems to be wavering in the balance. In the Halibut-group the eyes are almost invariably on the right side,* in the species of the *Citharus*-group the eyes may be either on the left or right side, but most frequently on the left.† This peculiar phenomenon seems to be connected with some changing element in the environment. In the Flounder *(P. flesus)*, for example, whose young migrate at an early stage from salt to fresh water, and in which the eyes are normally on the right side as in the other species of the Plaice-group, we find that from six to ten per cent. of the individuals on certain grounds may have their eyes on the left side. Why this change should occur in some individuals and species and not in others is still a mystery, but meanwhile we may note that it is a characteristic of the Hippoglosso-bothinæ.

Another great change from the Halibut type, whose meaning and importance are not yet clear, occurs in the olfactory organ. It is somewhat difficult to imagine any transitional stage between the lamellar form of olfactory epithelium and the rosette-shape form, but we may possibly yet find that both forms occur within the bounds of one of the transitional genera, *e.g. Paralichthys*, which is the most nearly allied to the Halibut-group. On the other hand, one might think that the rosette-shaped form was of greater physiological importance than the other, and we can thus understand its universal prevalence amongst the forms of the sub-temperate and tropical seas, where the eyes have degenerated and the sense of smell is the chief means of detecting food. These are problems for the future, however; at present it is only possible to point out their significance.

The *Citharus*-group appears to have sprung directly from the Hippoglossinæ. In the European fauna we have only one representative of the group, namely *Citharus* (*Hippoglossus* of Cuvier, 11), but in the American fauna the transitional stages are more in evidence, from *Paralichthys* with the ventral fins as in the Halibut-group, through *Pseudorhombus*, in which the ventrals are close to the base of the clavicles, to *Hemirhombus* and *Citharichthys*, in which the ventral fins have become slightly asymmetrical, but are still behind the clavicles as in *Citharus.* With regard to distribution, also, the American forms range further to the north than *Citharus*, overlapping the hippoglossoid-forms. As a sub-family this group has the widest range of any. Its altered hippoglossoid characters make it well adapted to the warm seas, and it ranges all round the globe within the tropical and sub-temperate zones of the southern apparently as well as of the northern hemisphere.

* Jordan (33, p. 2615) cites *Hippoglossoides elassodon* as being sometimes sinistral.

† The only writer, to my knowledge, who has examined any specimens of *Citharus* itself with the eyes on the right side, is Linneus (35, p. 1233). There he describes his genus *Linguatula*, which apparently applies to *C. linguatula*, as now known, as *Pleuronectes oculis a desctra.*

Thus far we have traced one of the main lines of descent from the Halibut-group from the Arctic Seas to the tropics. There is still another main line, but before proceeding to its discussion it is necessary to refer to a sub-branch or offshoot which has sprung from the Hippoglosso-bothinæ. This, the Turbot-group, has the essential characteristics of the former, and has varied from it through the eyes becoming definitely fixed on the left side, and through the ventral fin of the eyed side, or both fins, developing forwards anterior to the base of the clavicles. This group belongs almost exclusively to the northern hemisphere, the various genera having migrated northwards from the sub-temperate and tropical regions—the original home of the group. The northern forms, the Turbot, Whiff, and Topknots, show that they have become specialised, so that if we wish to retrace their affinities we must return through the Brill to *Arnoglossus*, and thence to *Citharus*. It is of interest to note also that whilst the Hippoglosso-bothinæ have remained predominant in the American fauna, and the Turbot-group is barely represented there, the reverse is the case in the European fauna. The Hippoglosso-bothinæ are represented by only one form, and the Turbot group is predominant.

The second main line of descent from the Halibut-group passes downward through the Plaice-group to the Soles. This at least is one of the sources from which the Soles have sprung, and it is represented mostly by the European Soleinæ. In these the ventral fins are symmetrical, and the eyes are on the right side as in the Pleuronectinæ. The specialisation within this sub-family displays itself in the gradual decrease in size of the pectoral fins (*Microchirus*), and the disappearance of the pectoral of the left or eyeless side (*Monochirus*). Accompanying these external changes is an internal change in the structure of the abdominal vertebræ, which is found also in the transitional forms of the Hippoglosso-rhombinæ and Rhombinæ. The posterior abdominal vertebræ bear hæmapophyses, and the first interhæmal spine decreases greatly in size. In these respects, therefore, as well as in the form of the olfactory organ, the Soleinæ display affinities to the *Citharus* and Turbot-groups, whilst in the structure of the mouth, position of the eyes, and symmetry of the ventral fins they are more nearly related to the Plaice-group. It is thus impossible to draw a hard and fast line between the separate groups, although the probability is in favour of this group of Soles having sprung from the Plaice-group. The similarity of the olfactory organ and of the abdominal vertebræ in *Citharus, Platophrys*, and the Soleinæ is the sign of a certain amount of similarity in the habits and surroundings of these genera, whilst the other characters seem to be the persistent inheritance from the more northern Plaice-group. If this were not the case, we should expect that these characters—the position of the eyes and of the ventrals—would also have changed. The forms which are allied to the plaice group are distributed chiefly in the tropical and sub-temperate zones, in the Indian Ocean (*Synaptura*), and Mediterranean, but a few species range as far north as the Scandinavian coasts (*Solea vulgaris*).

On the other hand, the American Soles seem to have sprung from the Hippoglosso-rhombinæ. The ventral fins are here asymmetrical, and the eyes are on the left side. They do not seem to range to the northward as the European Soles do, but towards the south into the tropical regions. As in the latter sub-family, the pectorals in the Achirinæ (American Soles) gradually degenerate until they finally disappear.

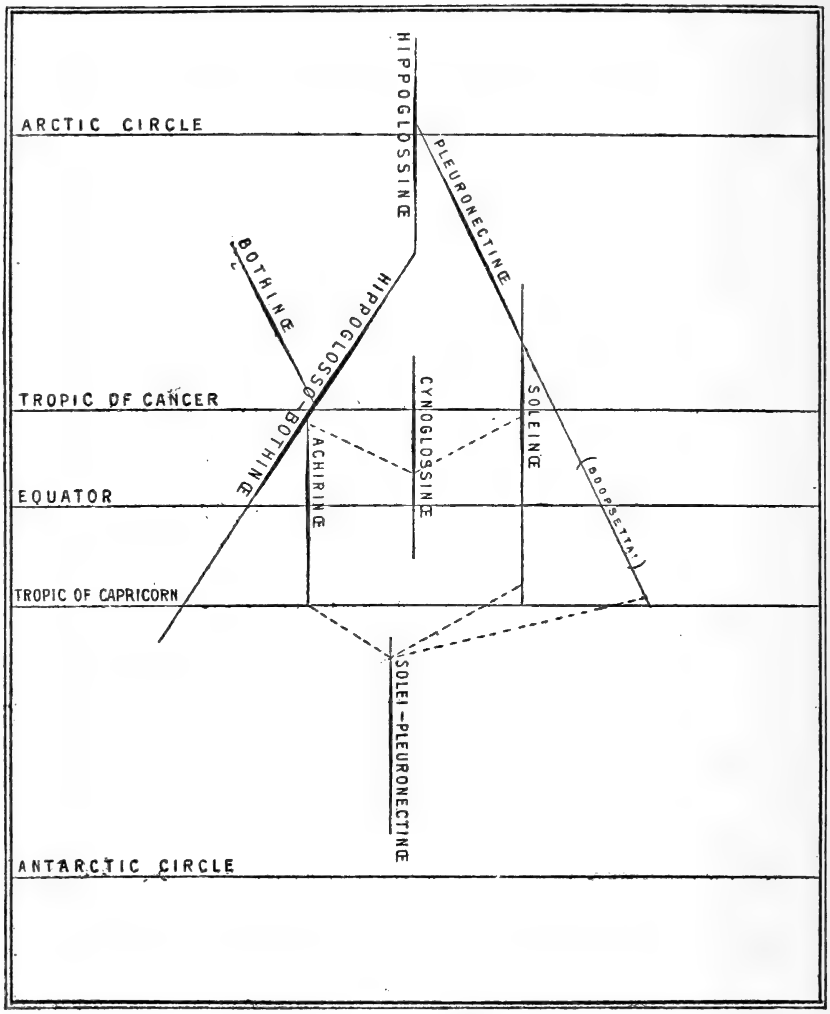
The specialisation of structures which is found in the Soleinæ and Achirinæ reaches the culminating point in the Cynoglossinæ. The pectorals and one ventral disappear, the eyes have become very small, and the termination of the vertebral column, continuing what had only begun in the previous sub-families, has assumed an axial form and become diphycercal. The distribution of this sub-family is similar to that of the tropical forms of the two preceding sub-families, and it is difficult to say from which of these two the Cynoglossinæ have been derived, probably from both.

Thus far it has been possible to pass over in review the various groups of the flat-fishes which are found between the Arctic Seas and the tropics. It has been assumed that their primitive home was in the former regions, and that the various changes in structure which present themselves as we pass from the one end to the other are specialisations or adaptations to special habits and habitats. Since the series from the least to the most specialised is fairly well complete, we might think that all the forms that could occur must lie somewhere within the groups which have already been described. In reality, however, we may have little more than half of the story, and the few forms yet known from the temperate regions of the southern hemisphere make this very probable. Passing over the aberrant *Lepidopsetta* (*Mancopsetta*) of South America, which is at present an isolated "fact," we have the Solei-Pleuronectinæ of the southern Australasian fauna, which display some remarkable transitional characters. They have been recognised by Jordan, even from the external characters, as having certain resemblances to the Pleuronectinæ, and this resemblance is still further increased by the fact that they have the same type of olfactory organ. In other characters—structure of the ventral fins and of the abdominal vertebræ—they resemble *Platophrys* of the Turbot-group and the *Achirinæ* amongst the Soles.

One may readily understand how the asymmetry of their ventral fins may have arisen, on the principle aforementioned that this asymmetry is chiefly a persistent inheritance from a tropical ancestor, but their having the type of olfactory organ which is found only in the temperate and Arctic regions of the northern hemisphere is harder to explain. There seem to be but two possibilities—either that some of the species which have made their way from the northern hemisphere through the tropics have retained this form of olfactory organ throughout, or that the olfactory organ has again changed in the temperate regions of the southern hemisphere from the rosette-shaped to the lamellar form, just as it changed in the reverse direction in the northern hemisphere.* Sufficient knowledge has not yet been gained to enable one to say definitely which of these possibilities is the correct one. On the former we should expect to find intermediate forms which have the lamellar form of olfactory organ, in the regions between Australia and the China Sea. If these are not to be found, we should be inclined to believe that these forms show a specialisation away from the Sole-type ; *i.e.*, in an environment similar to that of the temperate regions of the northern hemisphere, that the Sole type is gradually changing to the Pleuronectid. In such a case—and *Brachypleura* of the same regions is another example of the same process—we are led to think of Murray's hypothesis of the bipolar origin of the oceanic fauna (41), and its more recent discussion by Herdman (24) and Thompson (53). If it is possible for the structures of the flat-fishes so to alter as they pass from the tropics to the Antarctic circle that they reassume in many ways a similar appearance and similar structures to those in similar regions of the northern hemisphere, then it is not difficult to see how a false appearance of identity may arise between the forms of the Arctic and Antarctic seas.

* See footnote p. 361.

The subjoined sketch represents the distribution and the affinities of the various sub-families of the *Heterosomata*, the darker portions of the lines showing where each is most abundant, and the dotted lines show the doubtful affinities.



BIBLIOGRAPHY.

1. Alcock A.—Illustrations of the Zoology of the Royal Indian Marine Survey Ship *Investiyator*, 1898.
2. Alcock, A.—"A Guide to the Zoological Collections exhibited in the Fish Gallery of the Indian Museum," 1899.
3. Alcock, A.—"A Descriptive Catalogue of the Indian Deep-Sea Fishes in the Indian Museum," 1899.
4. Agassiz, A.—"On the Young Stages of Osseous Fishes," *Proc. Amer. Acad. Arts and Science*, 1877.
5. Agassiz, A.—"Development of the Flounders," *ibid.*, 1878.
6. Bateson, W.—"Sense-Organs and Perceptions of Fishes," *J.M.B.A.*, v. I., n.s., 1889-90.
7. Cole, F. J.—"Observations on the Structure and Morphology of the Cranial Nerves and Lateral Sense-Organs of Fishes; with special reference to the genus *Gadus*," *Jour. Linn. Soc.*, 1898.

8. Costa, O. G.—"Fauna del Regno di Napoli," Naples, 1850.
9. Cunningham, J. T.—"A Treatise on the Common Sole," 1890.
10. Do. —"Diagnostic Characters in Flat Fishes," *J.M.B.A.*, v. III., 1893-95.
11. Cuvier, G.—"Le Rêgne Animal," 1817.
12. Do. —"L'Histoire Naturelle," 1828.
13. Day, F.—"British Fishes," 1884.
14. Do. —"On a Supposed Hybrid between the Dab (*P. limanda, L.*) and the Flounder (*P. flesus, L.*)," *Proc. Roy. Soc.*, 1885.
15. Dean, Bashford—"Fishes, Living and Fossil," 1895.
16. Duncker, G.—"Der Elbbutt, eine Varietät der Flunder," *Schr. d. Natura-Ver. f. Schleswig-Holstein*, B. IX., 1892.
17. Duncker, G.—"Ein muthmalslicher Bastard zwischen, *P. platessa L. und P. Limanda L.*," *Zool. Anz.*, 15 Jhrg., N. 407, p. 451-453.
18. Edwards, H. Milne—"Leçons sur la Physiologie et l'Anatomie Comparée," vols. II. et IX., Paris, 1874.
19. Ehrenbaum, E.—"Eier u. Larven v. Fischen d. Deutschen Bucht," *Wissen. Meeresunter.*, 1896.
20. Günther, A.—"Catalogue of Fishes in the British Museum," v. IV., 1862.
21. Do. —"The Study of Fishes," 1880.
22. Do. —"The Voyage of H.M.S. *Challenger*: Report on the Shore Fishes," Zoology, v. I., 1880.
23. Günther, A.—*Ibid.*, "Report on the Deep-Sea Fishes," v. XXII., 1887.
24. Herdman, W. A.—Presidential Address to the Zoological Section of the British Association, Ipswich, 1895.
25. Holt, E. W. L.—"Studies in Teleostean Morphology," *Proc. Zool. Soc.*, 1894.
26. Holt, E. W. L.—"Recherches sur la Reproduction des Poissons Osseux," *Ann. du Musée d'Hist. Nat. de Marseille*, Mem. 2, 1899.
27. Howes, G. B.—"On the Intestinal Canal of the Ichthyopsida," *Jour. Linn. Soc.*, v. XXIII., 1890.
28. Huxley, T. H.—"On the Development of some Parts of the Skeleton of Fishes," *A.J.M.S.*, 1859.
29. Huxley, T. H.—"Ceratodus Forsteri, with Observations on the Classification of Fishes," *Proc. Zool. Soc.*, 1876.
30. Huxley, T. H.—"Anatomy of Vertebrate Animals," 1880.
31. Jordan, D. S., and Gilbert, C. H.—"Synopsis of the Fishes of North America," *Bull. U.S. Nat. Mus.*, 1883.
32. Jordan, D. S., and Goss, D. K.—"A Review of the Flounders and Soles (*Pleuronectidæ*)," *U.S. Comm. of Fish and Fisheries*, 1886 (1889).
33. Jordan, D. S., and Evermann, B. W.—"The Fishes of North and Middle America," Washington, 1898 (1899).
34. Kyle, H. M.—"On the Existence of Nasal Secretory Sacs and a Naso-pharyngeal Communication in Teleostei," *Jour. Linn. Soc.*, 1900.
35. Linneus, C.—"Systema Naturæ," T. I., p. 3.
36. Masterman, A. T.—"Skeleton of the Tunny," *Scot. Fish. Board Rep.*, v. XII., 1893.
37. Matthews, J. D.—"On the Structure of the Herring and other Clupeoids," *S.F.B. Rep.*, v. V., 1886.
38. M'Intosh, W. C., and Prince, E. E.—"On the Development and Life-Histories of the Teleostean Food and other Fishes," *Tr. R.S.E.*, v. XXXV., 1890.
39. Möbius, K., u. Heincke, F.—"Die Fische der Ostsee," Berlin, 1883.
40. Moreau, E.—"Poissons de la France," 1881.
41. Murray, G.—"The Voyage of H.M.S. *Challenger*: Summary of Results," v. II., p. 1459.
42. Owen, R.—"Comparative Anatomy and Physiology of Vertebrates," 1866.
43. Parker, W. K.—"Shoulder-Girdle and the Sternum in the Vertebrata," Ray Society, 1867.
44. Petersen, C. G. J.—"On the Biology of our Flat Fishes," *Rep. Dan. Biol. Station*, v. IV., 1893.

45. Raffaele, F.—"Le Uova Gall. e le Larve d. Teleostei nel Golfo di Napoli," *Mitt. a. d. Zool.-Stat. zu-Neapel*, VIII., 1888.

46. Ryder, J. A.—"On the Origin of Heterocercy and the Evolution of the Fins and Fin-rays of Fishes," *U.S. Comm. Fish and Fisheries*, 1884.

47. Sauvage, E.—"Mémoire sur la Faune Ichthyologique de la Période Tertiaire," *Comptes Rendus*, Paris, 1872.

48. Sagemehl, M.—"Beiträge zur vergleichenden Anatomie der Fische," I.-II. *Morph. Jahrbuch*, B. IX., 1884.

49. Sagemehl, M.—"Beiträge zur vergleichenden Anatomie der Fische," III., *ibid.*, B. X., 1885.

50. Smitt, F. A.—"Scandinavian Fishes," 1892.

51. Stannius, H.—"Anatomie der Wirbelthiere," Berlin, 1854.

52. Steenstrup, J.—"Fortsatte Bidrag—Oiestillingen hos Flyndrene," Copenhagen, 1878.

53. Thompson, D. W.—"On a Supposed Resemblance between the Marine Faunas of the Arctic and Antarctic Regions," *Proc. Roy. Soc. E.*, 1898.

54. Traquair, R. H.—"On the Asymmetry of the Pleuronectidæ," *Tr. Linn. Soc.*, 1865.

55. Wiedersheim, R.—"Grundriss der vergleichenden Anatomie der Wirbelthiere," Jena, 1898.

56. Williamson, H. C.—"Anatomy of the Pectoral Arch of the Grey Gurnard (*T. gurnardus*)," *S.F.B. Rep.*, XII., 1893.

DESCRIPTION OF PLATES (XI.-XII.)

Fig. 1. *Pleuronectes platessa;* viewed from in front, to show relative positions of dorsal fin (D.) and nasal organs (l.n.o. and r.n.o.).

Fig. 2. *Hippoglossus vulgaris;* do.

Fig. 3. *Rhombus maximus;* do.

Fig. 4. *Solea kleinii;* do.

Fig. 5. *Hippoglossus vulgaris;* to show olfactory organ (o.o.) of right (or eyed) side and nasal sacs (r.n.s. and l.n.s.). The laminæ of the sensory epithelium are arranged longitudinally to the main axis of the body.

Fig. 6. *Rhombus maximus;* olfactory organ of left (or eyed) side. The laminæ are arranged transversely to the main axis about a longitudinal rachis.

Fig. 7. *Solea lascaris;* olfactory organ of left (or blind) side. The olfactory laminæ are arranged longitudinally, the median rachis transversely, to the main axis.

Fig. 8. *Rhombus maximus;* abdominal and five of the caudal vertebræ, showing the unclosed nature of the ribs (p.r.) and parapophyses (p.p.), the transverse processes of the caudal vertebræ (t.p.) continuing into the "pleura-pophyses" (p.p.) of the abdominal vertebræ, and the first interhæmal spine curved forward at its extremity and continued by two small portions of cartilage, so that the abdominal cavity is almost completely enclosed.

Fig. 9. *Solea vulgaris;* abdominal and four of the caudal vertebræ. The hæmal arches are closed (h.p.), the transverse processes of the caudal vertebræ are continued by true transverse processes on the abdominal vertebræ. There is no single first interhæmal spine, but a group of four. These, and not the "hæmapophyses," mark the commencement of the caudal vertebræ.

Fig. 10. *Solea vulgaris;* third last abdominal vertebra. The hæmal arches are completely fused to form hæmapophyses.

Fig. 11. *Rhombus maximus;* third-last abdominal vertebra. The hæmal arches and ribs are free.

Fig. 12. *Rhomboidichthys mancus;* third-last abdominal vertebra. Hæmal arches as in *S. vulgaris.*

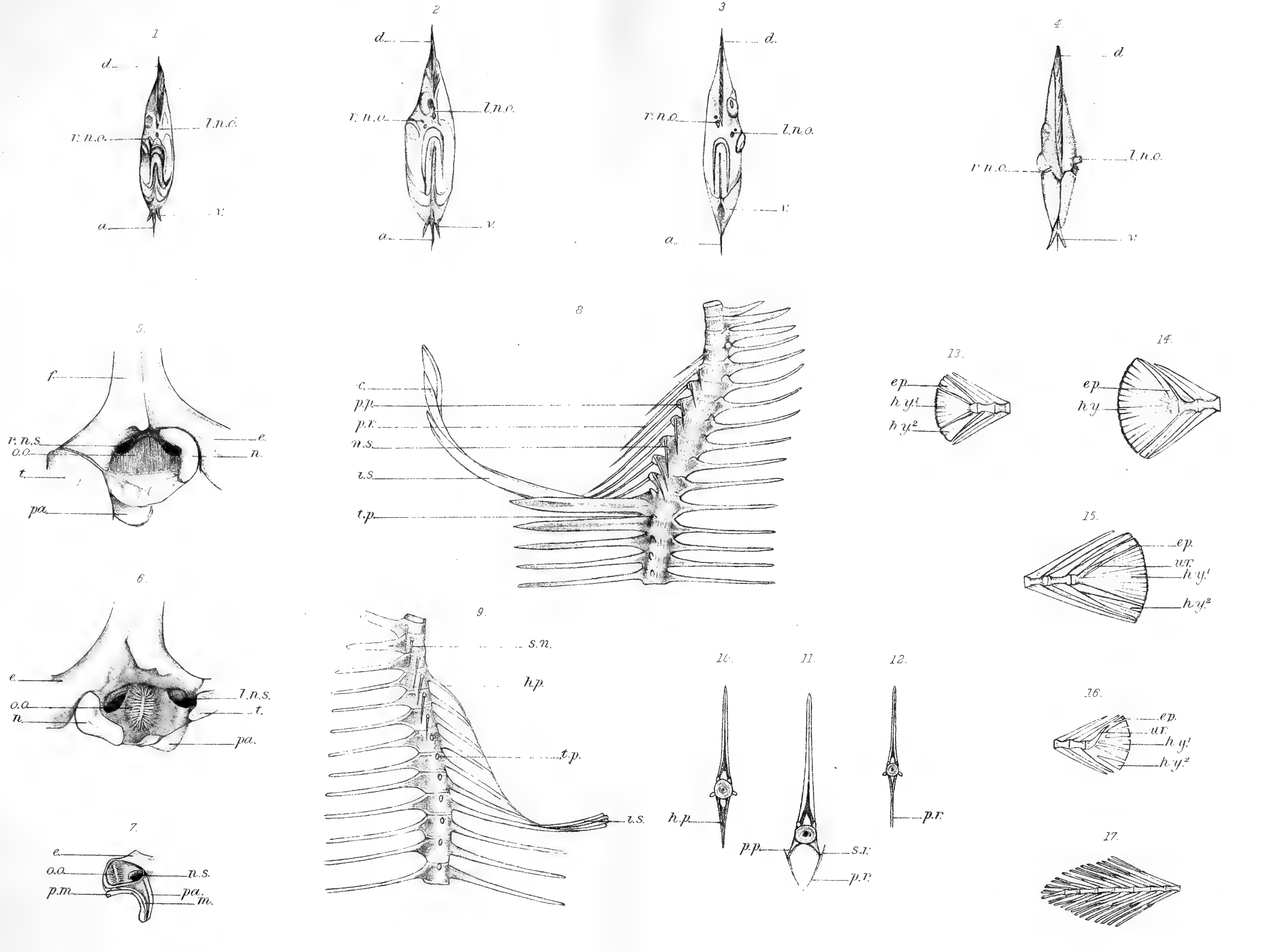
Fig. 13. *Citharus linguatula;* termination of vertebral column.

Fig. 14. *Solea vulgaris;* do.

Fig. 15. *Ibid.;* from post-larval specimen; do.

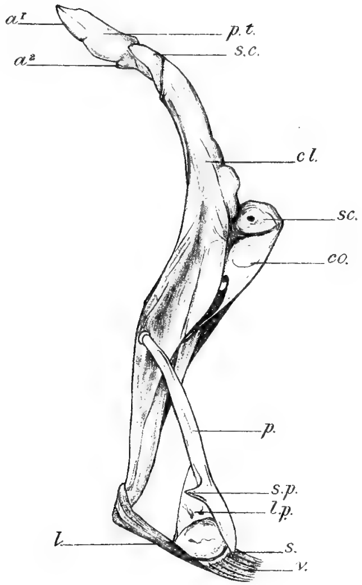
Fig. 16. *Rhombus maximus;* do.

Fig. 17. *Ammopleurops lacteus;* do.

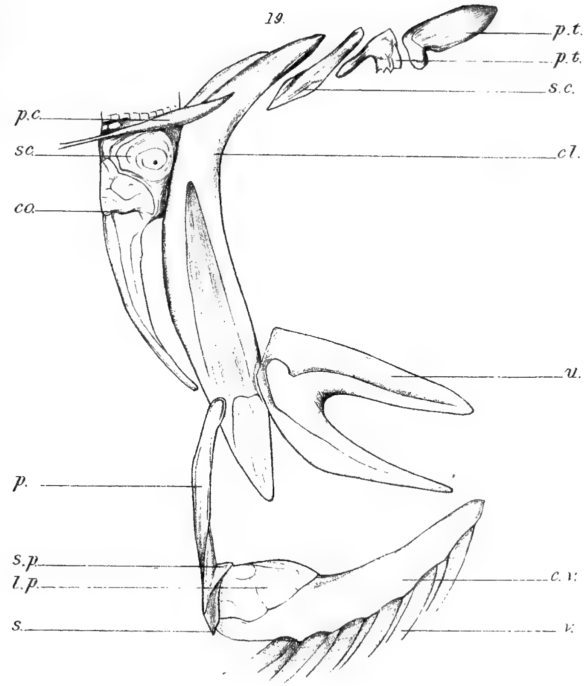


H. M. K., del. ad nat.

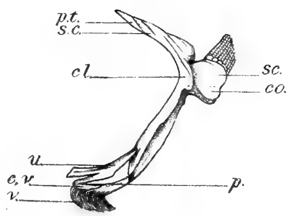
18.



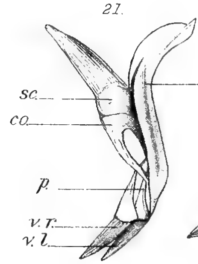
19.



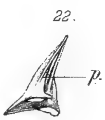
20.



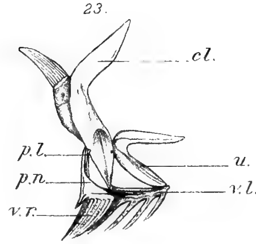
21.



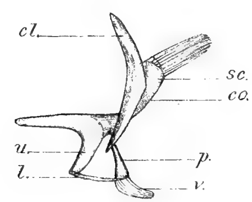
22.



23.



24.



H. M. K., *del. ad nat.*

Fig. 18. *Pleuronectes platessa ;* pectoral arch of right or eyed side from its inner aspect, showing the ventral fins (V.) lying posterior to the base of the clavicles (cl.).

Fig. 19. *Rhombus maximus ;* pectoral arch of left or eyed side from its inner aspect, showing the cartilaginous anterior extension (c. V.) of the laminar portion (l. p.) of the pubic bone (p.), the urohyal (u.) to which it extends, and the consequently prolonged anterior position of the ventral fins (V.) relative to the base of the clavicles (cl.).

Fig. 20. *Scophthalmus norvegicus ;* pectoral arch of right or blind side from its inner aspect, showing a further specialisation of condition found in *R. maximus ;* the pubic bone (p.) has its origin from the base of the clavicle (cl.), and the ventral fins (V.) are directly under the anterior extension of the urohyal (u.).

Fig. 21. *Citharus linguatula ;* pectoral arch of the right or blind side from its outer aspect, showing the adnate position of the pubic bone (p.) and ventral fin (V.l.) of the left or eyed side to the clavicles (cl.); both pubic bones and ventral fins are posterior to the clavicles, and those of the right or blind side (V.r.) are siightly posterior to those of the left (V.l.).

Fig. 22. *Ibid. ;* pubic bones, viewed slightly from ventral aspect, showing their relative positions and their fusion posteriorly in a spine.

Fig. 23. *Arnoglossus laterna ;* pectoral arch of the left or eyed side from its inner aspect, showing the transition from *Citharus* to *Bothus ;* the left ventral (V.l.) is prolonged in advance of the base of the clavicle (cl.), whilst the right ventral (V.r.) stops short at the base ; the rays of the former are widely separated from one another as in the turbot, those of the latter are close together as in *Citharus.*

Fig. 24. *Solea vulgaris ;* pectoral arch of right side from its inner aspect, showing the short clavicle (cl.) and the posterior position relative to it of the pubic bone (p.) and ventral fin, which is attached by a ligament only to the urohyal (u.).

REFERENCE LETTERS.

A.—anal fin.
$a._1$, $a._2$—articulating facets on *post-temporal.*
c.—continuation of first interhæmal spine.
cl.—clavicle.
co.—coracoid.
c. V.—cartilaginous continuation of l. p.
D.—dorsal fin.
e.—ethmoid.
ep.—epiural.
f.—frontal.
hy., $hy.^1$, $hy.^2$—hypural elements.
h. p.—hæmapophyses.
i. s.—first interhæmal spine.
l. n. o.—left nasal organ.
l. n. s.—left nasal sac.
l.—ligament.
l. p.—laminar portion of pubic bone.
m.—maxilla.
n.—nasal bone.
n. s.—nasal sac.
o. o.—olfactory organ.
pa.—palatine.
p.—pubic bone.
p. c.—post-clavicle.
pm.—premaxilla.
p. l.—left pubic bone.
p. p.—parapophyses.
p. r.—primary ribs.
p. t.—post-temporal.
r. n. o.—right nasal organ.
r. n. s.—right nasal sac.
sc.—scapula.
s. c.—supra-clavicle.
s. p.—spinous process on pubic.
s. terminal pubic spine.
s. r.—secondary ribs.
t.—turbinal.
t. p.—transverse process
u.—urohyal.
ur.—urostyle.
V.—ventral fin.
V. l.—left ventra
V. r.—right ventral.

X.—ADDITIONAL NOTE ON THE SURFACE-CURRENTS OF THE NORTH SEA.

By T. Wemyss Fulton, M.D., F.R.S.E., Scientific Superintendent.

In the Fifteenth Annual Report of the Board I described in detail the experiments devised by me to ascertain the direction and rate of the surface-currents in the North Sea, and the results obtained up to the beginning of 1897. The method adopted was to set adrift a large number of floats (chiefly bottles) at brief intervals over a long period and at various localities, and to collate the results derived from those that were recovered. Up to the time mentioned the number of "drifters" which had been returned to me, out of some 3550 which were made use of, was 502. Since then an additional 132 have been received, making a total of 634, or nearly 18 per cent. of those thrown into the sea. The "drifters" were of two kinds, paraffined wood and sealed bottles; and the statement previously made that the bottles proved far superior to the other kind is borne out by the further experience, since all of the 132 since recovered were bottles. About 30 per cent. of the bottles made use of were recovered.

The places where the 132 referred to were found were as follows:—Scotland 7 (5 at the Shetlands, 1 at the Orkneys, and 1 recovered by a trawl net east of May Island); England 1, on the coast of Northumberland; Germany (west coast of Schleswig) 6; Denmark, west coast, 49; Sweden, west coast, 16; Norway, 53. None were received from Holland, and those from Norway were found on various parts of the coast, from the entrance to Christianiafjord to the North Cape. When the previous results are combined we have the following:—

England.	Holland.	Germany.	Denmark.	Sweden.	Norway.
95 1	5 —	4 6	57 49	6 16	46 53
96	5	10	106	22	99

As may be seen from the Tables appended, the great majority were recovered in 1897; eight were recovered in 1898, and two in November and December 1899; but some of them did not reach me until the beginning of the present year.

Many of the bottles found belong to lots of which others were previously obtained, and the additional information which they furnish may be considered. Five of them were among the number thrown overboard by H.M.S. *Research*, when engaged in survey work in the Faroe-Shetland Channel, in July and August 1896. The one previously recovered from lat. 61° 1′ N., long. 3° 13′ W., was found near Lerwick, Shetland, about 100 miles to the south-east, in December 1896. One of

* The Currents of the North Sea, and their Relation to Fisheries, Part III., p. 334.

the two now recorded from the same station was picked up at Purköen, Nordland, Norway, on 22nd April 1897, and the other at the extreme northern point of Norway, viz., at the North Cape, on 29th May in the same year; the respective intervals being 266 and 312 days. The distance to the North Cape is about 900 geographical miles, and the rate of drift was about 2·9 knots per day. Of the floats thrown in on 4th August 1896, in lat. 61° 18½ N. and long. 4° 21¼ W., one was recovered after a short interval at Shetland; another was obtained on 3rd August 1897, or exactly a year later, at Rödö, in Helgeland, Norway. Of those set adrift in lat. 60° 2′ N., long. 7° 4′ W., on 6th August, 1896 five were recovered, two at Shetland, and, still earlier, three on the coast of Norway. Of the two since obtained, one was got at Veiholmen, Romsdal, Norway, on 4th November 1897 (after an interval of 455 days), and the other on 14th March 1898, at Mousa, Shetland, where it had doubtless been stranded long before.

By the aid of Mr. R. Duthie, Fishery Officer, a number of other bottles were set adrift on the 17th January 1897, from the s.s. *St. Giles*, at distances of 50 and 100 miles S.S.W. of Bressay Light, Shetland. Of the former lot (ten in number) three were recovered on the coast of Norway, in October and November 1897, and February 1898. One of these was found at Ingöen, Finmarken, near the North Cape, after an interval of 297 days; the distance is about 800 miles, and the rate of drift in this instance is about 2·7 knots per 24 hours. Four of the ten set adrift at the second place were also recovered—one, after 240 days, near the Skaw, Denmark; another, after 241 days, near Christiansand, S. Norway; the third, after 310 days, also near Christiansand, and the fourth, on 5th February 1898, still further to the north-east, near Kragerö, S. Norway.

Of those set adrift further south, one has been returned to me after the long interval of five years (1840 days); it was thrown into the sea eight miles off Buchan Ness, Aberdeenshire, on 5th November 1894, and found on Fröya, near Trondhjem, Norway, on the 20th November 1899. It had no doubt been lying there for years, because of other four of the 20 bottles set adrift at the same time which were recovered, three were picked up in December 1894, two near Trondhjem, and one at Brandesund, near Bergen; the fourth was found at the Fro Islands, also near Trondhjem, in December 1895. It is curious that all of them were got in the months of November or December. Another bottle, put away in the Moray Firth on 2nd August 1895, was found on 17th December 1899, after an interval of 1597 days, at Mandal, in the south of Norway. Other two of the same lot (ten in number) were picked up in the same locality in November 1895.

In many cases the results of the experiments illustrate in a marked manner the views expressed in my previous paper, as to the general direction of the surface-currents in the North Sea; and they show the necessity of conducting such observations with a large number of floats. For instance, of twenty bottles set adrift on 22nd July 1896, ten at the Bell Rock Lighthouse, and ten 10½ miles S.E. of Bervie, Kincardineshire, three were recovered on the Norwegian coast; one on 1st April 1897 (after 252 days), south of Stavanger, one on 15th May 1897 (after 297 days), near Bergen, and one at Engel Island, Nordland (very much further to the north), on 1st November 1897, after 467 days. These facts taken alone would point to a movement northwards from the region where the bottles were set adrift. But the previous records show that the bottles first of all moved south along the east coast of this country, because others were found on the coast of Fife and East Lothian a few weeks after they had been sent on their journey, and one on the coast of

Northumberland still later. The same result is shown in other cases. Of ten set adrift on the same date, 22nd July 1896, four miles south-east of Buchan Ness, Aberdeenshire, two were picked up at sea a few days later (15 and 24 miles S.E. of Aberdeen), and other three on the coast of Northumberland, 49, 51, and 57 days afterwards. On 5th May 1897 (287 days) one was found near Hantsholm, on the north-west coast of Denmark, and another on 3rd August 1897 (after 377 days) between Mandal and Christiansand on the south coast of Norway. Of ten put adrift on the same date, 8 miles N.N.E. of Scarnose Point, Banffshire, two were picked up on the adjoining coast to the south, a few days later; another was found floating in the sea 65 miles N.E. by E. of Spurn Point, Yorkshire, on 3rd December 1896, after an interval of 134 days; and a third was got near Stromstad, in the north of the west coast of Sweden, on 21st October 1897, after 456 days. In another case where ten bottles were set adrift on 13th October 1896, 5 miles south-east of Girdleness, Aberdeenshire, one was found at Whitby, in Yorkshire, 172 miles to the south, after an interval of 100 days; another was found on 16th May 1897, after 215 days, at Sondervig, on the west coast of Denmark; a third on 11th July 1897, after 271 days, at Römo, Schleswig; a fourth on 6th August 1897, after 297 days, near Varde, on the southern part of the west coast of Denmark; and a fifth on 7th July, after 267 days, on the west coast of Sweden.

Advantage was taken of the ordinary steamer routes from the Firth of Forth to the Continent to set off drifters at various parts of the North Sea, and the results of many of those are included in the Tables. The lines chosen were from Leith to the Naze of Norway, Leith to Hamburg, and Leith to the Hook of Holland. Along the first-named lines, the particulars that fall within the present paper are as follows:—On 21st August 1896, a number of floats were thrown overboard at intervals between the Isle of May and the Naze. Up to the distance of 100 miles E. ½ S. of the Isle of May, several of those set adrift were recovered on the coast of Northumberland, after periods which increased according to the distance from the May, ranging from 21 to 161 days. Since then others have been recovered on the coast of Denmark and Sweden—namely, two on the coast of Denmark, near Nymindegab, after intervals of 325 and 340 days, and two near Stromstad, on the west coast of Sweden, on 20th and 26th January 1898, after intervals of 517 and 523 days. Of those put out on this voyage at a distance greater than 100 miles from the Isle of May, only two have been recovered; one, set adrift at 130 miles, found after 150 days at the Lofoten Islands, 740 miles distant, and showing a drift at the rate of 4·9 geographical miles in the 24 hours; the other, set adrift at 250 miles, found also on the coast of Norway, much further to the south (Bömmel Island, S. Bergenhus), after an interval of 55 days and showing an apparent drift of 2·6 geographical miles per day.

The second series on this route were dispersed on the 23rd October 1896. Two of those set adrift 50 miles E. ½ S. from the May Isle were found 93 days later on the coast of Durham; three at 75 miles were recovered, one after 326 days on the west coast of Denmark, and the other two on the west coast of Sweden after the lapse of 341 and 428 days respectively. Of those set adrift at 100 miles, none have been recovered from the English coast; one was found at the Shetland Isles 153 days after, one on the west coast of Denmark after 263 days, and a third near Stavanger, on the coast of Norway, after 315 days. The aberrant case of the Shetland drifter was no doubt due to the remarkable reversal of the current in January 1897.*

* *Ibid* p. 361.

The third series was thrown into the sea on 6th November 1896. Of the five bottles put away at 10 miles from May Isle none have been returned to me. Of five set adrift at 130 miles, one was found on 6th September 1897, near Bergen, Norway; of five at 150 miles, one was picked up after 118 days at Sulen, Sognefjord, Norway, another at the same place four days later, and a third, after 129 days, near Slattero, Norway. Two of the five set adrift at 250 miles have been recovered; one at Trœnen, Nordland, Norway, 620 miles away, after 108 days (showing a drift-rate of 5·7 geographical miles), and the other at Blomvag, near Bergen, after an interval of 203 days.

The fourth series, sent adrift on 25th and 26th December 1896, has given much fuller results. Of 120 bottles used, 39 have been recovered, and, with the exception of one found at Shetland (due to the reversal of the current), all were picked up on the coast of Norway (32), Denmark (2), or Sweden (4); the earliest to be found were those put away at 250 miles, several of which were got in the neighbourhood of Stavanger within a week. The nearest point to May Isle at which the bottles were set adrift was 30 miles; two of these were recovered on the west coast of Denmark in July and August in the following year; one, a little later, at Sulen, Norway, and a fourth in December 1897, on the west coast of Sweden. Of the twenty set adrift at 100 miles, four have been recovered; one at Risör, Norway, on 30th March 1897, after an interval of 96 days; one near Lysekil, Sweden, after 170 days; one near Bergen, Norway, after 186 days, and the fourth near Stromstad, Sweden, on 20th January 1898, the interval being 390 days. Only one was recovered from the lot put away at 150 miles; it was found on 9th April 1897 (after 104 days) at Fetlar, Shetland, carried there, and stranded, by the reversed current referred to. Ten of the twenty set adrift at 200 miles were recovered, all found on the Norwegian coast between Sulen Island, N. Bergenhus, and Egersund, and mostly about Stavanger, towards the end of February and in the beginning of March, after intervals of from 56 to 67 days. Ten were also recovered of the twenty at 250 miles; nine of them in the same area as the above, from the beginning of January to the middle of February, the periods varying from six days to 55 days; one was picked up much further north, on 16th April 1897, after 111 days, near Molde, Romsdal. Nine of the twenty put away at 300 miles, or a point about 32 miles west of the Naze, on 27th December 1896, were recovered, all on the Norwegian coast. Five were discovered at the end of February in the neighbourhood of Bergen and Jæderen; one on 3rd March (67 days), near Molde; one on 16th April (112 days), near Egersund, S. Norway; one on 20th July at Rödö, Helgeland, and one on 30th September 20 kilometres south-south-east of Haugesund.

On the route between the Firth of Forth and Hamburg, series were set adrift on 15th and 16th August, 18th October, and 23rd and 24th December 1896. In the August series, one, put away at 13 miles S.S.E. of May Isle, was found on 19th May 1897, after 276 days, at Hillerslev, Denmark; one, at 20 miles, on 26th June, twelve miles east of Hantsholm, Denmark; one at 30 miles 27 days later, on 11th September 1896, at Blyth, Northumberland, and another of those at 30 miles, on 29th June 1897, after 317 days, 44 kilometres north of Bergen. Some of those put away at 130, 150, and 200, 250, and 300 miles were found at intervals of from 44 to 200 days, on the south and south-west coasts of Norway, on the west coast of Sweden, and the Christianiafjord.

Of fifty bottles thrown into the sea along this route on 18th October 1896, 17 were recovered. Four of the five set adrift at 20 miles S.E. by S. of May Isle were stranded on the Berwick and Northumberland coast within a few days; six of the ten at 30 and 50 miles were got on the coast of Yorkshire in from 14 to 16 days; one at 70 miles was picked up on the coast of Northumberland after 99 days; one, at 100 miles, was found at Manö, Jutland, on 11th August 1897, after 297 days; two at 130 miles were recovered, one on the coast of Northumberland, after 98 days—probably brought back by the reversed current—and one on 30th July 1897, after 285 days, on the Danish coast. One from each of the lots set adrift at 150, 200, 250, and 300 miles (the latter point about 74 miles west of Heligoland) were subsequently found. The one from 200 miles was caught in a trawl net 100 miles E. by N. of Spurn Point, Yorkshire. That from 150 miles was got on the Danish coast of the Skagerack on 28th September 1897; the one from 250 miles was found at Ringkjöbing, on the west coast of Denmark, in July; and that from 300 miles, at Jædern, Norway, on 26th February, after 131 days.

In the December series 120 bottles were used, of which 50, or nearly 48 per cent., were recovered. Seven of the twenty set adrift at 60 miles from May Isle were found on the island of Sylt, Schleswig, on the coast of Denmark, and the west coast of Sweden, from 31st July to 30th August 1897, the periods varying from 221 to 251 days; the one that went furthest—to the Bohuslän coast, Sweden, was picked up after 240 days. Two others of this lot were got later, in November and December, after 329 and 359 days, at the mouth of the Christianiafjord. Thirteen of the twenty set adrift at 100 miles were recovered, three off the Schleswig coast on 31st July and 12th and 13th August 1897, and the remainder in August and the first two days of September, on the west coast of Denmark. Six from 200 miles were found; one on 10th April 1897, at Sumburgh, Shetland, one on 28th October on the Danish shore of the Skagerack, one on the 30th of the same month, near Stromstad, Sweden, and the others on the coast of Norway, one near Bergen on 19th September, one on 28th October, after 309 days, further north, near Askevold, N. Berghus, the third on 20th March 1898, near Aalesund, Romsdal. Of those set adrift at 250 miles, seven were recovered; one, on 10th August 1897, at Harboore on the Danish coast; two on the west coast of Sweden on 18th September and 28th December; and the others in Norway in September, October, and December, between Kragerö and Udsire, off the Bukkefjord. Five of those set adrift at 300 miles were found in August and September 1897, four on the south and south-west coast of Norway, and one on the west coast of Sweden. Of twenty set adrift at 350 miles—about 24 miles west of Heligoland—ten were recovered; the first 16 days later at the Horn, Denmark; two others in July and August, also on the Danish coast; one on the west coast of Sweden in August, and six on the south-west coast of Norway in May, June, July, November, and December 1897.

The results, then, of this further information as to the surface-drift of the water of the North Sea are in agreement with the conclusions stated in my previous paper. The Atlantic water coming into the North Sea passes down the east coasts of Scotland and England to about the neighbourhood of the Wash; it then crosses towards the coast of Schleswig and Denmark and passes northwards to the south coast of Norway, and thence northwards along the west coast of Norway. Sometimes it passes into the Skagerack to the coast of Sweden and the Christianiafjord.

The value of the above drift-bottle observations is discussed in a recent work by Professor Otto Pettersson of Stockholm, dealing with the hydrography of the North Atlantic.*

* Die hydrographischen Untersuchungen des Nordatlantischen Ozeans in den Jahren, 1895-1896. *Petermann's Geogr. Mitteil,* 1900, Heft. 1., II.

TABLE SHOWING PARTICULARS OF DRIFTERS.

Date and Position where set Adrift.			No.	Date and Position where Recovered.		*Minimum Distance travelled in Geog. Miles.	Time between setting away and Recovery. Days.	Number previously Recovered of same Lot.
Date.	Number of Bottles.	Position.		Date.	Position.			
1894. 5 Nov.	20	8 miles S.E. of Buchan Ness,	503	20 Nov. '99	Fröya Island, S. Trondhjem, Norway,	480	1840	4
1895. 2 Aug.	10	Station VIII., Moray Firth,	504	17 Dec. ,,	2 miles W. of Mandal, S. Norway,	320	1597	2
1896. 22 July	10	½ mile S.E. of Bell Rock,	505	1 Nov. '97	Engel Island, Nordland, Norway,	.	467	5
,, ,,	10	10½ miles S.E. of Bervie,	506	1 April ,,	Jæderens Rev, 21 miles S. of Stavanger, Norway,	280	252	1
.	.	. . .	507	15 May ,,	Blom. Herlo, 5 miles from Bergen, Norway,	310	297	.
,, ,,	10	6 miles S.E. of Girdleness,	508	1 July ,,	Near Hirtshals Light, Denmark,	380	344	1
,, ,,	10	4 miles S.E. of Buchan Ness,	509	5 May ,,	Wangsaa, 8 miles S. of Hantsholm, Denmark,	315	287	5
.	.	. . .	510	3 Aug. ,,	Udvaar Oerne, between Christiansand and Mandal, Norway,	285	377	.
,, ,,	10	8 miles N.N.E. Troup Head, Banffshire,	511	12 July ,,	1 mile (Danish) S. of Thyboron Kanal, near Harboore, Denmark,	330	355	3
.	.	. . .	512	,, ,, ,,	Near Rinkjöbing, Denmark,	345	355	.
,, ,,	10	8 miles N.N.E. of Scarnose Point, Banffshire,	513	21 Oct. ,,	3 miles S. of Strömstad, Hæstersund, Sweden,	430	456	3
30 ,,	10	Lat. 61° 1′ N., long. 3° 13′ W.,	514	22 April ,,	Purköen, Vinjevaagen, Nordland, Norway,	700	266	1
,, ,,	.	,, ,, ,, ,,	515	29 May ,,	Stappen Island, North Cape, Norway,	930	312	.
4 Aug.	15	Lat. 61° 18½′ N., long. 4° 21¼′ W.,	516	3 Aug. ,,	Rödö, Helgeland, Norway,	.	365	1
6 ,,	20	Lat. 60° 2′ N., long. 7° 4′ W.,	517	14 Mar. '98	Mousa Island, Shetland,	200	587	5
,, ,,	.	,, ,, ,, ,,	518	4 Nov. '97	Veiholmen, Romsdal, Norway,	420	455	.
		Between May Isle and Hamburg.						
15 ,,	5	13 miles S.S.E. of May Isle,	519	19 May '97	Vigsobugten, Hillerslev, Denmark,	.	278	.
,, ,,	5	20 miles S.S.E. of May Isle,	520	26 June ,,	12 miles E. of Hantsholm, Denmark,	330	306	.
,, ,,	5	30 miles S.S.E. of May Isle,	521	29 ,, ,,	Skjaldoen, 44 kilom. N. from Bergen, Norway,	360	309	1
		Between May Isle and the Naze of Norway.						
21 ,,	5	10 miles E. ½ S. of May Isle,	522	27 July ,,	Husby, Nymindegab, Denmark,	320	340	2

*The distance stated is approximate.

TABLE SHOWING PARTICULARS OF DRIFTERS—*continued.*

Date and Position where set Adrift.			No.	Date and Position where Recovered.		Minimum Distance travelled in Geog. Miles.	Time between setting away and Recovery. Days.	Number previously Recovered of same Lot.
Date.	Number of Bottles.	Position.		Date.	Position.			
1896. 21 Aug.	5	20 miles E. ½ S. of May Isle,	523	12 July '97	Vangsaa, Hundborg, Denmark,	330	325	.
,, ,,	5	30 miles E. ¼ S. of May Isle,	524	22 June ,,	Bjerregaard, Nymindegab, Denmark,	320	305	.
,, ,,	.	,, ,, ,, ,,	525	20 Jan. '98	Sydkoster, Strömstad, Sweden,	450	517	.
,, ,,	5	50 miles E. of May Isle,	526	26 ,, ,,	Maskar, near Koster, Strömstad, Sweden,	430	523	1
13 Oct.	10	4 miles S.E. of Stonehaven,	527	12 July '97	3½ miles N. of Nymindegab, Denmark,	335	273	3
,, ,,	10	5 miles S.E. of Girdleness,	528	11 ,, ,,	W. side of Römo, N. Schleswig,	370	272	1
,, ,,	.	,, ,, ,, ,,	529	16 May ,,	Sondervig, Ringkjöbing, Denmark,	330	216	.
,, ,,		,, ,, ,, ,,	530	6 Aug. ,,	Near Varde, Ribe, Denmark,	340	298	.
,, ,,	.	,, ,, ,, ,,	531	7 July ,,	Rögö, Fjellbacka, Skagerack, Sweden,	430	268	.
14 ,,	10	4 miles S.E. of Buchan Ness,	532	8 ,, ,,	Alnmouth, Northumberland,	110	268	6
,, ,,	.	,, ,, ,, ,,	533	11 Dec. ,,	1 mile N. of Lodberg Light, Denmark,	320	424	.
		Between May Isle and Hamburg.						
1896. 18 Oct.	10	100 miles S.E. by E. of May Isle,	534	11 Aug. ,,	Manö, Jutland, Denmark,	240	298	.
,, ,,	5	130 miles S.E. by E. of May Isle,	535	30 July ,,	16 miles N. of Nymindegab, Denmark,	230	256	1
,, ,,	5	150 miles S.E. by E. of May Isle,	536	28 Sept. ,,	Raabjerg, Skagerak, Denmark,	280	346	.
,, ,,	5	250 miles S.E. by E. of May Isle,	537	12 July ,,	Vesterhavet, Ringkjöbing, Denmark,	140	268	.
,, ,,	5	300 miles S.E. by E. of May Isle,	538	26 Feb. ,,	Reime, Obristad Light, Jœderen, Norway,	220	132	.
		Between May Isle and the Naze of Norway.						
23 ,,	5	75 miles E. ½ S. of May Isle,	539	13 Sept. ,,	Klitmoeller, 3 miles S. of Hanstholmen, Denmark,	270	326	.
,, ,,	.	,, ,, ,, ,,	540	28 ,, ,,	Vorra Hamnen, Lysekil, Sweden,	380	341	.
,, ,,	.	,, ,, ,, ,,	541	24 Dec. ,,	Hono Island, near Göteborg, Sweden,	380	428	.
,, ,,	10	100 miles E. ½ S. of May Isle,	542	24 Mar. ,,	Sandwick Bay, Shetland,	210	153	.
,, ,,	.	,, ,, ,, ,,	543	12 July ,,	W. side Sanneshage, Jutland, Denmark,	260	263	.

TABLE SHOWING PARTICULARS OF DRIFTERS—*continued.*

Date and Position where set Adrift.			No.	Date and Position where Recovered.		Minimum Distance travelled in Geog. Miles.	Time between setting away and Recovery. Days.	Number previously Recovered of same Lot.
Date.	Number of Bottles.	Position.		Date.	Position.			
1896. 23 Oct.	.	100 miles E. ½ S. of May Isle,	544	2 Sept.'97	Obrestad Lighthouse, Naerbo, near Stavanger, Norway,	210	315	.
6 Nov.	5	130 miles E. ½ S. of May Isle,	545	6 ,, ,,	Ronglevar, 5 miles N. of Bergen, Norway,	250	273	.
,, ,,	5	150 miles E. ½ S. of May Isle,	546	8 Mar. ,,	Sulen Island, N. of Bergen, Norway,	275	122	1
,, ,,	.	,, ,, ,, ,,	547	15 ,, ,,	Goddehavn, 2 miles S. of Slattero Light, Norway,	.	129	.
7 ,,	5	250 miles E. ½ S. of May Isle.	548	29 May ,,	Blomvaag, near Bergen, Norway,	180	172	1
		Between Leith and the Hook of Holland.						
1 Nov.	7	46 miles N.E. by E. of Cromer, Norfolk,	549	6 April ,,	Thorupstrand, Thisted, Denmark,	300	157	1
,, ,,	.	,, ,, ,, ,,	550	18 May ,,	Near Husby, Ringkjöbing, Denmark,	260	199	.
,, ,,	8	57 miles E. ½ S. of Cromer,	551	2 April ,,	30 miles E. of Hantsholm, in the Jammerbugt, Denmark,	310	153	.
,, ,,	.	,, ,, ,, ,,	552	5 June ,,	Landö, East of Mandal, Norway,	330	217	.
,, ,,	8	57 miles E. by N. ½ E. of Lowestoft,	553	27 ,, ,,	Blokhus, Denmark,	320	239	.
,, ,,	8	37 miles N. by W. of Scheveningen, Holland,	554	9 May ,,	Oester Klit, near Sindal,	.	190	.
,, ,,	.	,, ,, ,, ,,	555	8 July ,,	Thorsminde, Jutland, Denmark,	230	250	.
,, ,,	.	,, ,, ,, ,,	556	7 ,, ,,	6 miles N. of Nymindegab, Denmark,	.	249	.
		Between the Isle of May and the Naze of Norway.						
25 Dec.	20	30 miles E. of May Isle,	557	9 ,, ,,	1 mile S. of Agger, near Vestervig, Denmark,	320	197	.
,, ,,	.	,, ,, ,, ,,	558	24 Aug. ,,	Lodbjerg Light, near Agger, Denmark,	320	243	.
,, ,,	.	,, ,, ,, ,,	559	28 ,, ,,	Kinn, near Sulen, Norway,	350	247	.
,, ,,	.	,, ,, ,, ,,	560	30 Dec. ,,	Near Karingo, Bohuslän, Sweden,	430	370	.
,, ,,	20	100 miles E. of May Isle,	561	30 Mar. ,,	1 mile W. of Risör, Norway,	310	96	.
,, ,,	.	,, ,, ,, ,,	562	14 June ,,	Stora Kornö Island, near Lysekil, Sweden,	360	172	.

TABLE SHOWING PARTICULARS OF DRIFTERS—*continued.*

Date and Position where set Adrift.			No.	Date and Position where Recovered.		Minimum Distance travelled in Geog. Miles.	Time between setting away and Recovery. Days.	Number previously Recovered of same Lot.
Date.	Number of Bottles.	Position.		Date.	Position.			
1896. 25 Dec.	.	100 miles E. of May Isle,	563	1 July '97	Humlekärr. 6 miles N.E. of above, Sweden,	360	189	.
,, ,,	.	,, ,, ,, ,,	564	27 Sept. ,,	Stolmöen, near Bergen, Norway,	240	277	.
,, ,,	.	,, ,, ,, ,,	565	20 Jan. '98	Lindholmen, S. of Strömstad, Sweden,	360	392	.
25 ,,	.	150 ,, ,, ,,	566	9 April '97	Airth, Fetlar, Shetland,	200	106	.
26 ,,	20	200 ,, ,, ,,	567	2 Mar. ,,	Maskerö, near Stavanger, Norway,	110	67	9
,, ,,	20	250 ,, ,, ,,	568	7 Mar. '98	Rakvaag, Akero, near Molde, Norway,	330	72	9
,, ,,	20	300 ,, ,, ,, (about 32 miles W. of the Naze of Norway),	569	16 April '97	8 miles S. of Egersund. Norway,	30	112	6
,, ,,	.	,, ,, ,, ,,	570	20 July ,,	Valvœr, Rödö, Helgeland, Norway,	600	207	.
,, ,,	.	,, ,, ,, ,,	571	30 Sept. ,,	20 kilom. S.S.E. of Haugesund, Norway,	80	279	.
		Between the Isle of May and Hamburg.						
23 Dec.	20	60 miles from May Isle,	572	31 July ,,	Island of Sylt, Schleswig,	320	221	.
,, ,,	.	,, ,, ,, ,,	573	14 Aug. ,,	Harboore, Denmark,	300	235	.
,, ,,	.	,, ,, ,, ,,	574	18 ,, ,,	Bjergehuse, Denmark,	.	239	.
,, ,,	.	,, ,, ,, ,,	575	19 ,, ,,	Island of Sylt, Schleswig,	320	240	.
,, ,,	.	,, ,, ,, ,,	576	19 ,, ,,	Längeskar, Hafstensund, Bohuslän, Sweden,	430	240	.
,, ,,	.	,, ,, ,, ,,	577	26 ,, ,,	1 mile N. of Horus Rev, near Varde, Denmark,	310	247	.
,, ,,	.	,, ,, ,, ,,	578	30 ,, ,,	Kjettrupgaard, Blokhus, Denmark,	350	253	.
,, ,,	.	,, ,, ,, ,,	579	18 Nov. ,,	Langöen, Vigsfjord, W. of Færder, Norway,	420	331	.
,, ,,	.	,, ,, ,, ,,	580	18 Dec. ,,	Onso, near Fredrikstad, Norway,	430	361	.
,, ,,	20	100 ,, ,, ,,	581	31 July ,,	Westerland, Sylt Island. Schleswig,	270	221	.
,, ,,	.	,, ,, ,, ,,	582	13 Aug. ,,	Near Kampen, Sylt, Schleswi	270	234	.
,, ,,	.	,, ,, ,, ,,	583	12 ,, ,,	Wijk, Föhr Island, Schleswig,	275	233	.
,, ,,	.	,, ,, ,, ,,	584	13 ,, ,,	Haurvig Jutland, Denmark,	250	234	.

TABLE SHOWING PARTICULARS OF DRIFTERS—*continued.*

Date and Position where set Adrift.			No.	Date and Position where Recovered.		Minimum Distance travelled in Geog. Miles.	Time between setting away and Recovery. Days.	Number perviously Recovered of same Lot.
Date.	Number of Bottles.	Position.		Date.	Position.			
1896. 23 Dec.	.	100 miles from May Isle,	585	17 Aug. '97	10 miles N. of Nymindegab, Denmark,	250	238	.
,, ,,	.	,, ,, ,, ,,	586	17 ,, ,,	Klegod, Jutland, Denmark,	250	233	.
,, ,,	.	,, ,, ,, ,,	587	18 ,, ,,	8 miles N. of Nymindegab, Denmark,	250	239	.
,, ,,	.	,, ,, ,, ,,	588	18 ,, ,,	Nordby, Fanö Island, Denmark,	270	239	.
,, ,,	.	,, ,, ,, ,,	589	20 ,, ,,	17 miles N. of Nymindegab, Denmark,	260	241	.
,, ,,	.	,, ,, ,, ,,	590	20 ,, ,,	7 miles N. of Ringkjöbing, Denmark,	250	241	.
,, ,,	.	,, ,, ,, ,,	591	20 ,, ,,	9 miles N. of Nymindegab, Denmark,	250	241	.
,, ,,	.	,, ,, ,, ,,	592	25 ,, ,,	Sonderho, Fanö Island, Denmark,	270	246	.
,, ,,	.	,, ,, ,, ,,	593	2 Sept. ,,	Vedsted, 7 miles S.W. of Ribe, Denmark,	270	254	.
,, ,,	20	200 ,, ,, ,,	594	10 April ,,	Upper end West Voe of Sumburgh, Shetland,	310	108	.
,, ,,	.	,, ,, ,, ,,	595	19 Sept. ,,	Lönöen, Fjeld, near Bergen, Norway,	300	271	.
,, ,,	.	,, ,, ,, ,,	596	28 Oct. ,,	Inside Hindo Island, near Askevold, N. Berghus, Norway,	360	310	.
,, ,,	.	,, ,, ,, ,,	597	28 , ,,	Skiveren, Raabjerg, Horns Herred, Skagerak, Denmark,	270	310	.
,, ,,	.	,, ,, ,, ,,	598	10 Dec. ,,	Onsöen, 2 miles E. of Lillesand, Norway,	250	353	.
,, ,,	.	,, ,, ,, ,,	599	30 ,, ,,	2 miles S.W, of Strömstad, Sweden,	340	342	.
,, ,,	.	,, ,, ,, ,,	600	20 Mar. '98	Fjortofr, Aalesund, Sondmore, Norway,	440	453	.
,, ,,	.	250 ,, ,, ,,	601	10 Aug. '97	Harboöre, near Lemvig, Denmark,	160	231	.
,, ,,	.	,, ,, ,, ,,	602	13 Sept. ,,	N. side of Udsire Island, 20 miles W. of Haugesund, Norway,	250	265	.
,, ,,	.	,, ,, ,, ,,	603	18 ,, ,,	1½ Swedish miles S. of Fjellbaka, Sweden,	310	270	.
,, ,,	.	,, ,, ,, ,,	604	13 Oct. ,,	Risevigen, Tananger, Stavanger, Norway,	250	295	.
,, ,,	.	,, ,, ,, ,,	605	18 ,, ,,	N. of Haugesund, at Bommelfjord, Norway,	260	300	.
,, ,,	.	,, ,, ,, ,,	606	3 Dec. ,,	Straaholmen, 4 miles N. of Jamfurlands Light, near Kragero, S. Norway,	280	346	.

TABLE SHOWING PARTICULARS OF DRIFTERS—*continued.*

Date and Position where set Adrift.			No.	Date and Position where Recovered.		Minimum Distance travelled in Geog. Miles.	Time between setting away and Recovery. Days.	Number previously Recovered of same Lot.
Date.	Number of Bottles.	Position.		Date.	Position.			
1896. 23 Dec.	.	250 miles from May Isle,	607	28 Dec. '97	Rässo Island, near Strömstad, Sweden,	330	370	.
24 ,,	20	300 ,, ,, ,,	608	1 Aug. ,,	Fiskeback, near Göteborg, Sweden,	290	220	.
,, ,,	.	,, ,, ,, ,,	609	17 ,, ,,	2 miles N. of Noshavn Tysnœsoen, near Bergen, Norway,	340	237	.
,, ,,	.	,, ,, ,, ,,	610	28 ,, ,,	Homborgsund, near Lillesand, S. Norway,	220	248	.
,, ,,	.	,, ,, ,, ,,	611	4 Sept. ,,	Ona, near Molde, Norway,	400	255	.
,, ,,	.	,, ,, ,, ,,	612	9 ,, ,,	Ulvosund, 20 kilom. E. of Christiansand, S. Norway,	230	260	.
,, ,,	.	350 ,, ,, ,, (about 24 miles W. of Heligoland)	613	20 May ,,	Klaksöen, W. of Stordöen, S. Bergenhus, Norway,	320	147	1
,, ,,	.	,, ,, ,, ,,	614	10 June ,,	½ mile W. of Bulbjerg, near Bjerget, Norway,	.	167	.
,, ,,	.	,, ,, ,, ,,	615	22 July ,,	Tranum, Rödhus, Aabybro, Norway,	.	208	.
,, ,,	.	,, ,, ,, ,,	616	18 ,, ,,	Hermö, near Bergen, Norway,	350	204	.
,, ,,	.	,, ,, ,, ,,	617	31 ,, ,,	Harboore Sojn, Ringkjöbing, Denmark,	110	218	.
,, ,,	.	,, ,, ,, ,,	618	25 Aug. ,,	Fjellbacka, Bohuslän, Sweden,	300	212	.
,, ,,	.	,, ,, ,, ,,	619	23 ,, ,,	3 miles E. of Hansthomen, Denmark,	160	210	.
,, ,,	.	,, ,, ,, ,,	620	20 Nov. ,,	Nœsvig Tellevaager, Nordhordland, 6 miles from Bergen, Norway,	350	330	.
,, ,,	.	,, ,, ,, ,,	621	10 Dec. ,,	Sartör, 20 miles W. by N. of Bergen, Norway,	350	350	.
28 Dec.	10	Off Girdleness, Aberdeenshire,	622	13 ,, ,,	Sanday Island, Orkney,	130	350	2
29 ,,	10	50 miles S. by W. of Copinsha Isle, Orkney,	623	4 April ,,	Meal, Cunningsburgh, Shetland,	130	97	1
		Between Isle of May and Hook of Holland.						
1897. 3 Jan.	20	46 miles N.E. by S. of Cromer, Norfolk,	624	31 Mar. ,,	Risberg, 10 miles S. of Hirtshals, Denmark,	350	87	.
,, ,,	20	32 miles N. by W. of Hook,	625	5 April ,,	1 mile W. of the Skaw, Denmark,	300	92	5
,, ,,	.	,, ,, ,, ,,	626	3 May ,,	Solost Rocks, Tysver, Stavanger, Norway,	300	120	.
17 ,,	10	50 miles S.S.W. of Bressay Light, Shetland,	627	26 Oct. ,,	Rosöen, Kvitingso, near Stavanger, Norway,	200	282	.

TABLE SHOWING PARTICULARS OF DRIFTERS—*continued.*

Date and Position where set Adrift.			No.	Date and Position where Recovered.		Minimum Distance travelled in Geog. Miles.	Time between setting away and Recovery. Days.	Numbe previously Recovered of same Lot.
Date.	Number of Bottles.	Position.		Date.	Position.			
1897. 17 Jan.	.	50 miles S.S.W. of Bressay Light, Shetland,	628	10 Nov. '97	Ingöen, 7 miles from Hammerfest, Norway,	900	297	.
,, ,,	.	,, ,, ,, ,,	629	18 Feb. '98	Godden, Finaas, 60 km. S. of Bergen, Norway,	190	397	.
,, ,,	10	100 miles S.S.W. of Bressay Light,	630	14 Sept. '97	4 miles E. of Hirtshals Light, Denmark,	350	240	.
,, ,,	.	,, ,, ,, ,,	631	15 ,, ,,	Komelsfjord, near Christiansand, Norway,	290	241	.
,, ,,	.	,, ,, ,, ,,	632	23 Nov. ,,	Randöen, near Christiansand, Norway,	290	310	.
,, ,,	.	,, ,, ,, ,,	633	5 Feb. '98	Straaholmen Island, near Kragero, S. Norway,	340	385	.
10 Feb.	100	4 miles E. of Isle of May, Firth of Forth,	634	*27 April '97	Got in a trawl net 6 miles E. of May,	2	76	.

* This is the only bottle recovered of 100 put away on this occasion; all were weighted to go to the bottom.

XI.—NOTES ON SOME GATHERINGS OF CRUSTACEA COLLECTED FOR THE MOST PART ON BOARD THE FISHERY STEAMER "GARLAND" AND EXAMINED DURING THE PAST YEAR (1899).

By THOMAS SCOTT, F.L.S., Mem. Zool. Soc. de France.

(Plates XIII. and XIV.)

The following "Notes" are intended to supplement a somewhat similar series published in Part III. of the *Seventeenth Annual Report.* These notes deal entirely with the Crustacea, and refer to species that have been observed in various gatherings of tow-net and dredged materials examined during the past year, and collected for the most part on board the "Garland." The majority of the species referred to have been obtained in gatherings collected in Loch Fyne and in the seaward portion of the Firth of Clyde, but a few are also from other parts of the Scottish coasts; moreover, with the exception of one or two brackish-water forms those recorded are all marine species.

A few of the copepods mentioned in the sequel are apparently undescribed, but most of the other forms have already been recorded. Further information concerning these has, however, been obtained bearing on their structural details or on the distribution of the species, which it will be of interest to notice.

My son, Mr. Andrew Scott (assisted by Mrs. Scott), has prepared drawings to illustrate where necessary the various objects described. Several forms other than those mentioned in the sequel have had to stand over, but these will be described later.

COPEPODA.

Eucalanus crassus, Giesbrecht.

1888. *Eucalanus crassus*, Giesb., Atti Acc. Lincei, Rend. (4), vol. iv,, sem. 2, p. 333.

A considerable number of specimens of this species were obtained in a bottom tow-net* gathering collected in Dornoch Firth, November 19th, 1898. The depth at which the tow-net was worked varied from 8 to 16 fathoms. A large proportion of the specimens obtained were more or less immature. This *Eucalanus* has been obtained in the Moray Firth district on several occasions during the past few years, but it was apparently more frequent in the present gathering than in any of those previously examined. It is somewhat difficult to distinguish the immature forms of the species, but the adults are comparatively easily distinguished. When it is remembered that the distribution of *Eucalanus crassus* extends south as far at least as the Gulf of Guinea, its presence in the Moray Firth from time to time is of more than usual interest.

* What is here called the "bottom tow-net" is the tow-net that is fastened to the trawl-head in such a way that when the trawl is working the tow-net just clears the sea-bottom.

Eucalanus elongatus (Dana).

1849. *Calanus elongatus*, Dana, Proc. Amer. Acad., vol. ii, p. 18.

A single specimen—a female—was obtained in the same gathering with the last. This is a larger species than *Eucalanus crassus*; the specimen referred to here measured fully 6mm. in length (about a quarter of an inch). In this species the last thoracic segment has the sides produced posteriorly into short pointed processes. The presence of *Eucalanus elongatus* in the Moray Firth is also of interest as bearing on the question of the distribution of species. These copepods are probably carried into the estuary by regular tidal currents or by temporary currents set up by the wind, should it happen to blow from one particular direction for a more or less lengthened period.

Neither of the two species named have yet been observed in the Firth of Forth or the Firth of Clyde. These two estuaries, though extending for a considerable distance inland, are comparatively narrow, and the entrance to each is obstructed to some extent by an island; the Moray Firth, on the other hand, presents an extensive opening to the North Sea and narrows very gradually westwards. Such a difference in the general contour of these inlets has probably a more or less distinct influence on the distribution of their local faunas.

Paracalanus parvus (Claus).

1863. *Calanus parvus*, Claus, Die freileb. Copep., p. 173, Pl. XXVI., figs. 10–14; Pl. XXVII, figs. 1–4.

This small species has been observed in gatherings collected during the past year both in the Clyde and Loch Fyne, and usually in bottom tow-net gatherings. It was, for example, observed in a bottom-gathering from Station V. (Whiting Bay, Arran), collected September 8th, and in another from Station XVII. (near the head of Loch Fyne), collected September 29th.

Stephus fultoni, T. and A. Scott.

1898. *Stephus fultoni*, T. and A. Scott, Ann. and Mag. Nat. Hist. (7). vol. i., p. 185, Pl. X., figs. 1–8; Pl. II., figs. 1–4.

Stephus fultoni has apparently not yet been observed outside the Clyde area. It was first observed in 1896 in some material dredged in Kilbrennan Sound, and subsequently in a small gathering of crustacea collected near the Spit, Loch Fyne, in 1897. I have now to record its occurrence for the second time at this Loch Fyne Station; the material in which it was obtained on the present occasion was collected during the early part of this year (1899), and a few specimens only were observed. *Stephus fultoni*, which seems to be a rare species, is comparatively easily distinguished from the other members of the genus by the somewhat larger size of the female and by the male having the fifth thoracic feet conspicuous and furnished with horn-coloured processes.

Bradyidius armatus (Vanhöffen).

*1897. *Bradyanus armatus* (Vanhöffen in:) Chun, Arkt. antarkt. Plankton, p. 28.

It was pointed out in my "Notes" last year that *Bradyidius armatus* was one of the more widely diffused of the Clyde copepods, and that it was also occasionally observed on the East Coast. During the past year

* *Vide* Das Tierreich, p. 32.

it has again been observed in several of the gatherings sent to the Fishery Board's Laboratory from the Clyde. In 1897 a new genus was instituted for this copepod by Dr. W. Giesbrecht, of Naples, but it appears to be one of those species whose lot it is to undergo several removals ere it reaches its ultimate destination, as indicated by the following quotation from a work lately published by Herr. O. Nordgaard, entitled, "Report on Norwegian Marine Investigations, 1895–97." At page 21 of his report, Herr. Nordgaard refers to the species under consideration as follows:—

"In 'Undersögelser over Dyrelivet i Arktiske Fjorde' Herr Sparre Schneider has mentioned a copepod that is called *Undinopsis bradyi*, G. O. Sars. This species is said to have been found in Kvænangen and at Tromsö. In the summer of 1897 I showed Professor Sars a preparation of a copepod that I was unable to identify. He then declared it to be the very *Undinopsis bradyi*, and afterwards informed me in a letter that the said copepod had been described by Mr. Brady (Monograph of the Copepoda of the British Islands, i., p. 46, Pl. IV., figs. 1–11).

The species was, however, there wrongly identified with *Pseudocalanus armatus*, Boeck, which, according to Mr. Sars, is another species. As Mr. Sars in his gigantic revision of Norwegian Crustacea will soon come to the Copepoda, I shall do nothing but here note the occurrence of *Undinopsis bradyi* at the following places:—

March 14th, 1896, Vestfjord (67° 32·5′ N.; 130° 24·5′ E.) in Plankton 0·200m.

March 5th, 1897; Ostnes-fjord in Lofoten.

March 7th, 1897, Irold-fjord in Lofoten, Plankton 0·65m.

Besides, I have this year (1899) taken several specimens of the species in fjords near Bergen."

This note by Herr. Nordgaard is of interest, if for nothing else than the information he gives concerning the distribution of the species, but it also indicates that Professor Sars' designation is likely to take precedence over that of *Bradyidius armatus* of Drs. Giesbrecht and Vanhöfen. It is doubtful, however, if this copepod will be allowed to rest under *Undinopsis bradyi*, for it is by no means a rare species, and, as Herr. Nordgaard and Professor Sars have shown, it has a wide distribution. It is probable, therefore, that it has not escaped the notice of some of the earlier naturalists, and may be described and named in their published works by a designation different from any of those referred to.

Isias clavipes, Boeck.

1864. *Isias clavipes*, Boeck, Forh. Vid. Selsk., Christiania, p. 18.

This, which is a moderately rare species, has again been observed in several of the tow-net gatherings forwarded from the Clyde during recent months. The specimens obtained were found for the most part in gatherings collected in the tow-net fixed to the head of the trawl, and appeared to be most frequent in the gatherings collected in September. The species was taken in Kilbrennan Sound at Stations III. and IV., near Sanda Island, and in the vicinity of Ailsa Craig. I have no records of *Isias* from Loch Fyne this year. It may be of interest to mention that it was also during September last year that *Isias* was chiefly observed.

Eurytemora velox (Lilljeborg).

1853. *Temora velox*, Lillj., De Crustac. ex ordin. tribus; Cladoc. Ostrac. et Copep. in Scania occurr., p. 177, Pl. XX., figs. 2–7.

This species was found in a small pond near the New Zoological

Station at Millport, Cumbrae, and also in shore pools at the south-west corner of the island on May 6th, 1899. Professor G. S. Brady obtained the species from Cumbrae many years ago, and it is interesting to find it in the same localities in which it was then observed.

Eurytemora affinis (Poppe).

1880. *Temora affinis*, Poppe, Abhandl. d. Naturw. Ver. Bremen, Bd. vii., pp. 55–60, Pl. III.

I find this species in rock pools near low-water mark at Bay of Nigg, Aberdeen (just in front of the New Laboratory of the Fishery Board for Scotland), where it is not uncommon. It also occurred in a large pool left by the ebbing tide near the bridge where the railway crosses the River Dee. These species of *Eurytemora* require careful examination in order to distinguish the one from the other.

Metridia lucens, Boeck.

1864. *Metridia lucens*, Boeck, Forh. Vid. Selsk., Christiania, p. 14.

This species was moderately frequent in a bottom tow-net gathering of Crustacea collected during the past year in Aberdeen Bay. In the Firth of Clyde, *Metridia lucens* appears to be one of the resident copepods, as it may be obtained there all the year round, though usually in small numbers. The more recent Clyde gatherings in which the species occurred, and of which I have notes, were collected in the bottom tow-net near the seaward part of the estuary.

Paramesophria cluthæ, Th. Scott.

1897. *Paramesophria cluthæ*, Th. Scott, *Fifteenth Rep. Fish. Board Scotl.*, Part III., p. 147, Pl. II., figs. 3–8; Pl. III., figs. 13–16.

This moderately large and distinct species was described from specimens dredged off Largabruach, Upper Loch Fyne, and I have now to record its occurrence at Tarbert Bank (off East Tarbert), Lower Loch Fyne; it was obtained amongst some material dredged from about 17 to 20 fathoms on October 21st, 1899. In one of the more recently published works on the Copepoda (Das Tierreich, Lief. 6), *Paramesophria* takes its place amongst the Centropagidæ.

Labidocera wollastoni (Lubbock).

1857. *Pontella wollastoni*, Lubbock, Ann. and Mag. Nat. Hist. (2), vol. xx., p. 406, Pls. X.–XI.

Last year I recorded this fine species from two Clyde stations, both of which are near the seaward limits of the estuary. This year I have to record its occurrence in a bottom tow-net gathering (12 to 26½ fathoms), collected in the vicinity of Sanda Island, near the mouth of the Clyde, on September 5th, 1899; it was also obtained in a second gathering collected two days later in about 55 fathoms and somewhat further seaward. In a gathering collected in November a number both of males and females were found. This gathering was also from the mouth of the estuary. I also take this opportunity to record *Labidocera wollastoni* from the Firth of Forth. During the past summer I overhauled some tow-net gatherings that had been collected a few years ago, and found that one or two of them had not before been examined; in one collected to the east of

Inchkeith on June 8th, 1891, I found amongst other things a single male specimen of the *Labidocera* referred to. I do not think that this species has been before recorded from the Firth of Forth.

Cyclopina gracilis, Claus.

1863. *Cyclopina gracilis*, Claus, Die frei-leb. Copep., p. 104, Pl. X., figs. 8–15.

Specimens of this small but distinct species were obtained in a gathering of material dredged in the vicinity of Otter Spit, Upper Loch Fyne, during the early part of the year. This gathering contained a large number of comparatively rare copepods, several of which are referred to in the present "Notes."

Notodelphys prasina, Thorell.

1859. *Notodelphys prasina*, Thorell, Bidr. till Känned. om Krustac. i Ascid., p. 46, Pl. V., fig. 7.

This copepod has occurred frequently in Ascidians dredged from Tarbert Bank, Loch Fyne, during recent months. *N. prasina.* has very short caudal furca, and by this character alone it may be readily distinguished from the other species of *Notodelphys* hitherto recorded from Scotland. *Notodelphys allmani*, Thorell, is also occasionally found in Clyde Ascidians, but does not seem to be just so common as the species first named.

Doropygus pulex, Thorell.

1859. *Doropygus pulex*, Thorell, op. cit., p. 46, Pl. VI., fig. 8.

A few specimens of this curious species were obtained in Ascidians dredged at Tarbert Bank, Loch Fyne (17-20 fathoms), in October 1899. In this species the caudal furca are "slightly elongate" and "becoming gradually thin, or tapering, towards the distal end" (Canu, Copep. du Boulonn., p. 195). *Doropygus pulex* appears to be somewhat rare in the Clyde area.

Doropygus (?) *gibber*, Thorell.

1859. *Doropygus gibber*, Thorell, op. cit., p. 52, Pl. VIII., fig. 11.

One or two specimens of a *Doropygus*, apparently belonging to this species, were found in some dredged material from Tarbert Bank, Loch Fyne. Dr. Giesbrecht * considers this to be more nearly related to *Notopterophorus* than to *Doropygus*.

Doropygus porcicauda, G. S. Brady.

1878. *Doropygus porcicauda*, Brady, Mon. Brit. Copep., vol. i., p. 138, Pl. XXVII., figs. 1–9; Pl. XXXIII., figs. 14–16.

Several specimens of this large and apparently distinct species were obtained in the same dredged material as the last. In this species the caudal rami are of considerable length, somewhat divergent and more or less curved. It does not seem to be very uncommon in Loch Fyne Ascidians.

Enterocola (?) *fulgens*, Van Beneden. (Pl. XIII., figs. 21-27.)

1860. *Enterocola fulgens*, Van Ben., Bull. Acad. Belg. (2), vol. ix., p. 151, Pl. I.

I have on one or two different occasions found in gatherings of dredged material from the Clyde odd specimens of an *Enterocola* usually of a

* *Mittheil. Zool. Stat. Neapel*, vol. iii., p. 328 (1882).

larger size than either *Enterocola fulgens*, Van Beneden, or *Enterocola betencourti*, Canu, and which to some extent differs also in some of its structural details from both these forms. I prefer, however, in the meantime to regard our specimens as a "form" or variety of Van Beneden's *Enterocola fulgens* rather than institute a new species for their reception.

These Clyde specimens are found in the intestine—not the branchial cavity—of a small Ascidian. Usually only one Copepod is observed in each specimen of the Ascidian in which the parasites occur, and it also usually so fills up the part of the intestine in which it is lodged that it is with difficulty detached with its ovisacs *in situ*, one or both frequently breaking away while removing the Copepod from its environment.

All the specimens of the Copepods obtained as described, and which I have examined, appear to belong to the one species, but they vary greatly in size. The specimen represented by the drawing (fig. 21), measures little more than two millimetres (2·2mm.) in length, whilst another that I have measured extends to at least four millimetres. The ovisacs are of a distinctly reddish colour, so that when examining the Ascidians in which the Copepods occur one can see at a glance and without dissection whether a parasite is present by the red colour of the ovisacs showing itself through the thin wall of the intestine of the host.

The mouth-organs of the *Enterocola* are difficult to make out; they are all simple, and do not show much structure. Figures 22 and 23 represent what appear to be one of the antennules and one of the antennæ. The mouth takes the form of a short and somewhat cone-shaped process. There appears to be no mandibles properly so called, and, according to Dr. Canu, the absence of mandibles is one of the distinctive characteristics of the genus *Enterocola*. The (?) maxillæ (fig. 24) are broad foliaceous appendages, bearing on their distal margin a number of stout ciliated spines. The posterior foot-jaws are very stout, and terminate in very short but strong claw-like processes (fig. 25).

The first four pairs of thoracic feet are all very much alike. They are two-branched; the outer branches appear to be one-jointed, and are moderately stout, and taper towards the distal end; they are also furnished with two moderately long and plumose terminal setæ; the inner branches consist of short, stout, tapering appendages of a simple and almost rudimentary character (figs. 26 and 27). The fifth pair are conspicuous and broadly dilated appendages. The caudal furca are about twice as long as broad. The female carries two ovisacs, which in well grown specimens are about as long as the body of the copepod.

Gunenotophorus (?) *globularis*, Costa. (Pl. XIII., figs. 28–34; Pl. XIV., figs. 37 and 38).

1852. *Gunenotophorus globularis*, Costa, Fauna del Regno di Napoli, Entom. (1840).

A somewhat curious copepod, agreeing in almost every detail of structure with the species described by O. G. Costa under the name of *Gunenotophorus globularis*, was obtained in some dredged material from the vicinity of Sanda Island, Firth of Clyde, in December 1898. The species is said to occur in the branchial cavity of Ascidians, but this Clyde specimen (only one was obtained) occurred free amongst the dredged material, having probably come from a dredged Ascidian.

The entire length of the specimen was about five millimetres (about one-fifth of an inch). The body was considerably dilated, but the abdomen was more slender, and was quite distinct; the whole animal was strongly incurved, as shown by the figure (fig. 28, Pl. XIII). The specimen, which had a somewhat macerated appearance, did not exhibit much segmentation of the cephalon or thorax, but the abdomen, which was moderately elongated and cylindrical, was divided into four distinct segments, the first three of which were smaller than the last one; the last—or anal segment—was about as long as the combined length of the two that preceded it. The caudal furca were short and very divergent, extending outwards at almost right angles to the abdominal segment (fig. 34, Pl. XIII.). The antennules, which showed very little jointing, were very short and stout except the end joint, which was a small one (fig. 29, Pl. XIII.) The antennæ (fig. 30, Pl. XIII.) were also short and stout, and armed with a moderately strong but short and slightly clawed terminal spine. The mandibles with their palps resembled very closely the figures of these appendages given by Dr. Canu in his interesting work on the marine Copepoda (*Les Copepodes du Boulonnais*, Pl. XI., figs. 3 and 4). The biting part of the mandible is armed with five large teeth, arranged widely apart, and several minute, close-set, and slightly elongated spinules, while the palp ends in two short setiferous branches (fig. 31, Pl. XIII.). The maxillæ are broadly foliaceous, the masticatory lobe is armed with a series of spiniform setæ along the margin, and a number of stout, elongated plumose setæ adorn the margins of the maxilla-palp. The anterior foot-jaws are stout but simple one-jointed appendages furnished with several stout plumose terminal setæ (fig. 37, Pl. XIV.). The posterior foot-jaws (fig. 32, Pl. XIII.) are moderately stout, and armed with a short but comparatively strong terminal claw. There are also a number of setæ on the inner margin of these appendages.

The first pair of thoracic feet (fig. 38, Pl. XIV.) are stout and moderately short; both branches are three-jointed and of nearly the same length, and they are both provided with elongated and densely plumose setæ on the inner margins. The next three pairs, which are somewhat similar to each other, have the inner branches short and slender and apparently three-jointed, while the outer branches, which are also three-jointed, are moderately stout and elongate; neither the inner nor outer branches were observed to carry setæ, their only armature appeared to consist of one or two minute spines. The fifth feet appeared to be obsolete, but this appearance may have been due to the specimen being somewhat imperfect.

When it is remembered that the specimen here described was found free amongst a quantity of mixed dredgings, and not *in situ* in any Ascidian, and that, moreover, from the habitat of the animal its whole structure is more or less flaccid and more liable to injury than the stronger free-swimming forms, it need not be surprising that it should differ to a small extent from the more perfect and better preserved specimens. After a careful study of the characters of this Clyde specimen, I have little doubt that it belongs to the species to which it has been ascribed.

There does not seem to be any previous British record of *Gunenotophorus globularis*, and its occurrence in the Clyde estuary is therefore of interest.

Botryllophilus (?) *ruber*, Hesse.

1864. *Botryllophilus ruber*, Hesse, Ann. Sci. Nat. Zool. (5), t. i., Pl. XII., figs. 1 and 2.

I have noticed two, or perhaps three, specimens of a *Botryllophilus* in some material that was dredged at Tarbert Bank, Lower Loch Fyne, in the vicinity of East Tarbert. The specimens were not found *in situ* within any Ascidian, but were mixed up amongst the debris; their host had probably been damaged by the lip of the dredge so that they escaped.

According to Dr. Canu, the characteristics of the genus *Botryllophilus* are shown particularly—First, in the structure and position of the thoracic feet; second, in the almost constant existence of a single ovigerous sac of a strictly spherical form sheltered between the fifth feet.

The peculiarity in the fifth thoracic feet in *Botryllophilus* consists mainly in their position on the last thoracic segment. Instead of occupying a position more or less on the ventral aspect of the segment, as is usual amongst the copepoda, the position of the fifth feet is more or less round towards the dorsal aspect, and as they each consist of a single-jointed, elongated, and somewhat curved spine-like appendage which projects more or less out from the body, they impart to the copepod a rather curious appearance.

After the above note on *Botryllophilus* had been sent to the printer, several specimens of the copepod were obtained *in situ* in a specimen of *Botryllus* sp. collected at Station X. in the Moray Firth on the 16th of June 1898. Some of the specimens carried a globular ovisac on the dorsal aspect between the fifth feet as stated above, but the ovisacs appear to be easily detached; they were of a pale cream colour, due, probably, to the long immersion in spirit of the *Botryllus*.

Canuella perplexa, T. and A. Scott.

1893. *Canuella perplexa*, T. and A. Scott, Ann. Scot. Nat Hist., vol. ii., p. 92, Pl. II., figs. 1–3.

This copepod was obtained in shore gatherings of Crustacea collected at Cumbrae, Firth of Clyde, between tide-marks May 6th, 1899, and in shore pools at Inverkip on the 13th of the same month. The species appeared to be moderately rare at both places. *Canuella* is widely distributed, but is apparently more frequent amongst weed and where the bottom is of a sandy nature.

Ectinosoma gracile, T. and A. Scott.

1896. *Ectinosoma gracile*, T. and A. Scott, Trans. Linn. Soc. (2. z.) vol. vi., p. 429. Pls. XXXVI., XXXVII., XXXVIII.

A few specimens of this very small species were obtained in shore pools at Inverkip, Firth of Clyde, May 13th, 1899. *Ectinosoma gracile* has already been recorded from near Sanda Island, Firth of Clyde; it appears to be widely distributed, but being very small is easily overlooked.

Tachidius brevicornis (Müller).

1776. *Cyclops brevicornis*, Müller, Zool. Dan., Prodr. (2414).

Though *Tachidius brevicornis* appears to be generally distributed, there are apparently few or no records of it as a member of the Clyde fauna. Being a brackish-water species, it need not be sought for except where such conditions exist, and as there are few shores around the British Islands where brackish-water pools are not to be found, the distribution of the species is correspondingly extensive. There are two species of *Tachidius* recorded for Britain, but the one referred to is readily distinguished by the structure of the fifth thoracic feet, which are of the form of two comparatively broadly, roundish plates, the free margins of which are fringed with setæ. The species was found in shore pools at Cumbrae in May 1899. The second species *Tachidius littoralis*, Poppe, has already been recorded from Hunterston, Firth of Clyde.*

Amymone nigrans, T. and A. Scott.

1894. *Amymone nigrans*, T. and A. Scott, Ann. and Mag. Nat. Hist. (6), vol. xiii., Pl. VIII., figs. 1–7.

This curious copepod is rather less than half a millimetre across the

* *Proc. Nat. Hist. Soc. Glasg.*, vol. V. (N.S.), p. 351, 1900.

longest diameter, and is of a blackish colour; it is therefore easily overlooked. The species have only hitherto been observed in Cromarty Firth, where it is not uncommon. I now record it for Loch Fyne, some specimens having been obtained in a gathering of dredged material collected near Otter Spit, Upper Loch Fyne, on January 12th, 1899.

Jonesiella fusiformis (Brady and Robertson).

1875. *Zosime fusiformis*, B. and R., Brit. Assoc. Rep., p. 196.

This seems to be the most frequent representative of the genus in Loch Fyne; in the Firth of Forth it is *Jonesiella spinulosa.*, B. and R., that is the more frequent species. *Jonesiella fusiformis* occurs not rarely in material dredged on Tarbert Bank, Lower Loch Fyne; it is collected here in almost every dredging that is taken. The latest record I have of *Jonesiella fusiformis* from this locality is December 12th, 1899.

Stenhelia blanchardi, T. and A. Scott.

1895. *Stenhelia blanchardi*, T. and A. Scott, Ann. and Mag. Nat. Hist. (6), vol. xvi. p. 353, Pl. XV., figs. 1–10.

This distinct but apparently rare copepod was dredged off Arisaig, Argyleshire, in 1892, though not described till 1895. No further specimens were observed till the present year (1899), when the species was again found; this time in some material dredged in the "Fluke Hole," off St. Monans, Firth of Forth, in 1896, and the examination of which had been delayed for want of time. This species is readily distinguished from others of the same genus by the form of the secondary branches of the fifth pair of thoracic feet, which terminate in hook-like processes. The occurrence of the species in the Firth of Forth tends to indicate that, though it seems to be rare, it may at the same time be widely distributed.

Canthocamptus inconspicuus, sp. n. (Pl. XIV., figs. 1–8.)

Description of the Female.—In general appearance this species is somewhat similar to *Canthocamptus parvus*, T. and A. Scott. The length of the specimen figured measures from the forehead to the end of the caudal furca 54mm. (about $\frac{1}{46}$ of an inch). The antennules, as in the species mentioned, are short and six-jointed; the third joint is longer than any of the others, being about equal to the entire length of the two joints preceding as well as of the two that follow it. The formula shows approximately the proportional lengths of the different joints—

Proportional lengths of the joints,	13 · 12 · 32 · 15 · 13 · 20
Number of the joints,	1 · 2 · 3 · 4 · 5 · 6.

The antennæ are each furnished with a one-jointed secondary branch. The mandibles are small, and they are provided with a small one-branched but moderately elongated palp (fig. 3). The first pair of thoracic feet have both branches three-jointed; the inner branches are considerably longer than the outer, and the first joint exceeds in length that of the second and third combined, as shown in the figure (fig. 5). The inner branches of the second, third, and fourth pairs, which are shorter than the outer branches, are only two-jointed, but the outer branches are three-jointed, moderately elongated, and sparingly setiferous (fig. 6). The fifth pair are small and foliaceous; the basal joint is broadly sub-triangular, while the secondary one is small and ovate; both are provided with a few setæ, arranged as shown in the drawing (fig. 7). The caudal segments are slender and about as long as the anal segment (fig. 8). The female carries one ovisac.

Remarks.—This copepod has a superficial resemblance to a small form, with six-jointed antennules, described by T. and A. Scott under the name of (?) *Canthocamptus parvus.** Like that form, the copepod now described has the antennules six-jointed, and the inner branches of the second, third, and fourth pairs of thoracic feet two-jointed, but the proportional lengths of the joints of the antennules are different, and the caudal furca, which in *Canthocamptus parvus* are very short, are in the species now described as long as the anal segment. No males have been observed.

Habitat.—Moray Firth; obtained amongst some dredged material.

Mesochra spinicauda, T. and A. Scott.

> 1895. *Mesochra spinicauda,* T. and A. Scott, Ann. and Mag. Nat. Hist. (6), vol. xv., p. 52, Pl. V., figs. 12–25.

This was one of several curious species that were found in shore pools at Musselburgh, Firth of Forth; the pools occurred between tide marks, but nearer low water, and were surrounded on all sides by beds of mussels. I am now able to record the occurrence of the species in shore pools near Millport, Cumbrae; it was obtained in some gatherings collected by hand-net on May 6th, 1899.

Tetragoniceps (?) *malleolata,* Brady. (Pl. XIV., figs. 9–17.)

> 1880. *Tetragoniceps malleolata,* Brady, Mon. Brit. Copep., vol. ii., p. 66, Pl. LXXVIII., figs. 1–11.

In Part III. of the *Tenth Annual Report of the Fishery Board for Scotland* (1892), p. 252,† I recorded the occurrence of a species of copepod which had been obtained in the Firth of Forth off St. Monans, and which I had ascribed to *Tetragoniceps malleolata,* G. S. Brady. I then pointed out, however, that this copepod, while agreeing in most points with the genus and species named, differed in so far as it possessed nine-jointed instead of eight-jointed antennules, and in the fifth pair of thoracic feet being two-jointed instead of being composed of only one joint. At the time the record was published, I was quite aware that the second of these two differences was, in view of the definition of the genus, a somewhat important one, but considered that, as the copepod referred to resembled the species named in almost all the other details of structure, it was better to ascribe it to that species rather than to institute a new genus or species for its reception.

During the past year I have obtained, in some dredged material from the Firth of Forth collected in 1896, but only recently examined, a few more specimens of the copepod referred to above, as well as of another and somewhat closely allied form that appears to be undescribed.

When the supposed *Tetragoniceps malleolata* was recorded in the *Tenth Annual Report* no detailed description of the form was given; a reference to the two principal points of difference was considered to be at that time all that was necessary for the identification of the form. The occurrence, however, of the closely allied and apparently undescribed species which I have alluded to makes it desirable that a description of both forms should now be given, so that the differences that have been observed between them may be more clearly indicated.

It may be considered doubtful whether the two forms to be described should be retained in the genus *Tetragoniceps,* but for the present, at

* *Ann. and Mag. Nat. Hist.* (6), vol. xviii., p. 6, Pl. II., figs. 14–22 (1896).

† Additions to the Fauna of the Firth of Forth, Part IV.

least, I prefer to leave them there. The earlier recorded form will be described first.

Description of (?) *Tetragoniceps malleolata*, Brady.

The body of this copepod is elongated and slender, tapering more or less gradually from the head to the extremity of the abdomen; the rostrum is short, the cephalic and thoracic appendages are moderately elongate, and the entire length of the specimen figured is ·89mm. (the $\frac{1}{28}$ of an inch). The antennules in the female are nine-jointed; the first joint is long, and the inner distal angle is produced into a stout and somewhat triangular tooth-like process; the next three joints are considerably shorter than the first; the last joint is about as long as the fourth, but the four joints that precede the last one are small; a moderately long sensory filament or *asthetask* springs from the end of the fourth joint as shown in the drawing (fig. 10). The antennæ, mandibles, and maxillæ are nearly similar to those in *Tetragoniceps bradyi*.* The posterior foot-jaws are three-jointed, but the end joint is very small; there are two terminal setæ—one moderately elongate, the other smaller and slightly plumose. The outer branches of the first to the fourth pairs of thoracic feet are all three-jointed, but all the inner branches are two-jointed. In the first pair, which are comparatively slender, the inner branches are elongate, the first joint being rather longer than the entire length of the outer branches; the second joint, which is scarcely half the length of the first, carries two stout terminal setæ—the inner one being the longer; there is also a small seta on the lower half of the inner edge of the first joint. The inner branches of the second, third, and fourth pairs are considerably shorter than the outer branches; those of the second and third pairs extend slightly beyond the second joint of the outer branches; but in the fourth pair the inner scarcely reach the middle of the second joint of the outer branches, and this difference is owing, in part at least, to the outer branches of the fourth pair being proportionally more elongated than the outer branches of the two preceding pairs. The fifth pair of feet are two-jointed; the basal joint is foliaceous and somewhat triangular in outline; it is provided with three small setæ on the lower half of the inner margin, and with a small apical seta. The second joint is elongated and narrow, and it tapers gradually till it becomes somewhat attenuated at the extremity; this joint is provided with a few small setæ on the outer edge and one on the inner, and also with a slender terminal hair. The caudal segments are slender, and about as long as the last abdominal segment.

The female carries one ovisac, which contains a few moderately large ova arranged in a single series.

The male differs little from the female, except that the antennules are hinged, and otherwise modified for grasping; the fifth pair of feet are also less fully developed; the basal joint is sub-quadrate, and the inner portion slightly produced distally and furnished with two moderately stout, spiniform apical setæ; the secondary joint is sub-cylindrical, and is armed with a moderately stout and elongated spine near the distal end of the inner margin. The first abdominal segment in the male bears slightly produced lateral appendages provided with three moderately long setæ; these appendages are situated immediately posterior to the fifth thoracic feet.

Habitat.—Firth of Forth, off St. Monans; rather rare.

Tetragoniceps brevicauda, sp. n. (Pl. XIV., figs. 18–22.)

As already stated, this copepod does not differ very greatly from

* *Vide* Part III. *Tenth Ann. Report Fishery Board for Scotl.*, p. 253, Pl. IX. (1892).

(?) *Tetragoniceps malleolata*, but, for the reasons stated below, I prefer to describe it under a distinct name rather than as a "variety" of the species referred to; for, after all, the question as to whether a thing is a "species" or a "variety" is very much a matter of opinion.

Description of the Female.—In general appearance the female of *Tetragoniceps brevicauda* is not unlike the form just described, but is somewhat smaller. The specimen figured (fig. 18) is only about ·7mm. (about $\frac{1}{36}$ of an inch in length). The antennules have a structure somewhat similar to those of (?) *Tetragoniceps malleolata*, and there is the same hook-like process on the distal extremity of the first joint; the proportional lengths of the nine joints are, however, somewhat different. The mouth-organs and swimming-feet resemble those of the species named, except that the first feet appear to be rather more slender, and the fifth pair are proportionally somewhat smaller, but the secondary joint of the fifth pair is distinctly more elongated proportionally than that of the fifth pair in (?) *Tetragoniceps malleolata* (fig. 21). The caudal segments (fig. 22) are distinctly shorter than those of the species named, and they are also proportionally stouter; the size and form of the caudal furca of the species under description are so different from those of the closely allied form previously recorded as not only to have suggested the name that has been applied to it, but were the chief characters that first attracted my attention when examining the material in which it was found.

No males of this form and only very few females have been observed.

Habitat.—Firth of Forth, off St. Monans.

Pseudolaophonte spinosa (I. C. Thompson).

1893. *Laophonte spinosa*, I. C. Thompson, Revised Report on the Copepoda of Liverpool Bay, Trans. L'pool. Biol. Soc., vol. vii., p. 24, Pl. XXX., figs. 1–13.

1896. *Pseudolaophonte aculeata*, A. Scott, Report Lancashire Sea Fisheries (1895), p. 11, Pl. III., figs. 7–23.

This rare copepod species occurred in a gathering of dredged material collected near Otter Spit, Loch Fyne; a male and a female specimen were obtained. The antennules in this species are each furnished with a prominent and strong spine on the lower (exterior) aspect of the second joint; both the male and female possess these spines; the female antennules appear to be only four-jointed. The species has a close general resemblence to *Laophonte*, so much so that, like Mr. I. C. Thompson, I was at first inclined to regard it as a member of that genus, but a close examination of the thoracic appendages, and especially of the swimming-feet, bring to light structural differences that must exclude it from the genus *Laophonte*. The principal differences, as pointed out by Mr. A. Scott, are observed in the structure of the second and third pairs of swimming-feet. In the second pair each foot consists of a single one-jointed branch, and in the third pair, though each foot is two-branched, both branches are only two-jointed. This interesting and somewhat anomalous copepod has not before been recorded from the Clyde district.

Leptopsyllus minor, T. and A. Scott.

1895. *Leptopsyllus minor*, T. and A. Scott, Ann. Scot. Nat. Hist. (Jan. 1895), p. 31, Pl. II., figs. 15–22.

This species belongs to a group of peculiarly slender copepods, the first of which was added to the British fauna in 1894.* Hitherto all the

* Part III. of *Twelfth Ann. Report of the Fish. Board for Scot.* (1894), p. 254.

described species have been found either in shore pools or in comparatively shallow water. The females do not appear to be very prolific; they usually carry but one ovisac, which contains only a few—frequently not more than three or four—ova. It is interesting to note, however, that though the creatures are small their ova are comparatively of large size.

Leptopsyllus minor, which has not before been recorded from the Clyde, was obtained in shore pools near Millport, Cumbrae, and also at Inverkip during the past summer.

Leptopsyllus herdmani, I. C. Thompson and A. Scott.

1900. *Leptopsyllus herdmani*, I. C. Thomp. and A. Scott, Trans. L'pool Biol. Soc., vol. xiv., p. 141, Pl. VIII.

A few specimens of this minute species were obtained, along with the species just recorded, in the shore pools at Millport, Cumbrae, in May 1899. One of the principal differences between this species and *Leptopsyllus minor* is in the comparative lengths of the inner and outer branches of the first thoracic feet; in the present form the inner branches are considerably longer than the outer ones, while in *Leptopsyllus minor* the inner are scarcely longer than the outer branches. There are some other differences, but they are less obvious than the one referred to.

Nannopus palustris, G. S. Brady.

1878. *Nannopus palustris*, G. S. Brady, Mon. Brit. Copep., vol. ii., p. 101, Pl. LXXVII., figs. 18–20.

This curious copepod was obtained in brackish-water pools at Inverkip, Firth of Clyde, on May 13th, 1899, but it did not appear to be very common. It has a superficial resemblance to *Platychelipus*, and may have sometimes been passed over as such. There are very few Clyde records for *Nannopus*.

Cylindropsyllus minor, T. Scott. (Pl. XIV., figs. 23–32.)

1892. *Cylindropsyllus minor*, T. Scott, Part III., *Tenth Ann. Report Fish. Board for Scot.*, p. 260, Pl. XI., figs. 17–24.

The copepod described under this name was discovered in 1891 off St. Monans, Firth of Forth. At that time no males had been observed, and therefore, though the characters of the female, so far as they could be made out, agreed very well with the definition of the genus *Cylindropsyllus*, there was still the probability that the species might not after all be a true member of that genus.

During the past year the examination of a gathering of entomostraca collected in the same locality where the species was first discovered yielded several additional specimens to those already observed, and this time both males and females were obtained. The occurrence of these specimens has enabled me not only to revise the previous description of the female, but to add to that a description also of the male, and to show conclusively that the species is a true *Cylindropsyllus*.

Description of the Female.—Body cylindrical (fig. 23); length of the specimen figured, 97mm. (fully $\frac{1}{25}$ of an inch). The antennules, which are comparatively short, are nine-jointed; the second joint is considerably longer than any of the other joints. Their proportional lengths are shown approximately by the formula :—

Proportional lengths of the joints,	7 · 43 · 14 · 10 · 10 · 8 · 16
Numbers of the joints,	1 · 2 · 3 · 4 · 5 · 6 · 7

The antennæ closely resemble those of *Cylindropsyllus lævis*, but the end joints are proportionally rather longer; the secondary branches (protopodites) appear also to be slightly more elongated. The mandible-palp, which is moderately slender, is of greater length than the same appendage in *Cylindropsyllus lævis*, and is composed of two joints, but the last joint is small (fig. 24). The maxillæ appear to be similar to those of the species named. The anterior foot-jaws (first maxillipedes) are small and apparently one-jointed; the single joint is somewhat dilated, and bears two elongate processes at the distal end of the inner margin; the terminal claw is also moderately large and stout (fig. 25). The posterior foot-jaws (second maxillipedes) are slender and two-jointed, and armed with a moderately long, slender, almost setiform, terminal claw (fig. 26). All the thoracic feet are as previously described. The caudal segments are nearly as long as the anal segment, and they are each furnished with a broad, sabre-like terminal spine nearly of the same length as the furcal segment, and each spine bears a secondary setiform process on the outer margin (fig. 29). The segments are also provided with one or two minute hairs.

Description of the Male.—The antennules of the male are modified for grasping. The cephalo-thoracic and other appendages are similar to those of the female, except in the following particulars:—(1) The outer branches of the second pair of thoracic feet, which are moderately stout and elongate, are each armed with a stout elongated falciform terminal process, bent inwardly at nearly right angles to the joint from which it springs. These processes are somewhat similar to those on the outer branches of the second feet of the male of *Cylindropsyllus lævis*, but the apex is somewhat differently modified, as shown by the drawing (fig. 30). (2) The short inner branches of the third pair differ from those of the female in having the first joint produced interiorly into a stout tapering spine, which is slightly sinuate, and extends beyond the end of the second joint; the second joint is dilated—both margins being convex (fig. 31). (3) The caudal segments are provided with terminal spines that are stout and tapering (fig. 32). It may also be noted that the exterior spine with which each of the fifth feet in the female is armed is wanting in those of the male.

Cylindropsyllus minor, though apparently not very common, is a widely distributed species; it has been obtained not only off St. Monans, Firth of Forth, but also at Ballantrae Bank, Firth of Clyde. I have not, however, observed male specimens other than those referred to in the preceding description, which are from the Forth estuary; probably the males are scarcer than the other sex.

Huntemannia jadensis, S. A. Poppe.

1884. *Huntemannia jadensis*, S. A. Poppe, Abhandl. d. Nat. Ver. Bremen, Bd. IX., p. 59.

In previous years I have recorded this curious species from the head of West Loch Tarbert (Cantyre), and from the Cromarty Firth, which hitherto appeared to be the only two Scottish localities where this copepod was known to occur. I have now to report two additional stations for *Huntemannia*, both of which are in the Clyde district. It was taken with the hand-net in shore-pools a little below high-water mark at the south-west corner of the Greater Cumbrae on May 6th, 1899, and in shore-pools at Inverkip on the 13th of the same month. At the latter place I obtained for the first time one or two females with ovisacs. I find that the females of this species carry two ovisacs of average size, which contain a considerable number of small ova. What we know of the distribution of this species tends to show that it is more or less restricted to brackish water.

Ilyopsyllus coriaceus, Brady and Robertson.

1873. *Ilyopsyllus coriaceus*, B. & R., Ann. and Mag. Nat. Hist. (4), vol. xii., p. 132, Pl. IX., figs. 1–5.

I have to record the occurrence of this small but interesting species from the Cromarty Firth. It was obtained in a brackish-water pool at the mouth of the River Alness in the summer of 1893, and only one specimen was observed. It was not recorded at that time, as it was expected that other specimens might be found, when a description with drawings of the species would have been prepared. No more specimens have, however, been discovered, and I now therefore place on record the solitary specimen obtained, which appears to be a female.

Quite recently the Rev. A. M. Norman very kindly presented me with a few specimens of this species collected by himself at Birterbuy Bay, Ireland, in 1874. These at first sight looked as if they belonged to another species, for, instead of the broad spathulate furcal setæ referred to in Prof. G. S. Brady's description and figures, the principal furcal setæ were long and slender; but this, it was afterwards found, was merely a sexual difference, the specimens I had received from Dr. Norman being males, whereas the Cromarty Firth specimen, like that described by Prof. Brady, was a female. Moreover, it was observed that a form of *Ilyopsyllus*, which, in my report on some Entomostraca from the Gulf of Guinea, I had described under the name of *Ilyopsyllus affinis*, resembled so closely these Birterbuy males that it is probably only a southern form of *Ilyopsyllus coriaceus*. The Gulf of Guinea specimens were obtained in a shore-gathering collected at the Island of Sao Thome. These Copepods are strongly gibbous on the dorsal aspect, and the peculiar spathulate furcal setæ of the female of *Ilyopsyllus coriaceus* serve to distinguish it readily from its congeners.

Scutellidium tisboides, Claus.

1866. *Scutellidium tisboides*, Claus, Die Copep.-Fauna v. Nizza, p. 21, t. iv., figs. 8–15.

This somewhat rare copepod has been obtained at various times in shore-pools between tide-marks at Bay of Nigg, Aberdeen. The species does not appear to be very rare in some of the gatherings obtained here. On the other hand, I have as yet failed to obtain it in the Firth of Clyde, and neither Mr. Robertson nor Prof. Brady appear to have observed it there; neither do I remember of its having been observed by us in the Firth of Forth—probably its distribution is local rather than rare. The colour of the Bay of Nigg specimens was generally not very pronounced; some were colourless, but usually they were tinged more or less with a light brownish pigment.

Clausia cluthæ, T. and A. Scott.

1896. *Clausia cluthæ*, T. and A. Scott, Ann. and Mag. Nat. Hist. (6), vol. xviii., p. 1., Pl. I., figs. 1–12.

Several specimens of this curious copepod have been obtained in dredged material from Tarbert Bank, Lower Loch Fyne. Though this is apparently the first time that *Clausia cluthæ* has been recorded from Loch Fyne, it is not the first time for the Clyde generally; the specimens from which the species was described were discovered in Ayr Bay in

1896. In this species the fifth thoracic feet project outward from each side of the body, and are more or less conspicuous. The genus *Clausia* was established by Claperède in 1863. Boeck, not knowing this, established a genus of free-swimming Copepods under a similar name in 1864, but in 1872 Boeck changed his "*Clausia*" to "*Pseudocalanus.*"

Corycæus anglicus, Lubbock. (Pl. XIII., figs. 1–14.)

1857. *Corycæus anglicus*, Lubbock, Ann. and Mag. Nat. Hist. (2), vol. XX., Pl. XI., figs. 14–17.

This pretty species was added to the British fauna by Sir John Lubbock in 1857 from specimens which had been obtained at Weymouth. For a considerable number of years afterwards our knowledge of the British distribution of the species was almost entirely limited to the information contained in the description which Sir John had published.

In 1880 Prof. G. S. Brady, by the publication of the third volume of his monograph of British Copepoda, was able to considerably extend the known distribution of our *Corycæus*. But though our knowledge of its British distribution continued to increase from year to year, there has apparently been no record of it from the Scottish seas till 1896, when a report of its occurrence in the Firth of Forth was published in Part III. of the *Fourteenth Annual Report of the Fishery Board for Scotland.* So far as I know, no further captures of *Corycæus* have been made in Scottish waters till the past summer, when it was taken in the Firth of Clyde. It occurred in a surface tow-net gathering collected in the vicinity of Ailsa Craig on the 29th of May.

The presence of *Corycæus anglicus* in our Scottish estuaries may be owing to changes in the trend of oceanic currents induced by the prevalence of certain winds,* or it may be that the methods of research being now more perfect than formerly, the presence of such organisms is more readily detected. Several specimens of *Corycæus* were obtained in the Clyde gathering collected on the 29th of May, and some of the colouring of the species still remained when they first came under my observation. Both males and females were obtained.

The female represented by the drawing on Plate XIII. measured slightly over one millimetre in length, while the length of the male, which is represented by one or two detailed figures on the same plate, was slightly less than that of the female. The female antennules are short and six-jointed. The proportional lengths of the joints are shown approximately by the formula :—

$$\text{Proportional lengths of the joints, } \frac{8 \cdot 8 \cdot 8 \cdot 10 \cdot 7 \cdot 5}{1 \cdot 2 \cdot 3 \cdot 4 \cdot 5 \cdot 6} \text{ Number of the joints,}$$

The antennæ (fig. 3) are stout; each is armed with a moderately strong and slightly-hooked terminal claw; an elongated spine springs from the inner distal angle of the first joint, while one or two smaller spines occur on the other joints. In the male the terminal claws of the antennæ are long and sickle-shaped (fig. 12). The biting part of the mandible is armed with a few moderately long teeth, and one or two spine-like lateral appendages. The palp is very small, and composed of a single one-jointed branch (fig. 4). The maxillæ are simple, one-jointed and moderately stout, and armed with a few short, stout, apical, and sub-apical spines (fig. 5). The anterior foot-jaws (fig. 6) are short and very stout, their structure is somewhat rudimentary, and their armature consists of several

* My son, Mr. Andrew Scott, in a letter to me on July 28th, incidentally mentioned that Mr. I. C. Thompson "had been getting *Corycæus anglicus* in abundance off Port Erin, Isle of Man, a week or two ago." That would be nearly about the time it was observed in the Clyde.

apical and sub-apical setæ. The posterior foot-jaws of the female (fig. 7) have moderately short and slender terminal claws, but those of the male (fig. 13) are armed with terminal claws of considerable length. The first three pairs of swimming-feet have both branches three-jointed. The inner branches, which are considerably shorter than the outer, are provided with a number of setæ on the inner margin and apex, but have apparently no terminal spines; the outer branches are also furnished with several setæ on the inner edge. Moreover, the first and second joints bear a short but moderately stout spine on the exterior distal angle, while the third joint carries two marginal and two apical spines, the inner one of the two apical spines being longer and stouter than the other (figs. 8 and 9). In the fourth pair (fig. 10) the inner branches are reduced to a single minute joint; the outer branches are also comparatively small, and they want, to a large extent, the spiniform armature of the outer branches of the preceding pairs. The fifth pair are small, and each consists of a single one-jointed branch, which is furnished with two apical setæ (fig. 11).

In the female the lateral processes of the fourth body segment extend backward to about the middle of the penultimate segment of the abdomen. This abdominal segment appears to be larger in the male than in the female, as shown by the figure (fig. 14). The caudal segments in both male and female are moderately elongated, being about one and a half times the length of the anal segment.

This species when living is one of the more brilliantly coloured of the British Copepods, but spirit extracts the colour very quickly.

Monstrilla (?) *danæ*, Claparède. (Pl. XIII., figs. 15–20.)

1863. *Monstrilla danæ*, Clap., Beobacht. üb. Anat. u. Enwickl.-wirbellos Thiere an der Küste v. Normandie angestellt., p. 95.

Representatives of this curious genus of copepods have, as in previous years, been occasionally observed in tow-net gatherings of entomostraca from the Clyde. Two or three species of the Monstrillidæ have been recorded from North Britain, but the only one that has hitherto been observed in the Clyde estuary is the species now referred to, and which I have for the present ascribed to Claparède's *Monstrilla danæ.* The genus *Monstrilla* was added to the British fauna in 1857 by Sir John Lubbock, when he described the *Monstrilla anglica.* For nearly thirty years afterwards little or nothing further appears to have been known concerning these organisms, so far at least as regards their distribution in the British seas, and in view of this it is somewhat remarkable that now not a year passes without a lesser or greater number of specimens, representing sometimes two or three different species, being observed.

In 1890 Gilbert C. Bourne published in the *Quarterly Journal of Microscopical Science* a little paper on the genus *Monstrilla*, and gave a short summary of the characters of the different forms. He divided them into two groups, distinguished by the number of furcal hairs. In the one group the number of setæ on each furcal member is said not to exceed three, while in the other there are said to be six setæ on each of the caudal furca. *Monstrilla danæ* was placed by Mr. Bourne in the first of these groups.

The Clyde specimens which I record here, and which I am inclined to ascribe to *Monstrilla danæ*, do not fit in with either of Mr. Bourne's groups as regards the number of furcal hairs. In the more perfect of the specimens there are five hairs on each of the caudal rami, four of which are prominent and one very small; of the four large hairs, three spring from the end of the furca and one from a notch on the outer margin; the small hair is also marginal.

The male and female have each three abdominal segments. Those of the male are nearly of equal size, but in the female the genital segment is about as long as the combined length of the next two, and it is provided on the ventral aspect with two moderately long setæ. In the specimen figured (fig. 15) several minute ova were observed attached to these genital setæ, as shown in the drawing. The fifth thoracic feet in the female (fig. 18) are sub-cylindrical, and rather longer than broad, and carry two apical setæ.

Monstrilla danæ appears to be more frequent in Upper Loch Fyne than in the seaward part of the Clyde. In a tow-net gathering collected on the 28th November last (1899) near the head of the loch as many as twenty-seven specimens of *Monstrilla* were obtained, apparently all belonging to this species. But a much larger number of specimens was obtained in a gathering collected, also near the head of the loch, in the month of September immediately preceding. This gathering, which was collected with the surface tow-net on the 29th of the month referred to, was a small gathering, and contained a considerable quantity of fibrous matter. It was not examined until the following month of March, when over eighty specimens were obtained! The specimens comprised both males and females, but whether they all belong to the one species I am not yet in a position to say. The fact that such a large number of specimens was found in a single small gathering is of no little interest in its bearing on the distribution of these curious animals.

Pseudanthessius thorellii (Brady and Robertson).

1875. *Lichomolgus thorellii*, B. and R., Brit. Assoc. Report, p. 197.

This species, which is one of the Lichomolgidæ distinguished by the possession of elongated caudal furca, has been obtained in dredged material from various parts of the Clyde area. It is quite easily distinguished from *Lichomolgus forficula*, which also has long furca, not only by the structure of the inner branches of the fourth pair of swimming-feet and the difference in the proportional lengths of the abdominal segments, but also by the difference in *habitat*. *Lichomolgus forficula* lives in the branchial cavity of large Ascidians, while *Pseudanthessius thorellii* appears to live free amongst weed or zoophytes, and perhaps also amongst *Filograna*. I have not on any occasion found it naturally inside an Ascidian, and neither does Professor Brady in his description of the species refer to it as a commensal.

Hermanella arenicola (G. S. Brady).

1872. *Boeckia arenicola*, G. S. Brady, Nat. Hist. Trans., Northumberland and Durham, vol. iv., p. 430.

A specimen of this fine species was obtained in a gathering of entomostraca from Loch Gilp (near Ardrishaig, Loch Fyne), which is a new Clyde Station for this species. The vicinity of Otter Spit is the only other locality within the Clyde area that I know of where *Hermanella arenicola* has been obtained.

Asterocheres (?) *echinicola* (Norman). (Pl. XIV., figs. 33–36.)

An *Asterocheres* is obtained in the water passages of a sponge (*Suberites* sp.), common both in the Clyde and Loch Fyne, which is closely allied to *Asterocheres echinicola* (Norman), and which may probably be only a variety of that species. It differs from the typical *Asterocheres echinicola* in having the caudal segments rather shorter than the anal segment, while in typical specimens these are slightly longer than that segment. The general outline of the cephalothorax, and especially the outline of the posterior margin of the third segment, seem also to be slightly different, as shown by the drawing (fig. 33). Moreover, the outer lobe of the maxillæ is also apparently somewhat shorter than that of the same appendages in *Asterocheres echinicola*, but whether such differences are constant seems somewhat doubtful.

A species of *Asterocheres* described by Dr. Giesbrecht, of Naples, under the name of *Asterocheres suberites*, seems to have a *habitat* similar to this Loch Fyne form, and it also agrees with the same form in having the caudal segments shorter than the anal segment; indeed the difference in the length of the caudal segments appears to constitute one of the principal points of distinction between *Asterocheres echinicola* (Norman) and *Asterocheres suberites* (Giesbrecht). Notwithstanding the points of agreement observed between this Clyde copepod and Giesbrecht's *A. suberites*, I prefer for the present at least to ascribe it to the *A. echinicola*, Norman. It may also be noted that *Asterocheres boecki* (G. S. Brady) was occasionally obtained in the water-passages of *Suberites* in company with the *A.* (?) *echinicola.*

Rhynchomyzon purpurocinctum (T. Scott).

1893. *Cyclopicera purpurocinctum*, T. Scott, *Eleventh Ann. Report Fish. Board of Scot.* (III.), p. 209, Pl. III., figs. 29-40.

This species, which has already been recorded from one or two places on the East Coast of Scotland, has only recently, and for the first time, been observed in the Clyde district. It occurred in the washings of dredged materials (weed, gravel, sand, etc.) collected in the vicinity of Otter Spit, Upper Loch Fyne, on January 12th, 1899, at a depth of about 8 to 15 fathoms. The occurrence of the species here would seem to indicate that though it may be, and probably is, a scarce one, it may be more or less generally distributed around our shores. The species is readily distinguished not only by its general form, but by the fact that it is adorned by a dark purple-coloured band extending across the thorax, and it is worth noting in regard to this band that a lengthened immersion in methylated spirits appears to have had little effect on it. Usually the spirit extracts the colouring matter very quickly from these microforms, but it would appear that in this case the purple pigment is of a more permanent character than that generally observed in the colours of copepoda.

Artotrogus orbicularis, Boeck.

1859. *Artotrogus orbicularis*, Boeck, Forh. Vid.-Selsk., Christiania, p. 2. Pl. I.

One specimen, about one millimetre in length and 0·78 millimetre in breadth, was obtained amongst some washings of material dredged on Tarbert Bank, Loch Fyne, on the 28th October last (1899). This is the second specimen of this rare species from the same locality.* I. C. Thompson has recorded this species from the Liverpool Bay district,† but Tarbert Bank, Lower Loch Fyne, is the only Scottish locality I know of where *Artotrogus orbicularis* has been obtained.

* *Sixteenth Ann. Report Fish. Board of Scot.* (III.), p. 272, Pl. XIV., figs. 12–21 (1898).
† *Trans. Lit. and Phil. Soc., Liverpool*, vol. viii., p. 37.

Parartotrogus richardi, T. and A. Scott.

1893. *Parartotrogus richardi*, T. and A. Scott, Ann. and Mag. Nat. Hist. (6), vol. xl., p. 210, Pl. VII.

This curious little species has not before been observed in the Clyde area. It is a form that is readily missed, and may therefore be more widely distributed than at present it appears to be. In Scotland it has only hitherto been observed in the Firth of Forth, but it has also been found in the vicinity of Naples by Dr. W. Giesbrecht.

AMPHIPODA.

A few of the amphipods observed in the tow-net and other gatherings sent from the Fishery steamer "Garland" may now be noticed. Only the rarer forms are recorded here.

HYPERIIDÆ.

Hyperia galba, *Parathemisto* (?) *oblivia*, and *Hyperoche tauriformis* have been occasionally observed in the tow-net gatherings sent from the Clyde and Loch Fyne. These may still be reckoned as comparatively rare amphipods in the Clyde area. Their scarcity here is in somewhat marked contrast to the frequency of the species on the East Coast.

PONTOPOREIIDÆ.

Urothoë marina has been obtained at Tarbert Bank, Loch Fyne, while *Argissa hamatipes* (Norman) has been observed in tow-net gatherings collected both in Loch Fyne and in the seaward portion of the Clyde estuary. *Argissa* is sometimes frequent in under surface tow-net gatherings from the Clyde. The somewhat remarkable difference in the dorsal aspect of the urosome in the male and female is an interesting feature of this species. *Argissa* was also obtained in a tow-net gathering collected in Aberdeen Bay in May 1898.

AMPHILOCHIDÆ.

A number of species belonging to this group have been observed in the gathering of tow-netted and dredged material sent from the "Garland" during the past year. One of these appears to be identical with a form discovered a few years ago in the Moray Firth. This form was described in the "Annals and Magazine of Natural History" * under the name of (?) *Cyproidia brevirostris*, T. and A. Scott; it is a very small amphipod, scarcely reaching to two millimetres in length; the Clyde specimens, which are of a somewhat chocolate-brown colour are easily overlooked. *Cyproidia brevirostris* comes very near *Cyproidia danmoniensis*, Stebbing. *Stegoplax longirostris*, G. O. Sars, is also another closely allied form. A few specimens of *Cyproidia brevirostris* were obtained in some dredged material from Tarbert Bank, Loch Fyne—a rocky bank which rises to within 15 or 17 fathoms of the surface, while all around the water is deep. This amphipod has not before been recorded from the Clyde area.

EPIMERIDÆ.

Epimeria cornigera (Fabricius), var. In Part III. of the *Fifteenth Annual Report of the Fishery Board for Scotland* (1897), p. 169, I recorded from the Clyde a specimen of what appeared to be *Epimeria tuberculata*, G. O. Sars; and since then a few more specimens of the

* Ser. 6, vol. xii., p. 244, Pi. XIII. (1893).

same form have been obtained. They are usually found in bottom tow-net gatherings from the deeper parts of the Clyde. It now appears that these Clyde specimens do not belong to Sars' *Epimeria tuberculata*, but are a deep-sea variety of *Epimeria cornigera*. They seem to form a connecting link between the two species named, and to belong nearly as much to the one as to the other. It is a form which is in some respects as handsome as typical specimens of either species, both in size and coloration.

Eusiridæ.

Specimens of *Eusirus longipes*, Boeck, have been occasionally observed during the year in bottom tow-net gatherings both from the Clyde and Loch Fyne, but few of the specimens appeared to be mature.

Gammaridæ.

Mœra othonis (M.-Edw), *Cheirocrates intermedius*, G. O. Sars, and *Lilljeborgia kinahani* (Spence Bate) have all been obtained in material dredged at Tarbert Bank, Loch Fyne, at a depth of 15 to 17 fathoms. *Megaluropus agilis* was captured in a tow-net gathering from the vicinity of Sanda Island, Clyde, collected September 5th, 1899.

Photidæ.

Leptochirus pilosus.—A few specimens of this species were recently obtained in material from Tarbert Bank. In most of the Clyde specimens I have seen, some of which were females with ova, the secondary branches of the antennules are only two-jointed, the end joint being quite small. Another species, *Microprotopus maculatus*, Norman, was obtained in a bottom tow-net gathering, recently examined, collected in Aberdeen Bay in May 1898.

Podoceridæ.

Of species belonging to this group the following may be mentioned:—*Ischyrocerus minutus*, which was obtained in the same gathering as that in which the *Microprotopus* referred to above, was observed. *Erichthonius abditus* occurred in a bottom tow-net gathering from 28 fathoms collected in the vicinity of Ailsa Craig, Firth of Clyde, October 10th, 1899.

Caprellidæ.

Protella phasma (Mont.) is not very rare at Tarbert Bank, Loch Fyne. There are few hauls with the dredge taken here in which it does not occur. *Caprella linearis* (Linn.) was obtained at Inverneil Bay, Loch Fyne, by Mr. F. G. Pearcey in November 1899. Males and females of the same pecies have also been captured by the fishery steamer in the Morays Firth.

Caprella septentrionalis, Kröyer.—One specimen of this somewhat rare species was captured in the Cromarty Firth on June 6th, and another on November 23rd, 1898. I am not aware of any previous record of this species for the East Coast of Scotland.

Isopoda.

There are few isopods to record. A considerable number of the chelifera have been observed during the year, but most of the species to which they belong have already been recorded. A few, however, require further study.

Several parasitic forms have been observed, among which are the following:—*Phryxus abdominalis*, attached to the under side of the abdomen of *Spirontocaris securifrons*, captured in the shrimp-trawl net of the fishery steamer "Garland" near the seaward limit of the Clyde estuary. *Pseudione affinis*, attached under the carapace of *Pandalus montagui*, also from near the mouth of the Clyde. *Pleurocrypta marginata*, attached under the thoracic shield of *Galathea dispersa*, taken at Station XIII. (Upper Loch Fyne), October 10th, 1899. *Aspidophryxus peltatus*, attached to the back of *Erythrops serrata* and *Erythrops elegans*,* from deep water to the east of Arran, Firth of Clyde, July 18th, also obtained at Station XIII. (Upper Loch Fyne) on 29th December 1899.

Cumacea.

Several species of cumacea have been obtained in recent gatherings of tow-net and dredged material, most of which have already been recorded, but the following may be mentioned:—*Campylaspis rubicunda* has again occurred in bottom-gatherings from the deep water of Upper Loch Fyne. *Cumella pygmæa* was obtained in dredged material from Tarbert Bank, Lower Loch Fyne. *Nannastacus unguiculatus* and species of *Diastylis* have also been observed in Clyde tow-net gatherings. *Cuma edwardsii* was obtained in a bottom tow-net gathering collected in Aberdeen Bay; while *Cumopsis edwardsii* (sp. Bate) (=*C. goodsiri*, Van Ben.†) was taken between tide-marks on the shore near Millport, Cumbrae, Firth of Clyde, on May 6th, 1899, where it had previously been found by Dohrn thirty years before.‡ *Cumopsis longipes* (Dohrn) (=*C. lævis*, G. O. S.) has also been recorded from the Clyde. These two species are somewhat like each other in size and general appearance, but in *Cumopsis edwardsii* the cephalo-thoracic shield is adorned on both sides with two oblique and arcuate lateral folds; while in that of the other species the lateral folds are altogether wanting. Moreover, the natatory branches of the first pair of feet in *Cumopsis edwardsii* are composed of ten joints, but of only eight joints in *Cumopsis longipes*.§ *Cumopsis edwardsii* did not appear to be very rare between tide-marks at Cumbrae. A considerable number of adult and young specimens were included in the gathering I collected at Cumbrae in May last.

Schizopoda.

Thysanoessa neglecta (Kröyer).—I have again to report the occurrence of this Euphausid from the Firth of Clyde. In my Notes published in the *Seventeenth Annual Report*, *Thysanoessa neglecta* is recorded for the Clyde for apparently the first time. The specimens referred to in that Note had been obtained in a bottom tow-net gathering from Station X., near the seaward limit of the estuary, collected on January 16th, 1899, at a depth of 26 fathoms. The specimens referred to on the present occasion were obtained in two separate bottom tow-net gatherings from Station XII., between Arran and Turnberry Head. These gatherings were collected, the one on the 18th and the other on the 24th of July 1899. In the first one five specimens were obtained, but only two were observed in the other. This species, though apparently rare in the Clyde district, is one of the more common schizopods on the East Coast. As pointed out by Dr. Norman in his useful "Synopsis of the British

* A specimen of the curious *Aspidœcia normani* occurred also on the back of a specimen of *Erythrops elegans*, from the same part of the Clyde estuary. (See also record of *Aspidœcia* in Part III. of the *Sixteenth Ann. Report of the Fishery Board for Scotland*.

† Cf. Scott, *S. F. B. Rept.*, 1888, p. 253.

‡ Cf. *Jen. Zeitschr.*, vol. v., 1869; *Unters. üb. Bau u. Entw. d. Arthropoden*, 1870, p. 23.

§ *Vide* Prof. G. O. Sars' description of the two species in his work *Middelhavets Cumaceer*.

Schizopoda," this *Thysanoessa* is readily distinguished from its near ally by having a spine over the base of the telson.

Mysidopsis gibbosa and *Mysidopsis angusta* have both been obtained in tow-net gatherings forwarded from the Clyde, as also have *Leptomysis gracilis* and *Praunus inermis*. *Neomysis vulgaris,* a Mysid which appears to be rare in the Clyde district, formed part of the contents of the stomach of a fifteen-spined stickleback (*Gasterosteus spinachia*) captured near the head of Loch Fyne on the 16th of April last (1899). The same Mysid has been obtained in the Dhu Loch, near Inveraray.

Siriella armata (M. Edw.) and *Siriella clausii*, G. O. Sars, were obtained in a gathering of crustacea from Loch Gilp by Mr. F. G. Pearcey, the naturalist on board the "Garland." The first—*Siriella armata*—has been occasionally captured in the Clyde during recent years, but the second—*Siriella clausii*—has, so far as I remember, only once before been recorded from the Clyde district, viz., in 1886, when one or two specimens were taken in East Loch Tarbert. The specimen now recorded from Loch Gilp is a male, apparently full-grown. It was captured in three to five fathoms on 31st October 1899.

Siriella armata, besides having a strongly produced rostrum, has usually some of the cephalic and caudal appendages ornamented with chocolate-coloured blotches. The body, especially on the ventral aspect, is also occasionally coloured. *Siriella clausii* appears to be colourless.

Erythrops serrata, G. O. Sars, and *Erythrops elegans*, G. O. Sars, have both been obtained in tow-net gatherings of the "Garland" forwarded from the Clyde. *Erythrops serrata,* which appears to be of more frequent occurrence than the other, has been observed for the most part in gatherings from the seaward portion of the estuary; while *Erythrops elegans* is taken occasionally in Loch Fyne, as well as further to seaward. Both are sometimes infested with parasites.

Anchialus agilis, G. O. Sars.—Two specimens of this rare Schizopod were obtained in a tow-net gathering collected at Station VI., Firth of Clyde (a little to the east and north of Sanda Island). They occurred in a bottom tow-net gathering from a depth of 20 to 27 fathoms collected on December 15th, 1898. Sars obtained the *Anchialus* in the Bay of Naples at a depth of six to eight fathoms, and he also obtained one near Messina at a depth of 20 fathoms.

Anchialus is one of the many interesting species which Dr. A. M. Norman has added to the British fauna. The single female specimen recorded by him was obtained at Plymouth in 1890. There does not appear to be any previous record of *Anchialus* from the Clyde estuary. Dr. Norman has seen my specimens.

Decapoda.

Xantho hydrophilus (Herbst).—A single specimen of this species—a male—was captured with the shrimp-trawl of the "Garland" at the mouth of the Clyde, at a depth of 60 fathoms, on June 15th, 1899, and forwarded by Mr. Pearcey to the Laboratory, Bay of Nigg, and is now in the collection there. One of the characters that seems to distinguish this form from *Xantho incisus*, Leach, is that the claws have the movable finger grooved on the upper aspect; the grooves extend nearly the whole length of the fingers. All the joints of the feet in *Xantho hydrophilus* are also ciliated on the upper edge, while in *Xantho incisus* the third only is ciliated.

Corystes cassivelaunus (Pennant).—A small male specimen of this species was captured in the same gathering as the last, and is now in the collection at Bay of Nigg. It measures about 20mm. from the extremity of the rostrum to the base of the dorsal shield.

Jaxea nocturna, Nardo.

In my paper on Clyde tow-net and other gatherings published in Part III. of the *Seventeenth Annual Report* (1899) I reported the occurrence of an interesting lucifer-like crustacean in the Firth of Clyde. I stated further that this crustacean had been identified with a form, also from the Clyde, which had been described in the Proceedings of the Royal Society, Edinburgh, vol. xv., p. 420, figs. 1 and 2 in the text (1889), by the late George Brook under the name of *Trachelifer*. In some additional remarks which immediately follow what had been stated in regard to Brook's description of *Trachelifer*, it is clearly shown that this "*Trachelifer*" was really the young of *Calliaxis adriatica*, Heller. Nothing further transpired concerning these Clyde organisms till last summer, when I received from Mr. F. G. Pearcey, the naturalist on board the "Garland," a number of fragments of a small *Nephrops*-like crustacean which he had found in the stomachs of some gurnards captured in the vicinity of Ailsa Craig, near the mouth of the Clyde estuary. It was at once evident that these fragments did not belong to *Nephrops norvegicus*, though in some respects they had a more or less close resemblance to that crustacean. The species, however, could not be made out for a considerable time. At first it was thought that the fragments might represent one or other of the described species of *Nephropsis*, but with none of these would they fit in satisfactorily. Failing, for various reasons, to arrive at a satisfactory solution of the difficulty, I applied to the Rev. T. R. R. Stebbing, who has not unfrequently proved in such matters to be a "friend indeed;" and he, after some investigation, found that the fragments which had given us so much trouble belonged to a species which Nardo in 1847 had described under the name of *Jaxea nocturna*. He, moreover, pointed out (as he does also in his *History of Crustacea*, p. 187) that *Jaxea nocturna* is identical with *Calliaxis adriatica*, Heller, described in 1856; and as *Trachelifer* is the young of *Calliaxis*, so also, as a matter of course, is it the young of *Jaxea*. The position of the species may therefore be stated thus:—

Jaxea nocturna, Nardo (1847).
= 1856. *Calliaxis adriatica*, Heller.
= 1889. *Trachelifer*, sp. (jun.), Brook.

Another point of interest that may now be considered is the *habitat* of *Jaxea*. Can we claim it as a member of the Clyde fauna? In regard to this point I am inclined, after a careful consideration of all the circumstances, to consider that we may fairly make this claim. We find these juvenile forms occurring at more or less frequent intervals in various parts of the Clyde area,* and occasionally in considerable numbers, two or three different stages of development being represented, and latterly, as pointed out, fragments of several adult specimens have been found in the stomachs of gurnards caught in the vicinity of Ailsa Craig. From the state of preservation in which these fragments were found it is scarcely likely that the time that had elapsed between the capture by the gurnards of the specimens to which the fragments belonged and the capture of the gurnards themselves in the "Garland's" trawl-net could have been very great. All this seems to indicate that the adult *Jaxea* are not very far off from the places where these larvæ and fragments were obtained. It

* *Trachelifer* was obtained in a bottom tow-net gathering collected at Station V. (Whiting Bay)—a station well within the limits of the Clyde estuary—on October 11th, 1899.

might be thought that if *Jaxea* were present in the Clyde, specimens occasionally ought to be taken in the trawl or dredge, yet none have ever been observed. This, however, does not militate against the supposition that this crustacean occurs within the Clyde estuary, for its *habitat* may be about rocky ground, where neither trawl nor dredge could be used, but which would offer no obstruction to gurnards in their search for food. Moreover, it was shown in my paper in Part III. of the *Seventeenth Annual Report* (1899) that at Naples, though the larval forms of *Calliaxis* (*Jaxea*) are met with amongst the surface fauna, the adult has only been found once in 25 years. But whatever be the opinion concerning the *habitat* of this apparently rare species—that is, "rare" as regards its adult form—the fact that fragments of adults were found in the stomachs of gurnards caught in the vicinity of Ailsa Craig is in itself of much interest to students of the British crustacea. The fragments referred to above are now in the Laboratory at Bay of Nigg.

After the preceding notes had been sent to the printer, Mr. Pearcey kindly forwarded the posterior portion of another specimen of *Jaxea*, which he had obtained in the stomach of a witch sole (*Pleuronectes cynoglossus, L.*) captured at Station VIII., Firth of Clyde, on the 20th of November last (1899). Station VIII. is about five miles west by south of Ailsa Craig. (This specimen is in our collection at Bay of Nigg with the others previously referred to.)

EXPLANATION OF THE PLATES.

PLATE XIII.

Corycæus anglicus, Lubbock.

Fig. 1.	Female, dorsal view	× 70.
Fig. 2.	Antennule	× 190.
Fig. 3.	Antenna	× 190.
Fig. 4.	Mandible	× 380.
Fig. 5.	Maxilla	× 380.
Fig. 6.	Anterior foot-jaw	× 380.
Fig. 7.	Posterior foot-jaw	× 190.
Fig. 8.	Foot of first pair of swimming-feet	× 190.
Fig. 9.	Foot of third pair ,, ,,	× 190.
Fig. 10.	Foot of fourth pair ,, ,,	× 190.
Fig. 11.	Foot of fifth pair	× 760.
Fig. 12.	Antenna, male	× 190.
Fig. 13.	Posterior foot-jaw, male	× 190.
Fig. 14.	Abdomen and caudal stylets, male	× 160.

Monstrilla (?) *danæ*, Claparède.

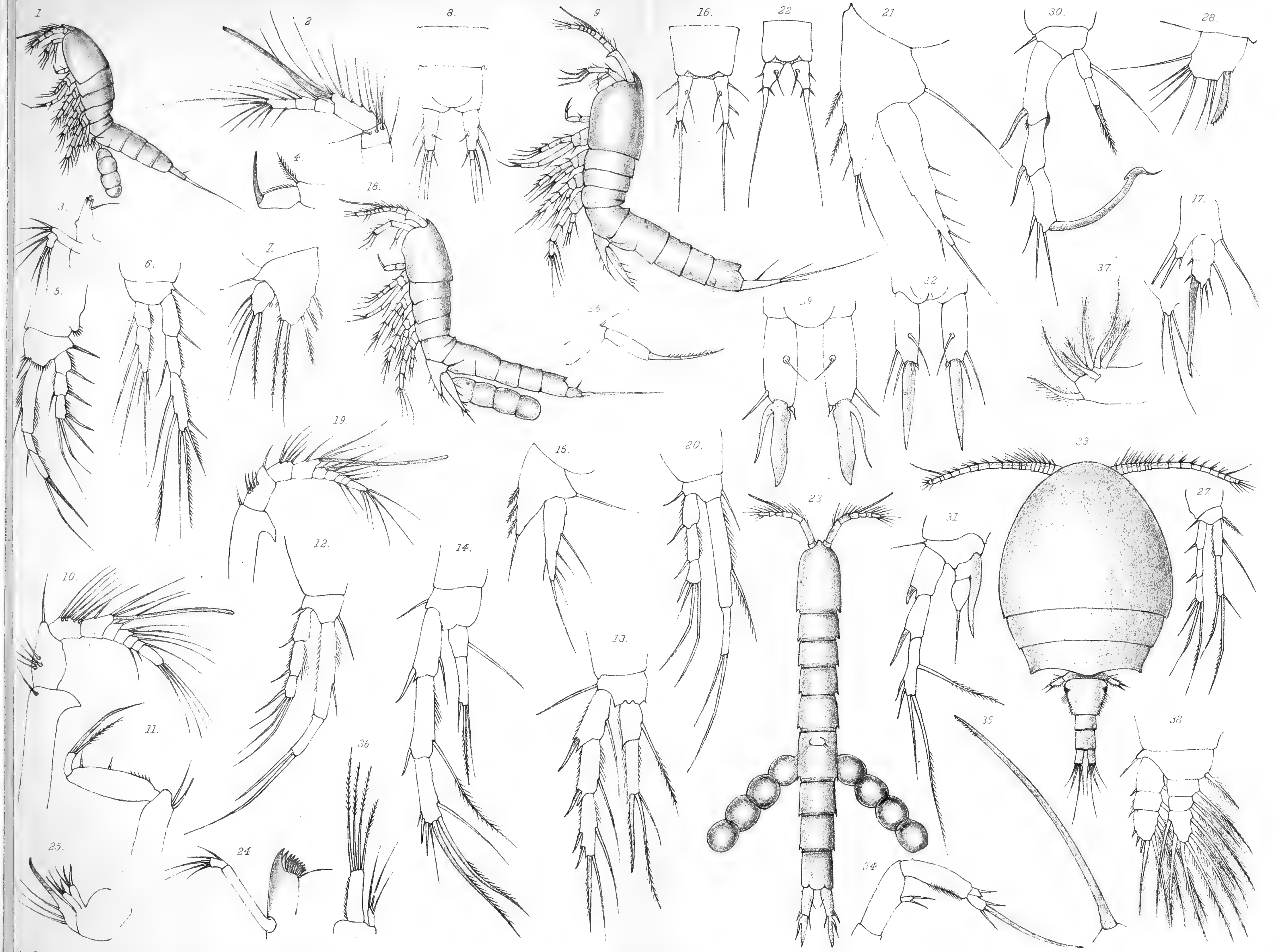
Fig. 15.	Female, dorsal view	× 20.
Fig. 16.	Antennule, male	× 40.
Fig. 17.	Foot of first pair of swimming-feet, female	× 80.
Fig. 18.	Fifth thoracic feet, female	× 40.
Fig. 19.	Last thoracic segment, abdomen and caudal stylets, male	× 80.
Fig. 20.	Fifth thoracic feet, male	× 40.

Enterocola (?) *fulgens*, Van Beneden.

Fig. 21.	Female, dorsal view	× 40.
Fig. 22.	Antennule	× 160.
Fig. 23.	Antenna	× 160.
Fig. 24.	Maxilla	× 190.
Fig. 25.	Posterior foot-jaw	× 253.
Fig. 26.	Foot of first pair of swimming-feet	× 126.
Fig. 27.	Foot of second pair ,, ,,	× 126.

A. SCOTT, *del. ad nat.*

FIGS. 1-14.—*Corycæus anglicus* (Lubb.). FIGS. 15-20.—*Monstrilla* (?) *danæ* (Clap.) FIGS. 21-27.—*nterocola* (?) *fulgens* (V. Ben.). FIGS. 28-34.—*Gunenotophorus* (?) globularis (Costa).



A. SCOTT, *del. ad nat.*

FIGS. 1-8.—*Canthocamptus inconspicuus*, sp. n. FIGS. 9-17.—*Tetragoniceps* (?) *malleolata* (Brady). FIGS. 18-22.—*Tetragoniceps brevicauda*, sp. n.

FIGS. 23-32.—*Cylindropsyllus minor* (T. Scott). FIGS. 33-36.—*Asterocheres* (?) *echinicola* (Norman). FIGS. 37 and 38.—*Gunenotophorus globularis* (Costa).

Gunenotophorus (?) *globularis*, Costa.

Fig. 28.	Female, lateral view	× 17.
Fig. 29.	Antennule	× 190.
Fig. 30.	Antenna	× 19.
Fig. 31.	Mandible and palp	× 84.
Fig. 32.	Posterior foot-jaw	× 190.
Fig. 33.	Foot of fourth pair of swimming-feet	× 80.
Fig. 34.	Last segments of the abdomen and caudal stylets	× 40.

PLATE XIV.

Canthocamptus inconspicuus, sp. n.

Fig. 1.	Female, side view	× 80.
Fig. 2.	Antennule	× 380.
Fig. 3.	Mandible	× 380.
Fig. 4.	Posterior foot-jaw	× 380.
Fig. 5.	Foot of first pair of swimming-feet	× 380.
Fig. 6.	Foot of fourth pair ,, ,,	× 380.
Fig. 7.	Foot of fifth pair	× 380.
Fig. 8.	Last segments of the abdomen and caudal stylets	× 80.

Tetragoniceps (?) *malleolata*, Brady.

Fig. 9.	Female, side view	× 80.
Fig. 10.	Antennule	× 253.
Fig. 11.	Posterior foot-jaw	× 380.
Fig. 12.	Foot of first pair of swimming-feet	× 253.
Fig. 13.	Foot of third pair ,, ,,	× 150.
Fig. 14.	Foot of fourth pair ,, ,,	× 150.
Fig. 15.	Foot of fifth pair	× 166.
Fig. 16.	Last abdominal segment and caudal stylets	× 126.
Fig. 17.	Foot of fifth pair and appendage of first abdominal segment	× 253.

Tetragoniceps brevicauda, sp. n.

Fig. 18.	Female, side view	× 80.
Fig. 19.	Antennule	× 253.
Fig. 20.	Foot of first pair of swimming-feet	× 380.
Fig. 21.	Foot of fifth pair	× 380.
Fig. 22.	Last abdominal segment and caudal stylets	× 126.

Cylindropsyllus minor, T. Scott.

Fig. 23.	Female, back view	× 80.
Fig. 24.	Mandible and palp	× 380.
Fig. 25.	Anterior foot-jaw	× 380.
Fig. 26.	Posterior foot-jaw	× 380.
Fig. 27.	Foot of first pair of swimming-feet	× 253.
Fig. 28.	Foot of fifth pair ,,	× 380.
Fig. 29.	Last abdominal segment and caudal stylets	× 190.
Fig. 30.	Foot of second pair of swimming-feet, male	× 380.
Fig. 31.	Foot of third pair of swimming-feet, male	× 380.
Fig. 32.	Last abdominal segment and caudal stylets, male	× 190.

Asterocheres echinicola, Norman.

Fig 33.	Female, dorsal view	× 80.
Fig. 34.	Antenna	× 190.
Fig. 35.	Mandible and palp	× 190.
Fig. 36.	Maxilla	× 126.

Gunenotophorus (?) *globularis*, Costa.

Fig. 37.	Anterior foot-jaw	× 126.
Fig. 38.	Foot of first pair of swimming-feet	× 95.

GLASGOW:

Printed for Her Majesty's Stationery Office
By JAS. HEDDERWICK & SONS.

The follow... ...ally, and can be subscribed for...
TRADE OF THE UNITED KINGDOM WITH BRITISH POSSESSIONS AND FOREIGN COUNTRIES, showing the Quantities and the Declared Value of the Articles.
The Proceedings of Parliament in Public and Private Business are published daily—House of Lords, price 1*d.* per 4 pp.; House of Commons, 1*d.* per 8 pp.
TRADE REPORTS of the several British Colonies, with information relative to their population and general condition.
TRADE REPORTS by Her Majesty's Representatives in Foreign Countries, and Reports on Commercial and General Interests.

State Trials, being Reports of the Chief State Trials which have taken place between 1820 and the present time, published under the supervision of a Committee appointed by the Lord Chancellor. 1820-1823 to 1850-1858. 8 vols. Roy. 8vo. Price 10*s.* each.

Challenger, H.M.S. A Report on the Scientific Results of the voyage of, during the years 1873-76, under the command of Captain G. S. Nares, R.N., and Captain F. Turle Thomson, R.N. Prepared under the superintendence of the late Sir C. Wyville Thomson, Knt., F.R.S.; and now of Sir John Murray, K.C.B. Fifty Volumes. Price 101*l.* 15*s.*

Military:—
AFRICA. BRITISH CENTRAL PROTECTORATE. Précis of information concerning. Price 3*s.* 6*d.*
ARTIFICERS. MILITARY. Handbook for. Price 1*s.*
ELECTRICITY AND MAGNETISM. Text-book. By Capt. W. P. Bull, R.S. Price 9*s.*
FIELD SERVICE MANUAL. CAVALRY. 1899. Price 4*d.* MOUNTED INFANTRY. 1899. Price 3*d.*
INFANTRY. Mounted. Regulations. 1899. Provisional issue. Price 3*d.*
NILE, AND COUNTRY BETWEEN DONGOLA, SUAKIM, KASSALA, AND OMDURMAN. Report on the. Price 4*s.* 6*d.*
RHODESIA. SOUTHERN. Précis of information concerning. By Major C. T. Dawkins, C.M.G. January 1899. Price 2*s.*
SMALL WARS. Their Principles and Practice. New edition. Price 5*s.*
SUDAN. Handbook of the. Part I., Geographical. Part II., Historical. Price 2*s.*
DITTO. Supplement to. July 1899. Price 2*s.* 6*d.*
VOLUNTEER CAMPS. Pay, &c. Instructions relating to. Price 1*d.*

Naval:—
NAVAL PRIZE COURTS. Rules of Court. Table of Fees, &c., &c. Price 3*s.*

Geological:—
BELFORD, HOLY ISLAND AND THE FARNE ISLANDS. By W. Gunn, F.G.S. Price 2*s.* 6*d.*
SOUTH WALES COAL FIELD. Part I. Country round Newport, Mon. By Aubrey Strahan. Price 2*s.*

Local Government Board:—
DAIRIES, COWSHEDS AND MILK SHOPS. Model Regulations. Price 1*d.*
ENTERIC FEVER IN THE URBAN DISTRICT OF COLEFORD AND THE RURAL DISTRICT OF WEST DEAN. Report on. Price 8*d.*
BOARDING-OUT OF PAUPER CHILDREN. 1898-99. Report of Miss H. Mason and of Miss F. M. Chapman. Each 2*d.*

Emigrants' Information Office, 31 Broadway, Westminster, viz.:—
COLONIES, HANDBOOKS FOR. April 1900. 8vo. Wrapper.
No. 1. Canada. 2. New South Wales. 3. Victoria. 4. South Australia. 5. Queensland. 6. Western Australia. 7. Tasmania. 8. New Zealand. 9. Cape Colony. 10. Natal. Price 1*d.* each.
No. 11. Professional Handbook dealing with Professions in the Colonies. 12. Emigration Statutes and General Handbook. Price 3*d.* each.
No. 13 (viz., Nos. 1 to 12, in cloth). Price 2*s.*
CONSULAR REPORTS, SUMMARY OF. America, North and South. June 1899. Price 2*d.*
INTENDING EMIGRANTS, INFORMATION FOR:—Argentine Republic, price 2*d.* California, price 1*d.* Ceylon, price 1*d.* Federated Malay States, January 1900, price 4*d.* Maryland, price 1*d.* Newfoundland, price 1*d.* South African Republic, price 3*d.* West Indies, price 6*d.*

Excise Laws. PRACTICAL ARRANGEMENT OF THE LAWS RELATIVE TO THE EXCISE, &c., &c. By Nath. J. Highmore, Assist. Solicitor of Inland Revenue. 2nd Edition. 2 Vols. Price 30*s.*

Foreign Office:—
AFRICA BY TREATY. The Map of. By Sir E. Hertslet, K.C.B. 3 Vols. Price 31*s.* 6*d.*
COMMERCIAL TREATIES. (Hertslet's.) A complete collection of Treaties, &c., between Great Britain and Foreign Powers so far as they relate to Commerce and Navigation, &c. By Sir E. Hertslet, K.C.B., &c. Vols. I. to XX. Price 15*s.* each.
STATE PAPERS. British and Foreign. Vol. 80. General Index (chronologically and alphabetically arranged) to Vols. 65 to 79 (1873 to 1888). Vol. 81 (1888-1889). Vol. 82 (1889-1890). Vol. 83 (1890-1891). Vol. 84 (1891-1892). Vol. 85 (1892-1893). Vol. 86 (1893-1894). Vol. 87 (1894-1895). Price 10*s.* each.

Board of Trade Journal, of Tariff and Trade Notices and Miscellaneous Commercial Information. Published weekly. Price 1*d.*
Index to Vols. 1 to 14. Price 2*s.* And to Vols. XV. to XX. July 1893 to June 1896. Price 1*s.* 6*d.*

Kew: Royal Botanic Gardens. Bulletins of Miscellaneous Information. Volume for 1898, price 3*s.*; and Monthly parts, 1899, price 4*d.*

H. & S.—875—7/1900.

EIGHTEENTH

ANNUAL REPORT

OF THE

FISHERY BOARD FOR SCOTLAND,

Being for the Year 1899.

IN THREE PARTS.

PART I.—GENERAL REPORT.
PART II.—REPORT ON SALMON FISHERIES.
PART III.—SCIENTIFIC INVESTIGATIONS.

PART III.—SCIENTIFIC INVESTIGATIONS.

Presented to Parliament by Command of Her Majesty.

GLASGOW:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE
BY JAMES HEDDERWICK & SONS,
AT "THE CITIZEN" PRESS, ST. VINCENT PLACE.

And to be purchased, either directly or through any Bookseller, from
JOHN MENZIES & CO., 12 HANOVER STREET, EDINBURGH, and
90 WEST NILE STREET, GLASGOW; or
EYRE & SPOTTISWOODE, EAST HARDING STREET, FLEET STREET, E.C., and
32 ABINGDON STREET, WESTMINSTER, S.W.; or
HODGES, FIGGIS, & CO., LIMITED, 104 GRAFTON STREET, DUBLIN.

1900.

[Cd. 211.] *Price 3s. 9d.*

ND,

US.