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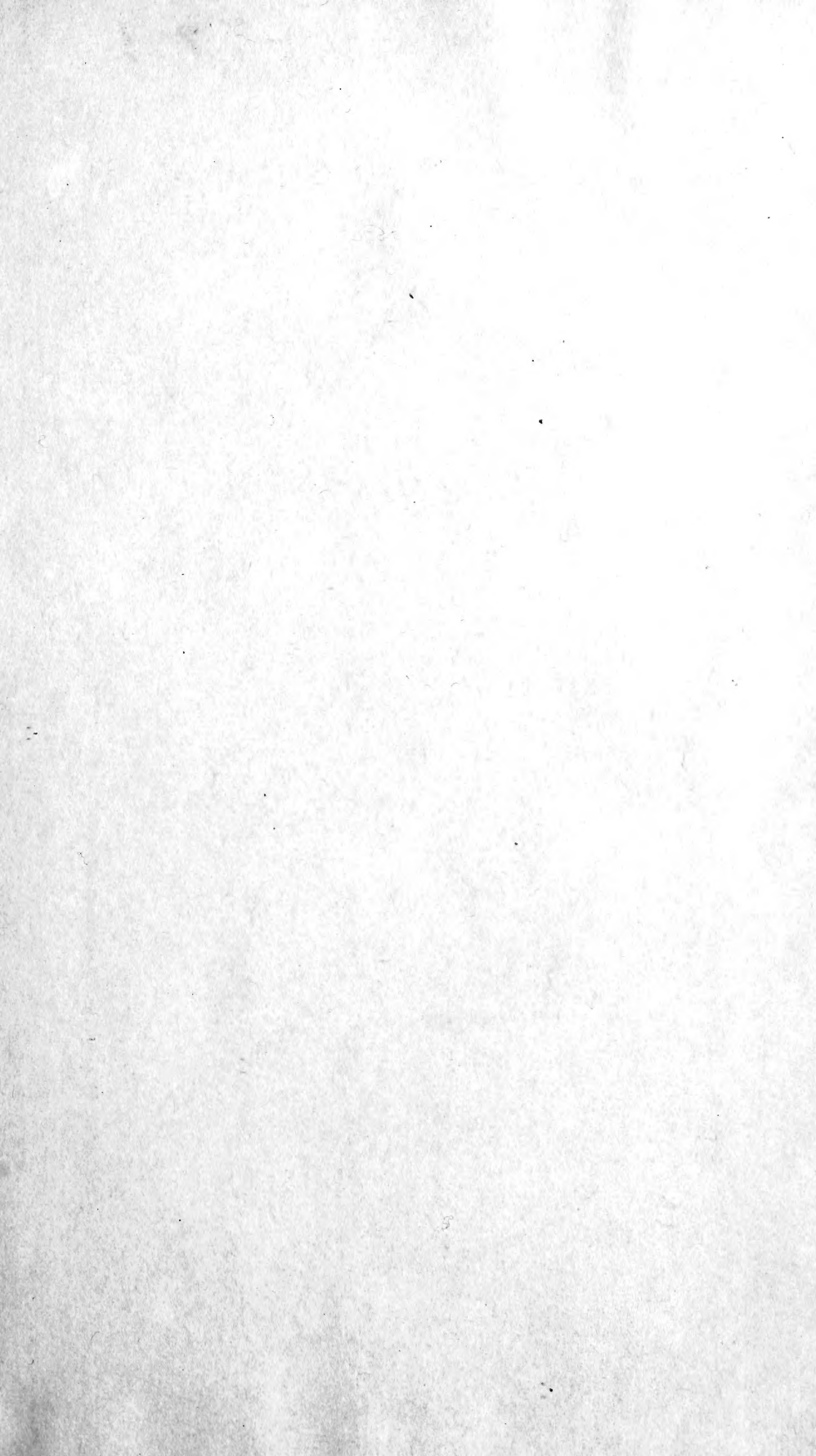
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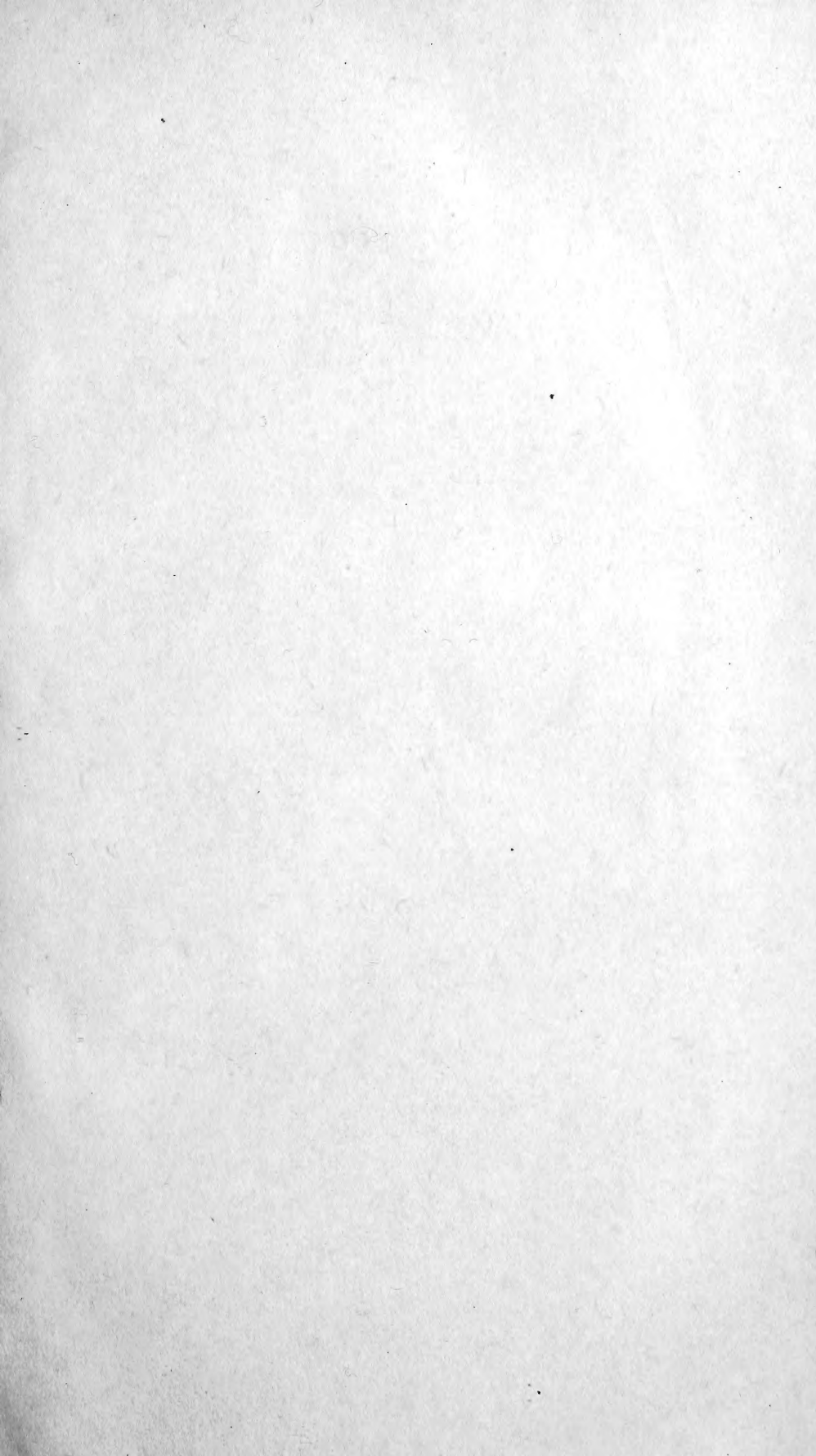
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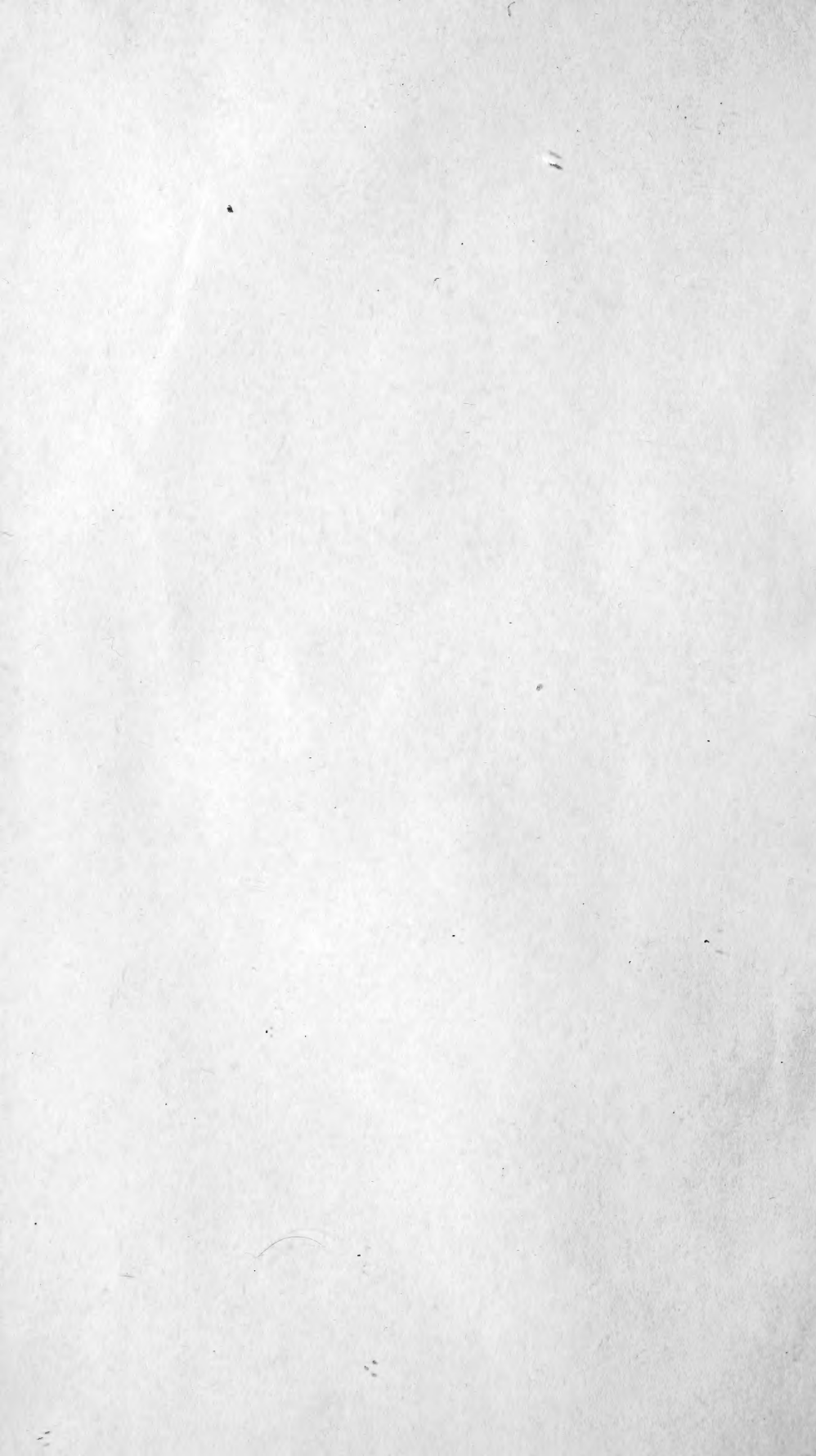
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**TWENTY-EIGHTH
ANNUAL REPORT**

FISHERY BOARD FOR SCOTLAND,

Being for the Year 1909.

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 His Majesty.



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TWENTY-EIGHTH ANNUAL REPORT.

TO THE RIGHT HONOURABLE

LORD PENTLAND,

His Majesty's Secretary for Scotland.

OFFICE OF THE FISHERY BOARD
FOR SCOTLAND,
EDINBURGH, *April*, 1910.

YOUR LORDSHIP,

In continuation of our Twenty-eighth Annual Report, we have the honour to submit—

PART II.—REPORT ON SALMON FISHERIES.

We have pleasure in stating that during the season 1909 the take of salmon throughout Scotland has considerably improved. The weight of salmon carried by railways and steamships shows an increase over the average for the last five years of 320 tons. It is satisfactory, also, to notice that the improvement is not confined to any particular district or districts, but is common to the whole country. As formerly, we have divided the coastal area into four groups of districts—the first reaching from Berwick to Cairnbulg Point, at the entrance to the Moray Firth; the second, from this point to Cape Wrath; the third, from Cape Wrath to Glasgow; and the last, from Glasgow to the eastern limits of the Annan district in the Solway, this (including the Kirtle) being, for salmon fishery purposes, the southern limit of Scotland.

We have thought it unnecessary to repeat the details of the individual years since 1894, but in the following summary are given the three quinquennial averages since that date, and the total weight of

salmon carried during last season, the details being separated into the four districts already referred to:—

District.	Average, 1894 to 1898.				Average, 1899 to 1903.				Average, 1904 to 1908.				Year 1909.			
	Tons.	Cwts.	Qrs.	Lbs.	Tons.	Cwts.	Qrs.	Lbs.	Tons.	Cwts.	Qrs.	Lbs.	Tons.	Cwts.	Qrs.	Lbs.
<i>a</i> Berwick to Cairnbulg Point,	1,206	18	1	1	839	1	2	9	887	8	2	24	1,018	10	3	19
<i>b</i> Cairnbulg Point to Cape Wrath,	900	17	3	6	737	10	3	17	608	13	1	19	705	18	-	22
<i>c</i> Cape Wrath to Glasgow, . . .	403	7	1	21	274	18	1	27	209	3	3	6	229	15	2	26
<i>d</i> Glasgow to the Border, . . .	260	3	2	6	183	6	1	19	160	9	3	15	231	13	3	6
Totals, . . .	2,771	7	-	6	2,034	17	1	16	1,865	15	3	8	2,185	18	2	17

In the accompanying chart of curves, the fluctuations of the annual record are shown from the year in which detailed statements were obtained (1894).

Mr. Calderwood, in his report, draws attention on this occasion to the extent to which fixed nets are used in the Solway for the capture of salmon and for white fish (Appendix III., p. 25).

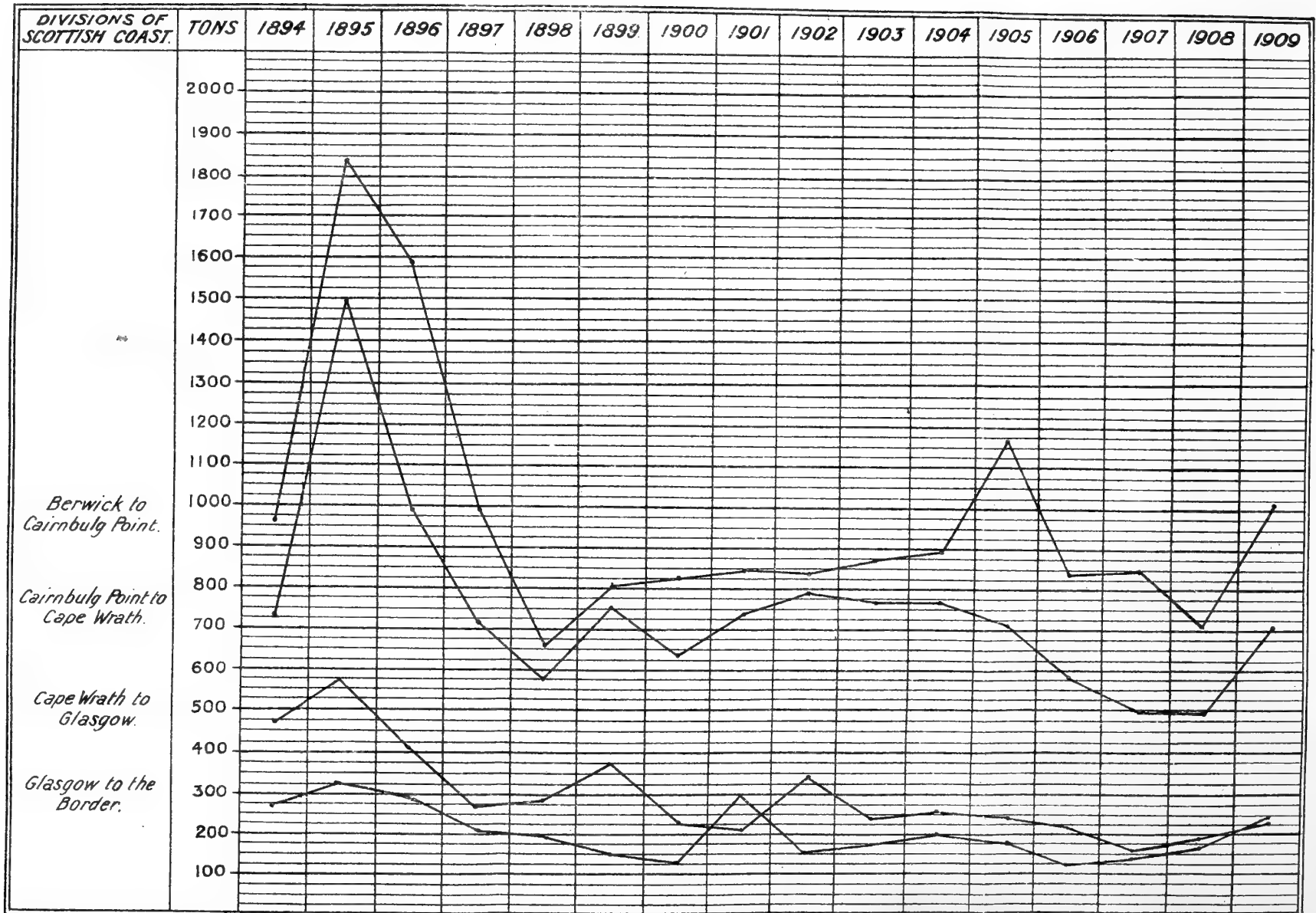
The Inspector has also given much attention, during 1909, to the various conditions which govern the construction of successful salmon passes at waterfalls and weirs. His observations are embodied in the First Appendix to his report.

As a result of the marking of salmon and the study of their scales, which has been undertaken for a considerable number of years, Mr. Calderwood now emphasises the ascertained fact that salmon do not spawn as frequently as was previously supposed, that it is rare to find a salmon showing indications of having spawned more than twice; and that very many appear to spawn only once. The bearing which this has on the capture of fish returning to fresh water to spawn is evidently important, and it is with satisfaction that we recognise that the netting of salmon in fresh waters, where they naturally congregate before becoming distributed over the upper river areas, is more and more giving place to the netting of salmon in the sea. In the general interests of the fisheries, we consider that this is a beneficial tendency. At the same time, Mr. Calderwood considers that the stock of salmon in Scotland will not become restored to the former condition of plenty till powers are given for reducing the capture of grilse and young "maiden" fish. Questions of pollution and the removal or modification of obstructions to the ascent of fish also require attention.

The reports from District Fishery Boards and others reflect the improvement already noted. In a few instances, returns of the actual numbers of fish caught are supplied. While greatly appreciating the receipt of such statistics, we still are very sensible of the disability under which we suffer in being unable to secure annual statistics from all the districts of Scotland showing the numbers of fish taken. Although the weight of fish represents their commercial value, it is a very poor indication of the number taken, since in certain districts grilse and other small fish greatly predominate.

As an indication of present rentals in leading districts, the following table is given. The figure £23,715, given for the Tay, constitutes

CURVES SHOWING APPROXIMATELY THE TONS OF SALMON CARRIED BY
SCOTTISH RAILWAYS & STEAMSHIPS SINCE 1894.





a record. In 1908 the assessable rentals of 33 districts from which reports were received amounted to £121,521. In 1909 the total for the 33 districts amounts to £140,224. These figures do not include those relating to the Beauly, Conon, and Thurso.

YEAR.	Tweed.	Tay.	N. Esk.	Dee.	Spey.
	£	£	£	£	£
1900, . . .	..	22,548	6,510	18,989	..
1901, . . .	..	22,558	6,466	19,418	8,608
1902, . . .	..	22,663	6,494	19,455	8,146
1903, . . .	15,338	22,648	6,494	18,393	8,147
1904, . . .	15,439	23,099	6,494	19,078	7,396
1905, . . .	15,499	22,675	6,489	19,332	8,364
1906, . . .	15,499	22,838	6,485	19,068	8,740
1907, . . .	15,732	23,202	6,490	18,940	8,990
1908, . . .	16,093	23,508	6,474	18,893	9,243
1909, . . .	16,092	23,715	6,614	18,335	9,396

In Appendix VII. will be found a table giving the details of value for 31 Fishery Districts.

A complete list of the Appendices to the Report is:—

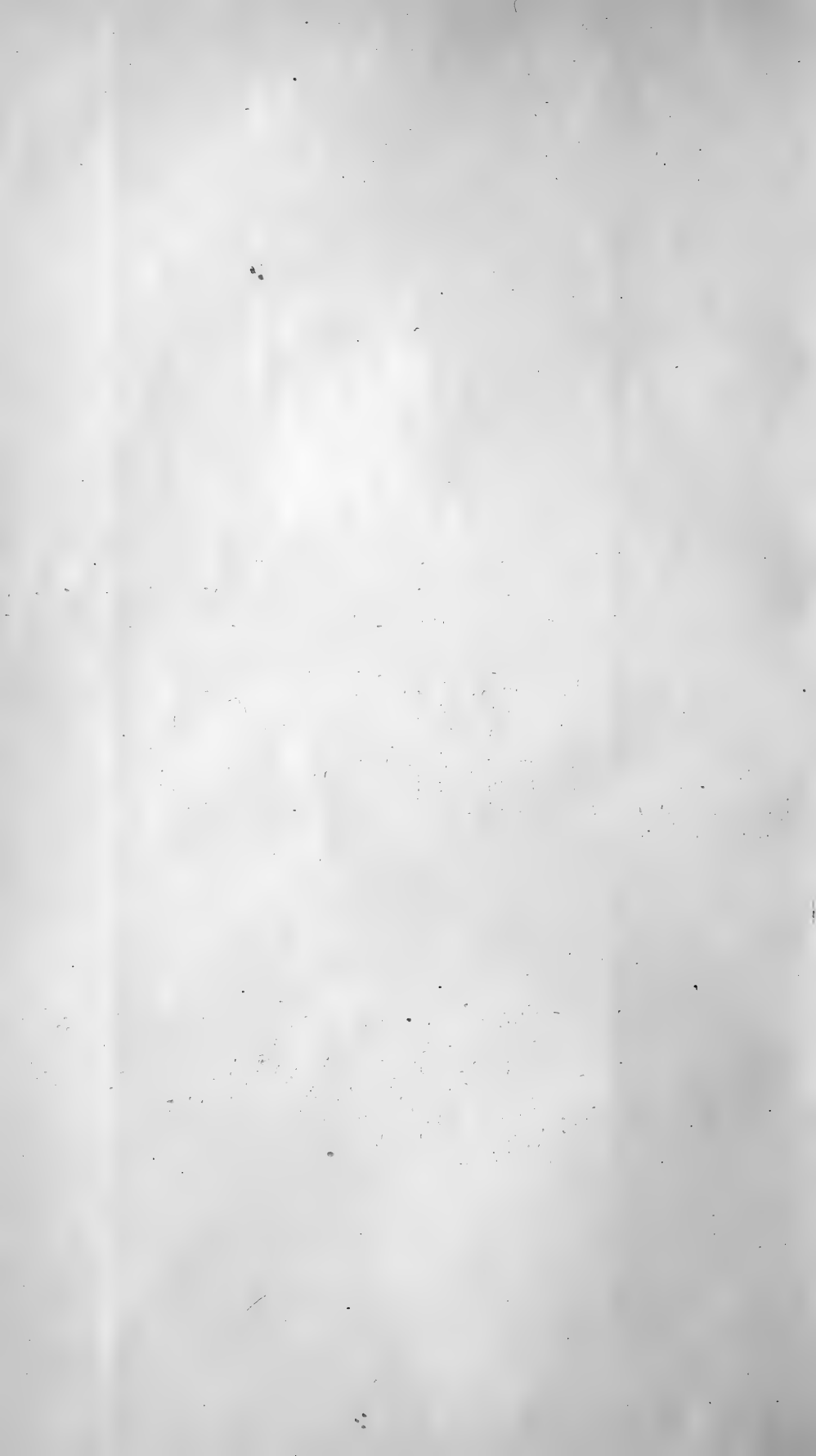
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- VIII. Annual Close Times applicable to Scottish Salmon River Districts.
- IX. List of Chairmen and Clerks of District Fishery Boards.

We have the honour to be,

Your Lordship's most obedient Servants,

ANGUS SUTHERLAND, *Chairman.*
 D. CRAWFORD, *Deputy-Chairman.*
 D'ARCY W. THOMPSON.
 W. R. DUGUID.
 L. MILLOY.
 D. MEARNS.
 H. WATSON.

DAVID T. JONES, *Secretary.*



ANNUAL REPORT
OF
THE INSPECTOR OF SALMON FISHERIES
FOR SCOTLAND.

MR. CALDERWOOD'S REPORT.

FISHERY BOARD FOR SCOTLAND,
April 1910.

I have the honour to submit my Report for the year 1909. My annual inspection commenced by an examination of the Solway districts from Dumfries westwards. I was especially anxious to notice more closely than I had previously had an opportunity of doing, the so-called white-fish nets, which are commonly fished in the Solway estuaries in close proximity to the mouths of rivers. I was aware that those nets had frequently been the cause of complaint by salmon fishers, and while I fully appreciated the fact that any interference with the public right of white-fish fishing should be most carefully guarded against, I had been led to suspect that a very considerable amount of salmon fishing was being carried on under the guise of white-fish fishing. My inspection fully bore this out; indeed it appears that, at the time of my visit, there were more stake-nets ostensibly fishing for white-fish than for salmon. My contention is that it is quite unnecessary to fish for white-fish with expensive nets of a pattern exactly similar to recognised salmon nets, and that these so-called white-fish nets are not infrequently placed where white-fish cannot well be expected. There is no doubt that these nets do catch salmon. I have had proof of this personally, and the Courts have from time to time convicted the owners of such nets of taking salmon. I consider that an abuse of white-fish fishing obtains, and I have ventured, in the detailed paper on this subject which I have placed as Appendix III. to this Report, to describe the stake-nets which are used on the Lancashire shores for the capture of white-fish—engines which are not roofed, and have no "heads" or traps of any kind, and

which, if used in the Solway, would remove all cause of complaint, and at the same time, I believe, catch white-fish most efficiently. I would respectfully ask that the Board consider the need of bringing in a bye-law on the subject of the pattern of fixed net to be used for the capture of white-fish in the estuaries of the Solway.

Nith.—When in Dumfries I had an opportunity of observing the manner in which the salmon sweep nets are used in the river Nith below the town. As a result, I have had correspondence with the Clerk of the District Fishery Board, and I hope that in future the nets in question will not be fished in any way which may be regarded as “drift net fishing.” The stock of salmon in the Nith still remains far from satisfactory; spring fish are practically absent. Little has been done, in spite of strong recommendations, to open up the weirs which obstruct much of the natural spawning ground of the district. The estuary is still polluted to a considerable extent, chiefly because the new system of sewage purification does not, as yet, include the trade waste from the large manufactories. The third cause of the district’s backward condition, viz., the excessive netting by means of paidle nets and haaf nets in the estuary, has recently been the subject of litigation, and is referred to in the Appendix dealing with white-fish nets, to which I have already referred. So long as these conditions remain, it is futile to hope for earlier-running fish; while to continue even rod fishing later than the present season would, in my opinion, be only adding to the risk of injury.

Solway Dee.—When in the Kirkcudbright district, I took the opportunity of visiting the Doaches of Tongueland. At the Big Doach, the river being low and the traps open, I found that the water had a fall of 2 feet 9 inches or 2 feet 10 inches; that at the Priory Doach the water falls 18 inches at the sill, and from the rocks at this point makes a further descent of about 2 feet. At the Little Doach, that is the one next the right bank, the water falls from the lower sill about 2 feet, while a natural fall exists about 30 yards above. A large and solid bastion of concrete has, since my last visit, been built on the left side of this doach in place of the stonework in a wooden frame which previously existed. I was much struck with the very great waste of water which is allowed to continue. Just previous to my visit the dam across the numerous channels above the mill had been renewed, but the sill had been formed of creosoted wood, which I feared would for some time affect any fish lying below. A small percentage of creosote in a river is sufficient to taint salmon to a surprising degree. In spite of this renewal of the sill and the closing up of gaps with stones, a great amount of water percolated through the substance of the dyke, since no cement had been used. A more remarkable waste was noticeable in a disused lade at the mill. The lade now used runs behind the mill, *i.e.*, the mill stands between the river and the lade. The old lade is on the river side of the mill, and is allowed to run full of water, and the old wheel, destitute now of floats, still occupies its old site. I visited Tongueland on a Saturday afternoon when the mill was not working, and found this waste of water going on. The inference was clear that all through the weekly close time the same waste would continue, and fish checked by the doaches would be further impeded from overcoming the obstructions at the only time during which they have much

opportunity of doing so. M'Ready, the fisherman, tells me the sluices are never put down unless something is wrong with the mill. This is not as it should be. The fishings are now held by Captain Hope, of St. Mary's Isle, who also has bought the fishing rights formerly held by the Cally Estate. The Yairs of the Dee are also in Captain Hope's hands, those owned by the Burgh of Kirkcudbright being rented by him. In this connection, I understand that when Captain Hope took over these fishings in 1905 he offered to sell certain of them to the upper proprietors for the sum paid, in order to improve the river. This proposal referred to the doaches and the two net and coble shots below the doaches and above Tongueland Bridge. This most valuable opportunity for removing the doaches, which undoubtedly stand most materially in the way of real improvement in the Solway Dee, was unfortunately not taken advantage of. The river is still netted in three or four places above, however, and to deal in any satisfactory manner with the resuscitation of this beautiful river, it is necessary that all netting and cruive fishing above tide-reach should cease. It is unusual in these days, when salmon angling is so valuable, to find a chance of this sort thrown away. I believe it would not be difficult to find one or two enterprising sportsmen who would willingly take over the river if negotiations for the removal of the nets could be successfully carried through.

Cree.—In the report from this district, published in Appendix IV., appears the statement that there are no pollutions. On inspecting the river on 21st June, I was more than surprised at the gross pollution which is allowed to enter from the town sewers of Newton-Stewart. The outfall is above tide reach and a short distance below the outlying houses of the town. The slaughter-house is in close proximity, and at the time of my visit the outfall was running red with blood. Domestic sewage is apparently quite untreated, while in the neighbourhood of the outfall is a horrible litter of all manner of town refuse. I understand from the Clerk to the District Fishery Board, whom I spoke to on the matter, that the site of the outfall was selected by way of compromise after discussion between the County Council and Lord Galloway, and that it has been complained against by the proprietor of Maharmore House, which stands opposite the outfall. In my view, it is most objectionable in the interests of salmon fisheries. The Cree is not a large river, and such an outfall cannot fail to check the ascent of fish in normal conditions of water, and to prevent them entering fresh water when the river is low. The fixed nets of this and of the Fleet district are separately referred to in Appendix III., which deals with the white-fish nets of the Solway.

Bladenoch.—The Board which was constituted in this district in 1906 has lapsed owing to an irregularity at the time of its formation and the opposition of certain local interests. A proposal for an alteration of close time which I learned had since come up for consideration amongst interested proprietors, I explained would now, owing to the absence of a Board, be irregular. A petition was sent from this district to the Secretary for Scotland in 1894, and was not entertained for the same reason.

Ayr.—Proceeding to the Ayr district, I visited the new salmon passes at Catrine which have now been placed upon the obstructions I referred to in a previous Report (the Twenty-fourth Report, p. 11).

I found that the pass on the upper dyke had been partially destroyed by a flood which had washed out the concrete work between the pass and the left bank. I met Mr. Muir, representing the firm of James Finlay & Co., the owners, the manager of the Catrine Mills, and Mr. Macrorie, the Clerk to the District Fishery Board, and as a result it was arranged that a new pass be constructed in the centre of the weir, having a gap of 6 inches in the sill and down-stream face. I also arranged the details of the structure; Messrs. Finlay & Co. agreeing at the same time to fill in the abrupt rise to the coping of the dyke, and that the old pass would be filled up. I next visited the steep dyke a short distance lower down, to which I took such exception on my previous visit. I found that the suggestions I had previously made had been carried out most successfully, a deep gap having been cut down into the substance of the weir, and an easy slope to the pool secured. At some rocks which exist at the bend of the river below this weir, I found also that a passage had been blasted so as to secure an easier ascent for fish. The rock here is soft and stratified in thin layers. The result of the operations seemed to me in every way satisfactory. I then proceeded down the river to Ballochmyle, where a serious double weir exists, which in my opinion is now the most difficult obstruction in the river. I here met Mr. Campbell, representing the owner, and discussed with him how the structure might best be rendered easier of ascent. The height of the two weirs I estimated as about 8 feet. Each is of a very steep gradient, the upper being about 1 in $3\frac{1}{2}$, and the lower practically perpendicular. Both dykes are very old and rather out of repair. Mr. Campbell informs me that they date from 1817. The suggestion of cutting gaps in the wooden sills brought up the question as to whether or not the structures would collapse. As a result, I suggested leaving the lower sill intact and making the pass run through below it, about a third of the way from the right bank, the passage to be 6 feet wide and 2 feet deep, measuring from the under surface of the beam. To this Mr. Campbell agreed. With regard to the upper dyke, it was finally decided that Mr. Macrorie should examine it in a lower state of the river, more especially noting the extreme end of the sill at the right bank, to see if the removal of short pieces of wood, which have apparently been attached to the sill, would create at this point a sufficient gap, and otherwise to endeavour to arrange with Mr. Campbell for a suitable flow at this point. I attach much importance to the overcoming of this obstruction, and hope the negotiations may lead to a successful result. The dam dyke below Stair Bridge, which I next visited, does not appear to be a very serious obstacle, but the ascent of fish would certainly be improved if a pass were provided as required by statute. I am informed that last autumn a great many fish were stopped at this weir. Reports all go to show that since the opening up of the various weirs of the Ayr was commenced, and the netting at the mouth of the river stopped, the stock of fish has very greatly improved. Unfortunately, no one in the district seems to keep accurate account of the fish killed by rod, so that it is impossible to say definitely what the improvement amounts to. I have been informed, however, that in Auchincruive water in 1907, one rod took 19 salmon in two days, and the reports of fish seen ascending the weirs go to show that the

number has greatly increased in recent years. In my inspections of the Ayr and the Doon, which I also visited, I was greatly facilitated by the arrangements kindly made by Mr. Macrorie.

Awe.—In visiting this district, where nets have been entirely removed from the river by the action of the Angling Association, I was struck with this apparent anomaly, that the two netting stations just outside the mouth of the river, owned by Ardchattan and Inverawe, are now worked by seven boats and seven nets, although each proprietor has only about 200 yards of shore. This seems to be an instance of the difficulty which is overcome by the regulations in force in England, where a "weir-shot" may not be made within a certain distance of another net. I am informed that since the removal of the river nets, also, a certain, but probably limited, amount of netting has been carried on in Loch Awe. There is no doubt that as the stock of fish in this district increases, fishing in Loch Awe will become more valuable, and, if fish are found to run sufficiently early, rod fishing for salmon will be added to the attractions of the loch. A few salmon were caught on the rod in 1909.

Other inspections were in Glen Etive, Kingairloch, Ardgower, Invermoriston, and Inverpolly, at which places special interest attached to the formation of salmon passes. In Appendix I. reference to this subject will be found.

INFREQUENCY OF SPAWNING AMONGST SALMON.

A most important point, brought out by the marking of salmon and by the study of the scales of fish caught at different stages of growth, is that we must now modify our views as to the regular or frequent spawning of the salmon. During the last twelve years several thousands of salmon have been marked in Scotland, and although a series of most interesting and important recaptures have been made, the total number of the recaptures is, compared with the number of fish marked, comparatively small. In view of the high percentage of sea fish which have been recovered after marking, surprise has sometimes been expressed that in rivers, where fish would appear to be much more under command, the percentage is so small.

The reason for this small return of marked fish is not that the marks are lost from the fins, or that many are overlooked, but that salmon do not make frequent returns to fresh water, do not spawn often in their lives, and do not therefore come often within the reach of nets and rods so that a chance of taking them is possible. For our recapture of marked fish we are dependent on the infrequent return of the spawning salmon.

The smolt-marking carried on in the Tay has shown that the return of any one season's smolts is spread over a period of fully four years. Grilse are the fish which return after an absence of one year; small spring fish are those which return after a second winter in the sea; summer and autumn fish of this second season are likewise from the same batch of smolts; while large spring fish and many others, which are by this time mixed up with fish of dissimilar age, are also from the same batch of smolts, and are all returning to fresh water for the first time; while a few fish may further be taken, up to the end of the fourth season—*i.e.*, fish fully six years of age, counting from the time

of hatching. In other words, a smolt, when it leaves the river for its great feeding-place, the sea, may return for the first time in any one of the following four seasons, though the majority seem to return within three years. We have no evidence to show that the first return is delayed beyond the fourth year.

In the same way, we yet lack evidence to prove what nevertheless may be true, that spring fish produce spring fish, or autumn fish produce progeny which run at a corresponding season. In passing, I may also state that we do not know as yet the proportion of smolts which reach maturity under natural conditions.

With regard to our information from marking, we know that the 8840 fish of which I have particulars have spawned at least once. The fish have all been marked in fresh water, and we know that no salmon eggs can come to fruition in the sea. The reproductive period in the salmon is in all probability very much the same as in the brown trout. All evidence points in this direction. If we take the reproductive period as ceasing when the fish is about eight or nine years old, we may notice that this corresponds with the time when the fish ceases to appear in our rivers, and when the salmon ceases to return from the sea we cease to know anything about it.

I have received 380 recovered marks, discounting a certain number of very unimportant recaptures, such as clean fish taken a second time before they had returned to the sea, kelts taken in the same way, and also discounting all sea trout marked.

If for the present purpose only such fish as were marked as kelts and recaptured as clean fish be selected, we have to confine ourselves to 144 records. Of these, 63 fish had adopted the long absence in the sea, and 81 the short habit.

The 144 fish were no doubt all going to spawn a second time, but they are only a sixtieth of the number marked. It must not be forgotten that an unknown number of fish bearing marks are or were in our rivers, and that the 144 are only a proportion of those, but none the less the number is a strikingly small one.

Of the 81 fish which returned to fresh water after a short migration in the sea, it is possible that a few might have spawned a third time. We have to recollect that even a marked fish is usually knocked on the head, and its record thus ended. So far as our marking shows, we have only one example of a fish spawning thrice. This is the fish referred to in my last year's Report as having been originally marked 1396, in the Helmsdale in the spring of 1905, when a kelt. It was recaptured for the first time in September 1906, when a fish approaching spawning condition, and the mark was changed to 2797. In September 1908, when the watchers were again netting for spawners in the same part of the river, the fish was again recaptured. If men netting for commercial purposes, or rod fishers, had caught this fish it would have been knocked on the head at the first recapture. We never should have had the information about the second, let alone the third appearance in the same river. This is important, for it implies that some of the fish recaptured and killed, if again set at liberty, might have told the same tale, and that we are not at liberty to base an argument upon the numbers of recaptured fish.

Allowing this, we still, however, have the evidence deduced by the examination of the scales. The "spawning mark" is a very distinct

feature: even in the case of the scales of old fish, where the periods of growth may be indistinct, the "spawning mark" is still obvious. Mr. Johnston, in 1907, pointed out* that many of the Tay salmon five and six years old showed no spawning mark on their scales. In a paper in Appendix II. to this Report he again, and more fully, refers to the same matter. It appears certain that some Tay fish up to and even over 30 lbs. have not spawned before the date of their capture. Again and again within recent years it has been pointed out that the scales of salmon showed how seldom they spawn. Mr. J. Arthur Hutton, who has contributed valuable papers on the subject of scales, has kindly informed me that in 1908, 1909, and 1910 he examined the scales of 304 salmon from the river Wye, and that of this number only 21 had previously spawned, and only 1 of the 21 had spawned twice. The particulars are:—

	No. of Fish.	Unspawned.	Previously Spawned.
1908	32	29	3
1909	117	105	12
1910	155	149	6
	<hr/> 304	<hr/> 283	<hr/> 21

Evidence of this nature seems to me more likely to produce reliable information on the infrequency of spawning amongst salmon, than the evidence from marking, since the indeterminate factor of non-recaptured marked fish is eliminated.

Mr. Hutton examined the scales of three Wye fish of 40 lb., 42 lb., and 44 lb., taken last season, and found that the fish were six years old and had never spawned. His returns go to show, therefore, that only about 7 per cent. of the Wye fish taken have already spawned.

It is further significant, as Mr. Johnston pointed out in an earlier Report, that all recaptured fish which have been marked as kelts show this "spawning mark," while it is absent from the scales of the majority of salmon netted or caught by rod in the Tay. Mr. Johnston, in the paper above referred to (Twenty-fifth Report, 1907) says:— "The first period in the salmon's life after it returns to the river at which it spawns is the grilse stage in its fourth year. Many of the Tay salmon, one and even two years older, have no indication of a previous spawning on their scales, and have perhaps spent three years in the sea. They are younger, but, owing to continuous feeding, may be heavier than some fish of similar appearance returning at the same time on their second visit to the spawning beds."

Observations made on the species of salmon which inhabit the rivers of the Pacific Coast of America go to show that at anyrate the sockeye, humpback, and dog salmon only spawn once in their lives, and that certainly all the summer run of these fish die after spawning. On all hands the evidence at command goes to show that the fish composing the salmon family are infrequent spawners.

On the question as to whether or not fish which have once entered fresh water drop back to the sea, evidence is not very explicit. After floods, and especially perhaps after floods of cold snow water, fish no

* Twenty-fifth Annual Report, Pt. II., p. 65.

doubt do drop back in the river. Our marking has shown this to some extent, and it is the experience of netmen who fish near the mouths of rivers that after floods they frequently catch coloured fish which have certainly been in the fresh water. On the other hand, there is no evidence to show that the upper water fish of such rivers as the Tay or the Inverness-shire Garry, or the Orchy, or the Dee, ever drop back till they have spawned in the autumn. In the Garry the evidence is strengthened by the fact, as it appears, that no autumn fish run the river at all, and that the spawners of the upper streams—the Kingie and Quoich—must therefore be the fish which entered the lower Garry in spring. The conditions present in certain rivers may tend to make fish drop back more than is certainly the case in other localities.

Be this as it may, it is clear that even if fish do drop out of a river, and take up their abode in the sea once more before spawning, this only further strengthens the argument which I am endeavouring to enforce, viz., that the protection of the fish which enter our rivers to spawn is of far greater importance than was previously supposed, and that the proper regulation of such netting as is still conducted so as to catch fish which are making for their spawning grounds in fresh water is all-important.

W. L. CALDERWOOD.

APPENDIX I.

SALMON PASSES.

BY W. L. CALDERWOOD.

From early times salmon fishery legislation has provided, *inter alia*, for the distribution of fish in upper waters, and has decreed that gaps and passes be provided in obstructions.

The obstructions to the ascent of salmon may be either natural waterfalls or artificial weirs and dam dykes. In a few cases a combination of these two types exists, natural barriers of rock having been levelled up by super-imposed building. The owner of an artificial obstruction in a salmon river is required, under the general Scottish Salmon Acts, to provide a salmon pass; while either artificial or natural obstructions may be purchased by a District Fishery Board for the purpose of removal or, in the case of a waterfall, for the purpose of erecting a fish pass. Agreement on the part of the owner is, however, required in the latter case. It is unnecessary, and it would be unwise, to speculate what may be deemed proper in future legislation, but undoubtedly the benefit of opening up all available spawning grounds is more and more realised as our salmon fisheries continue to increase in value.

Amongst the earliest artificial obstructions were the cruive dykes or fishing weirs which once were so numerous in Scotland, but which now, fortunately, are to be found only in a few rivers. The gap in the cruive dyke—called also the “mid-stream”—was at one time required to be of such size “as a swine of 3 yer elde, well fed, is of length so that neither “the grouzie nor the tail may wyn till any side.” In process of time the rule has become more observed in the breach than the observance, or, in other words, the rule requiring the breach has not been observed. Ultimately the Courts held that the rule had fallen into disuetude; but this seems to have happened simply because witnesses could not point to any cruive which retained a mid-stream, being in ignorance, presumably, of the Inverawe cruive, which, with its ample mid-stream, has existed in its present form since about 1480, in the reign of James III. of Scotland.

I desire in the present instance to describe what I regard as the important features in salmon passes, since it seems to be from the study of the fundamental principles, and how they may be applied, that we are most likely to arrive at really or approximately satisfactory arrangements. I have seen all the passes in Scotland, and I have seen many of them on several occasions. I do not hesitate to say that the majority of them are unsatisfactory. Some useful purpose will therefore, I hope, be served by an attempt to distinguish the valuable from the useless or harmful features, and by showing how the valuable features may be applied.

One has at the outset to state that obstructions are clearly so very different that it is necessary to consider carefully the precise conditions of each. Weirs have, no doubt, certain features in common—the height is well defined, the sill is more or less uniform, the water above is almost invariably smooth; yet the down-stream face may be gently sloping, or it

may be perpendicular. Fish may be assisted up a sloping weir, but have to be led round a perpendicular one. With natural waterfalls, however, a very great variation exists, and an infinite number of expedients may be resorted to. No hard and fast rule of any kind can be applied. Each case must be judged separately. A tendency has appeared from time to time to apply one type of pass, which has been successful in one or two cases, to all classes of obstructions. This I believe to be fundamentally unsound. A good type of pass at a comparatively low obstruction may be useless when it has to be adapted to a high fall.

Amongst *preliminary considerations* it has to be borne in mind that no pass, be it ever so good, is as efficacious for the ascent of salmon as the unobstructed channel of the stream; hence it follows that if conditions permit, and the interests of the salmon alone can be considered, the best possible course is to remove the obstruction altogether. Even a considerable waterfall can sometimes be entirely cleared away (as has been done in the Tilt). Such a course is almost necessary if spring fish are hoped for above, since an obstruction which would be quickly surmounted by fish in summer or autumn forms a complete barrier when the water temperature is low. There are very many small falls in Scotland up to which spring fish ascend, but beyond which they will not attempt to go till April or May, when the wintry conditions of temperature have left the water. A spring fish does not leap at a fall; a fish in summer does. The particular time at which fish naturally congregate below an obstruction has therefore a definite bearing upon the question as to the sort of pass which is necessary. A pass with rough broken water is of no use for the ascent of spring fish.

Similarly, in the case of passes for summer and autumn fish, one has not merely to ask what will the fish be able to surmount, but how can suitable conditions be secured to enable gravid female fish to ascend without difficulty. Man's knowledge of the salmon's energy and powers of leaping has too often been a snare in trying to construct a salmon pass. A fairly steep gradient may do well enough if a fish has to surmount only a few feet, while a very easy gradient, when long drawn out, may be too difficult for a running fish if no rest is provided. Undoubtedly, the gradient should in all cases be as easy as possible; but at the same time, in small streams, if the obstruction is not far up from the sea so that it may be reached by fish in vigorous condition, a very easy gradient is not so essential.

There are two points of special moment in all passes, apart from considerations of gradient—(1) the position of the entrance or lower end, and (2) the most suitable level of water at which to insert the pass.

(1) *Entrance*.—One may have the best possible pass, but if fish do not readily find the entrance it will serve very little purpose. In this connection the natural channel of the river below the obstruction must be noted as a guide to the point at which fish will first encounter the obstruction, and the area in which they will naturally lie. In the case of weirs there is usually little difficulty. Moreover, the water flowing over the sill is usually fairly uniform, while the pass, adjusted as it should be at a lower level than the sill of the weir, receives the chief flow. This concentration of water acts in itself as a useful guide to the entrance. Care must be taken, however, that the entrance is not placed so far down stream from the weir that ascending fish, by the time they reach the obstruction, have already passed the entrance. There is a strong disposition frequently manifested, when it is proposed to make a straight chute-like pass in the down-stream face of a weir which is of rather steep gradient, to project the pass down-stream into the pool below so as to obtain an easier gradient. It is better to project the pass up-stream into the pool above, cutting deeply into the sill of the weir to allow of the

easy gradient in the pass. A rectangular trough excavated in the weir below the floor of the pass is also, under certain conditions, of great advantage. As "breaks" to descending water the alternating projections, which give a zig-zag direction to the water, adopted by Foster, Forsyth, & Smith, of Deanston, are now generally discarded, and rows of upright stones are much used. This chute type of pass is, however, only suitable for low weirs. If possible, a pass of easy gradient may be carried round one end of the weir, or even, first of all, in a direction away from it, and then returning to the pool above, the arrangement being adopted as the river bank and bed most readily permit, so long as an easy gradient be secured and the entrance kept close to the foot of the obstruction. It should be understood, also, that an easy and uniform gradient is quite compatible with a pool pass, the various sills of pools being points in the uniform gradient.

A recent example of a pass of uniform gradient, but with the mouth placed too far from the obstruction, is at the Airthrey Dam Dyke, in Allan Water, just above Bridge-of-Allan. Here the new pass has been carried up the right bank, beyond some flat rock-shelves, the entrance being at the side of the river, but so far from the dyke that ascending fish pass it as they swim up the main flow. The greater part of the pass has a gradient of about 1 in 17, but the lowest section has a considerably steeper gradient, so that the water becomes very rapid and broken, and additionally unsuitable for the entrance of fish. The rock ledges which now lie between the pass and the weir are at a considerably higher level than the bed of the river, and, moreover, have sheltered pools some four feet or so in depth between the ledges. Ascending fish naturally run up to those pools, and in the autumn of 1909 they accumulated here in great numbers. Unfortunately, the District Board have agreed, when arranging with the owner of the weir and with the tenant of the adjoining paper mill, as to water flow in the lade, to the placing of a beam all along the sill of the weir so as to heighten it by six inches. This now gives an abrupt coping at the crest of the dyke, so that fish ascending from the rocky ledges are quite unable to surmount the crest. It seems to me that in allowing this beam to be placed on the sill the District Board have omitted to notice that Clause 7 of Schedule G of the 1868 Salmon Act reads:—"No dam shall be so altered "as to create a greater obstruction to the free passage of fish than at "present exists." In any case, the presence of the beam is now most injurious, for fish do not enter the pass, and are now prevented ascending the weir. On the 3rd and 6th November last, 293 fish were lifted out in landing nets below the weir and carried to the water above.

With waterfalls the selection of the best place for the entrance is more difficult. The pool or pools below a fall may be extremely deep, and fish may have several "lies," and may move from one lie to another under different conditions of level, or even at different times of the day. Some falls which are partial obstructions are ascended by fish in dead low water; others can only be negotiated in flood. As in the case of artificial obstructions, it is important that the entrance be not placed too far downstream from the fall. The position must be selected in relation to the most suitable level of the river for fish running, coupled with the adaptability of the neighbouring rocks for constructing the lower end of the pass. For instance, if "running" fish freely enter a large pool below a fall, but, on account of heavy white water, are unable then to ascend further, the best position for the entrance is not close up to the fall, but close to the "lie" where the running fish congregate below the white water. When the river shrinks to a lower level these fish will probably move up nearer the fall and leap at the obstruction; but the river is not now in its best running order, though it is reduced so that fish can try the leap. If they can be assisted in their leap good and well—an additional chance of

getting them up is secured—but the best chance for the pass proper is when the river is at the level at which the fish freely entered the pool. There are even cases in which the possibility of planning the course of the pass so as to secure a well-protected upper end may fairly influence the position of the entrance, but in no case should this imperil the real value of the entrance, or cause it to be moved far from what is considered the best position. An instance of this is seen at the Tummel Falls pass.

(2) *Level*.—From what has just been said, it is apparent that when dealing with waterfalls the question of water level bears a close relation to the question of the selection of the entrance. I consider that it should first be determined in what state of the river fish freely enter the fall pool; in other words, the level of the fall pool should be marked when fish are running, their natural "lie" ascertained, and the entrance selected as close as possible to the place where they congregate. If allowance be then made for the depth of water in the pass when working at its best, the position of the actual floor of the pass at the entrance can at once be ascertained and measured from any selected datum point. An estimate of the line of the pass may then be laid out and the position of the upper end selected. This, in my view, is a much surer method than, as is sometimes done, commencing by selecting the upper end and then working downwards. When the two ends of the pass have been approximately fixed, it is well to erect two water-gauges and note the rise and fall with changes of volume in the river. It not infrequently happens that owing to the constriction of the rocks at the fall, the rise and fall of water is by no means the same above and below the obstruction. A knowledge of this is very useful when the details of the pass come to be adjusted. For want of it curious discrepancies are apt to occur.

It may now be instructive to describe a pass in which the two vital considerations of suitable entrance and proper water level have been disregarded—a useless pass. I may select as an instance the Mugiemoss Dyke Pass on the river Don. The dyke is elliptical in shape, and has a steepish slope on the down-stream face. The pass is a single chute 45 feet long in the centre of the dyke. The entrance to the pass is certainly where, under ordinary conditions, fish would naturally find it, but in the Mugiemoss dyke the area between the two arms of the ellipse, projecting down stream on either bank of the river, has been filled up with masonry or concrete, the surface being a flat table-land of smooth cement. Immediately below this is a deep pool. The water descending the pass (which it does with undue velocity—the gradient being 1 in 5) flies over the flat area of smooth cement before it reaches the deep water where fish can alone lie. When the water level is best suited for fish ascending the pass, the smooth cement flat has but a thin sheet of fast water, so that fish cannot remain upon it. When the water-level has risen sufficiently to enable fish ascending from the pool to swim over the flat area, the pass has become a raging torrent which no fish can take. As a matter of fact, the fish which manage to negotiate this bad dyke do so in high conditions of water by disregarding the pass altogether, making the ascent over the surface of the weir close to the left bank. To render the present pass of value it is necessary to get a suitable depth of water on the surface of the flat area of cement. This flat area, from the foot of the chute to the edge of the deep water, is about 60 feet. The height of the weir above it is 9 feet. There is room, on the surface of the flat area, for two pools of 30 feet, which could, without great difficulty, be constructed by building two subsidiary dykes across the flat area from bank to bank. If the lower of the two dykes were 3 feet high and the upper 6 feet high, the result would be a two-pool pass with three rises of 3 feet each. The two subsidiary dykes would each have a short gap and pass, arranged so that the inflow and outflow of water is not in a straight line, and the level of water in the

upper of the two pools would flood the existing chute so that it would harmonise with the two other rises of 3 feet. If only one large pool were constructed, the velocity of the existing chute, with its gradient of 1 in 5, would still be very considerable, and it might be necessary to deepen it and project it into the pool above the weir so as to reduce the gradient. The two-pool pass is, in my opinion, the better plan.

Arrangements are now in progress for the alteration of Mugiemoss obstruction, so that, I trust, a suitable pass may be erected.

RECENT PASSES OF UNIFORM GRADIENT WITHOUT POOLS.

A type of pass has recently been much employed which is constructed with the floor of uniform and easy gradient, usually from 1 in 20 to about 1 in 24, and having as "breaks" to the descending water rows of upright stones at intervals. It has been employed a good deal in the neighbourhood of Perth, at the outlet from the Shochie Loch, the Dupplin cruive dyke on the Earn, the Bertha dyke on the Almond, and also on a large scale at the second Invermoriston pass,* the Loch Vennacher outlet,† and more recently at the Loch More outlet in the Thurso district, as well as at the Airthrey dyke on Allan Water, already referred to.

Loch More was previously 170 acres in extent; now the level has been raised by the erection of a massive dam dyke at the outlet, and the acreage of the loch has become 511. The dyke is constructed with an angle, the one arm being longer than the other. The pass runs along the outer side of the long arm, and is 200 feet in length, 12 feet wide at the top, and 25 feet wide at the foot or fish entrance. The gradient is 1 in 20. To provide for a flow of water down the pass when the level of Loch More has sunk below the top of the pass, two apertures in the dam dyke have been constructed. These outlets are 3 feet square and are sluiced.

This introduces the consideration of a condition which has not yet been touched upon. In the case of a pass at an obstruction in the course of a river, I have pointed out the great value of determining the level at which fish chiefly run, and of adapting the pass to suit that level. In the case of a pass at a loch outlet, the pass becomes virtually a portion of the river flowing from a sheet of water subject to considerable fluctuation of level. It is, perhaps, very natural that an attempt should be made to adjust the pass to various levels of loch, because any level of loch can supply the pass. At the Loch More pass the highest level at the head of the pass is unsluiced. To provide for lower levels of loch, the two sluiced openings, as already mentioned, enter the pass at the side through the substance of the retaining wall. These side openings send in water, therefore, at right angles to the pass, and this water spreads out in thin fan-like shape and strikes against the opposite side of the pass before it is conveyed down the direct line of the structure. I cannot think that fish will find these side openings easy to negotiate. The dam at Loch More was, however, primarily intended to impound water which could be used for flooding the river Thurso, and the possibility of arranging a pass to suit such conditions is beset with peculiar difficulty, when at the same time the loch above is to be regarded as an important angling water. In the Helmsdale arrangement, Badanloch is not so regarded, the angling tenants preferring that the river should be primarily improved, and giving comparatively little heed to the fishing for salmon in the loch. It is manifestly not easy, while securing a good run of fish in the river by lowering the loch, to arrange a pass which will take fish into the loch at different levels. The pass would require to work at its best when the level of the loch had

* Described and figured in the Twenty-second Report, Part II., p. 109.

† Described and figured in the Twenty-sixth Report, Part II., p. 1.

become somewhat reduced. There would be advantage, therefore, in making the main line of advance, the direct inlet, at a distance below the summit of the dam to be fixed by the amount of water necessarily run off to complete the artificial flood on the river. This requires a somewhat nice calculation of the volume of water shown to be available after a careful survey of the land surface to be flooded by raising the loch.

In the Loch Vennacher pass there are two inlets at different levels, but these are parallel, and are both direct inlets from the loch. They unite at an angle or turn of the pass, after which the channel is single. This in my opinion is preferable to the arrangement at Loch More, but unfortunately the sluices at Loch Vennacher outlet are opened by being lowered rather than raised, hence if a fish ascends the pass when—as commonly may be the case—one or other sluice is only partially opened, it is met by a perpendicular iron sluice gate, over which it has to leap if it can manage to do so.

The same drawback exists at the Loch Katrine outlet and pass, the reason, no doubt, being that the Glasgow Water Trust engineers sought to conserve the water supply held up in these lochs in the best possible way, so that accurate measurements could be obtained at the gauges. In cases such as these, where water is required for most important economic and domestic purposes, the interests of the salmon must necessarily occupy a secondary place, yet I think modifications might have been so arranged as to secure a more hopeful result for the ascent of salmon. But it is extremely difficult to adjust passes at proper levels when other purposes have first to be fulfilled.

Sluices at Waterfalls.—I now desire to say a word or two about sluices at natural obstructions in rivers. As at dam dykes, pass-makers have generally adopted sluiced inlets at waterfalls in order to prevent flooding. The erection of a sluice is perhaps the most natural expedient thought of, such a structure being commonly used with satisfactory results at the intakes of lades and water channels. We have to think of salmon ascent as well as water-flow, however, and I confess I have become very sceptical of the benefits of sluices. A pass at a waterfall being adjusted to the most suitable level of the river, when a rise of water-level takes place, a considerable pressure soon is exerted on the sluice. This not only often jams the sluice, but causes a violent up-boiling at the back of it as the water rises towards its own level. If a little experiment be made by operating a sluice where a sufficiently strong power can be exerted, it will be seen that as the water is cut off from the pass the inrush gradually takes the form of a rectangular douch of increasing pressure and velocity, and that, conversely, as the sluice is opened the pressure is relieved, till the water assumes the appearance of a deep but natural current. Now it may be admitted that by lessening the actual amount of water in the pass flooding is avoided, and the entrance or lower end is kept from possibly becoming too rapid and aerated; but by lessening the amount of water the intake receives such pressure that a new obstacle to the ascent of fish is created. I am convinced that in the case of most sluiced inlets of any size which I have studied, the partial closing of the sluice or sluices results in such force of water that no fish entering the pass can readily get out of it.

Another objection to the partially-closed sluice—and especially of a fixed and restricted opening of any kind—is that the natural rise of river is not communicated to the pass, the result being that the water at the “entrance” tends to be thrown out of proper relation to the river. A pass-entrance, to be attractive to fish, to make its presence felt in the fall-pool, must necessarily be supplied with a good amount of water. When the river is in running order and the pass is working at its best, the allowance of water in the pass should be sufficient to provide the best conditions. When,

however, the river rises, if the rise be not communicated to the pass, the attractiveness of the pass is lessened, the water does not assert itself as formerly, it is in much smaller proportion. Apart from these matters, sluices always require someone to work them on each material alteration of water-level.

But, it will be argued, if the pass is open at the intake and flood water is allowed to descend, the water will become a raging torrent and the pass useless for fish. To this I am inclined to reply that if the pass is in the form of a gradual and even slope, the result will be as stated, and that, especially when the waterfall is high and the pass a long one, this result will be pronounced. Under such conditions also rows of upright stones are quite insufficient to check the water; they rather break it up and increase the foam. The arrangement of the pass must provide a much greater check to descending water, so that in moderate flood it will still be possible for fish to ascend if it is possible for them to run through the fall-pool. In really high floods, however, no fish need be looked for close to high falls.

At the Invermoriston new pass, two powerful sluices were fitted, opening, it is true, from the river at a point where the current is always considerable, and where in times of flood the current is very powerful indeed. After some experience of the working of this pass, one of the sluices was permanently opened and a substantial barrier of concrete was erected outside of it in such a way that water coming to the intake had to follow a narrow but deep and tortuous channel, the commencement of which channel opened at an acute angle to the line of the river's flow. This is found to work much better than the partial closing of the sluice.

I have seen an effective method of a simpler kind in the passes of the Sand River in Norway. A barrier is here constructed of rough hewn logs placed horizontally one above another outside the inlet of each pass. This log barrier allows water to pass below it, and is arranged at such a height as to have no influence upon the pass at ordinary levels. When the river rises, however, the surface flood water is at once impeded, and, owing to the oblique direction of the barrier, turned off to a considerable extent. Ascending fish pass up below the barrier.

THE SINGLE INTAKE TO A PASS FROM A LOCH.

I have already, under the heading of "Recent Passes of Uniform Gradient," dealt with the difficulty of satisfactorily making two or three intakes at different levels from a loch to a pass, and given several instances of attempts to solve this difficulty.

If, however, the water of a loch is not required to supply artificial floods to the river, and is in other respects completely under the control of the river interest, it is possible to have a single intake and to regulate the loch to suit the pass. These conditions have, I think, been practically met at Glengalmadale, near Kingairloch, in Argyll. The loch is an artificial one of no very great size, and there is a pass with a single unsluiced inlet. To provide against flooding, a bye-wash channel, quite separate from the pass, has been constructed in a wide sweep of easy gradient. This joins the river below the foot or entrance of the pass. At ordinary levels this channel is dry, but in high floods it will form an easy pass in itself. Owing to the steep nature of the surrounding hills, and the very considerable rainfall of the neighbourhood, floods are apt to be sudden and violent; a large storm-overflow has therefore been found necessary. To regulate the loch so as to suit the level to the pass, a further device is, however, necessary. This takes the form of a valve outlet passing through the base of the embankment, but drawing water only from the surface of the loch, down a vertical water tower. By opening or closing this flume, the surface of the loch is manipulated independently of any storm-water

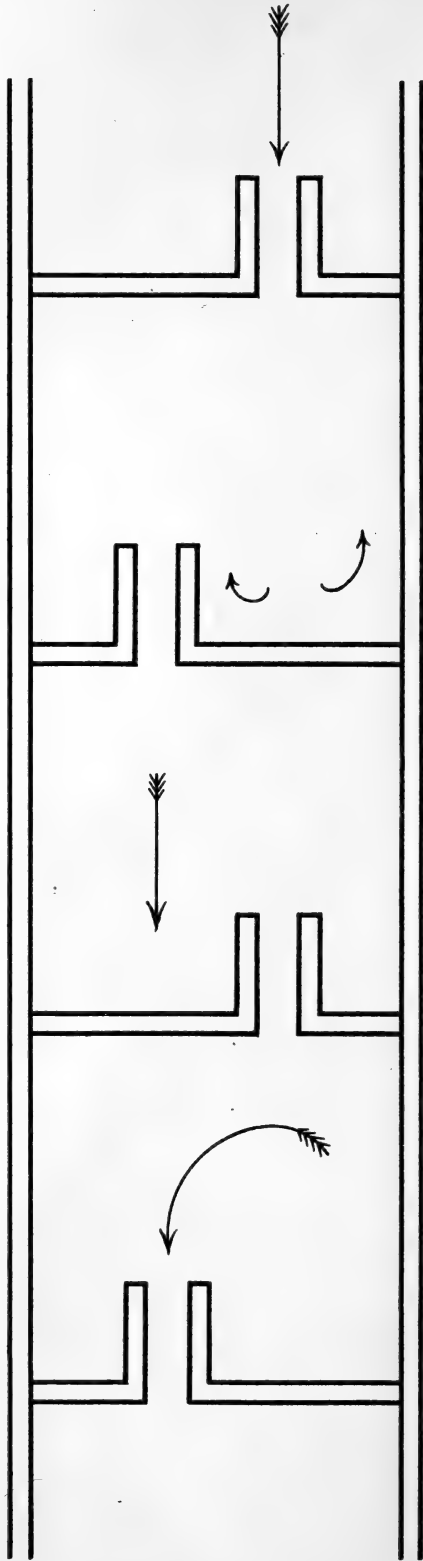
bye-wash. The arrangement is an expensive adjunct, but, in my opinion, it provides most satisfactorily the sort of regulative operation necessary to overcome the drawback of having more than one inlet to a single pass. It is apparently an adaptation to the needs of a loch fish pass of a system of outlet employed in reservoirs. I have not seen it employed in any other fishing loch for the purpose of regulating the pass. If used in a loch of any size it would necessarily have to be of considerable dimensions, but that it is a valuable addition I have no doubt. I shall refer to the pass at Kingairloch when dealing with the subject of pools. For the present I seek to emphasise the advantage, as it seems to me, of doing away with a sluiced pass-inlet even in a loch, and of securing a direct and single pass.

POOL PASSES.

The pass which has as a radical part of its structure a series of pools seems to me to present, in the main, the most satisfactory results. In the natural channel of a river of steep gradient, if there are no pools, the current is swift and troubled. When pools occur, the aeration disappears, and the water pauses in its hurry. As a consequence, short intervals become more steep, but, within limits, the ascent is easier for fish. A quick effort enables them to swim from pool to pool, and in the pools they can rest. In my opinion, a long pass should provide the same conditions, and pools can be so formed as to provide a maximum of resistance to descending water and yet enable fish easily to swim from pool to pool. I do not think pools should be constructed, or need be constructed, which require fish to leap. A fish never leaps if it can swim. I had rather, therefore, provide a pooled pass of this nature with an open unrestricted inlet and allow of flooding, than accept the disadvantages I have tried to indicate as inseparable from an unpooled pass of a uniform incline with breaks at intervals, if it is necessary to cut off water to preserve its tranquility. In the upper part of the Invermoriston new pass, it was found that the gradient was faulty, and that an abrupt drop occurred at the intake. The proper gradient was restored by forming pools in this upper portion. Battens were placed across the pass where the rows of stones previously occurred, and a depth of four feet was secured. This, with the alteration of the intake already referred to, resulted in a great improvement.

At Loch Doon outlet, there are two separate passes of good gradient which are formed in tunnels through a rocky barrier over which a road crosses. Below the tunnels, a considerable section of the cutting is open. They are adjusted to suit high and low levels of the loch, and they answer their purpose well. They were first formed about a hundred years ago, but were much altered in 1885.* The low-level pass is seldom used, and is made without pools. The passes are each about 155 feet in length, and the gradient of the one chiefly employed is about 1 in 20. The water has considerable depth, owing to the presence of wooden barriers placed across the pass at intervals so as to form pools. Fish ascend over the wooden barriers, as in the upper part of the Invermoriston Pass. The number of fish which may be seen at times leaping at the difficult fall which occurs away above Loch Doon, sufficiently indicate how well salmon are able to ascend the pass in question. The water in the Doon pass pools is "black," because of the gentle gradient plus the depth of the water in each pool. Two other arrangements of pool formation have to be noted, however. In the one case—that of the Torrbol pass on the Carnach, a tributary of the Fleet in Sutherland—the walls of the pools are built so high that the water cannot overflow them and has to circulate in the pools before it is able to find an exit. In the other case—that of the Glen-

* A plan of this Pass was given in the Annual Report for 1887, Part II., Appendix IV.



PLAN OF POOL PASS AT TORRBOL, SUTHERLAND.

galmadale pass, near Kingairloch, in Argyll—the pools are excavated, so to speak, in the floor of the pass. The former makes the ascent of a steep gradient much more possible than would otherwise be the case. Both arrangements give strong resistance to descending water. They are the only passes of their kind in Scotland, and in my opinion deserve much more attention than they appear to have received from those who are interested in this subject.

The Torrbol Pass is the longest in Scotland, and has also the reputation of being the first successful pass at a high waterfall. It was designed and executed 45 years ago under the superintendence of the late Mr. Bateson, who was then shooting tenant at Cambusmore. The stream is by no means large, while the waterfall is about 55 feet high. There are rapids and cascades for some distance above the fall; and the pass, being carried beyond these, enables fish to surmount almost 70 feet. Few people seem to know that an obstruction of such great height has been successfully opened up in Scotland.

One of the leading features of the pass is that, when in use, practically the whole water of the stream is sent down it. This has been secured by the formation of a weir at a natural rocky cascade above the fall, where the inlet is situated. This is a valuable factor, since fish are inevitably led into the channel provided for them; but it is only practicable in a stream of moderate size.

The pool at the foot of the fall is large and deep, and the water level has been raised so as to secure a better entrance at the pass-mouth. From the fall-pool the fish are now led up through a series of built pools situated in what was previously a rocky defile and the course of a small burn. The gradient of the lowest portion of the pass is very steep, having been estimated as nearly 1 in 4, but the formation of the pools is such that a wonderful check is secured on the descending water.

This steep section is about 138 yards in length, and is in a direction away from the stream. The pass then is turned to the right in a sharp elbow towards the stream. Here the gradient soon becomes easy, so that presently the course is simply that of a natural burn with water flow unchecked by artificial means. The total length is about 378 yards, about 240 of which form the upper section of easy gradient. In the lower, or steep section, there are 23 built pools; other seven pools are formed in the lower portion of the pass above the elbow, after which a gradually diminishing series of irregular dykes and stones merge into the flat portion of the pass above. The pools are not all of the same size, the natural features of the defile having been seized upon to adapt the pass in the best manner. The plan of the pools is, however, similar in every case, and will be best understood from the accompanying sketch plan.

The walls forming the pools are made in the manner of Scottish farm dykes, or dry stone walls. In recent years a certain amount of cement has been used to render them more water-tight, and in every case the floors of the pools have been paved with stones grouted in cement. The pools are roughly square, and commonly measure 12 feet to 15 feet. The walls are about 6 feet high.

In the lower part of the pass, the short runs which connect the pools are distinctly steep, but when the pass is well supplied with water these do not hold such rough water as would be supposed on viewing them when dry. Sea trout run the Fleet in numbers, and such steep runs present no difficulty to such expert climbers; but salmon also ascend the pass satisfactorily, and are reported to take well in the stream above.

It will be noticed that the flow from each channel enters a blind section of the pool below, and has here to circulate before it emerges by the next channel. This is the secret of the great check to the water, and the reason why so steep a gradient can be satisfactorily dealt with.

The intake of the pass from the stream above is sluiced, but as the volume of water is not great, no severe pressure is exerted. Moreover, the sluice is either fully opened or fully closed according as the pass or the waterfall is supplied with water.

Unfortunately, a good deal of silt is carried into the pass from an accumulation of sand and gravel which forms at the intake owing to the presence of the weir. This bank is annually dug out and shovelled over the weir or into the sand trap of the weir. Many of the pools of the pass have to be cleared at the same time. The difficulty might, I think, be in great part overcome if the intake were moved—as it could be without much trouble or expense—to the upper part of the pool, and the bank at the new intake protected against scouring.

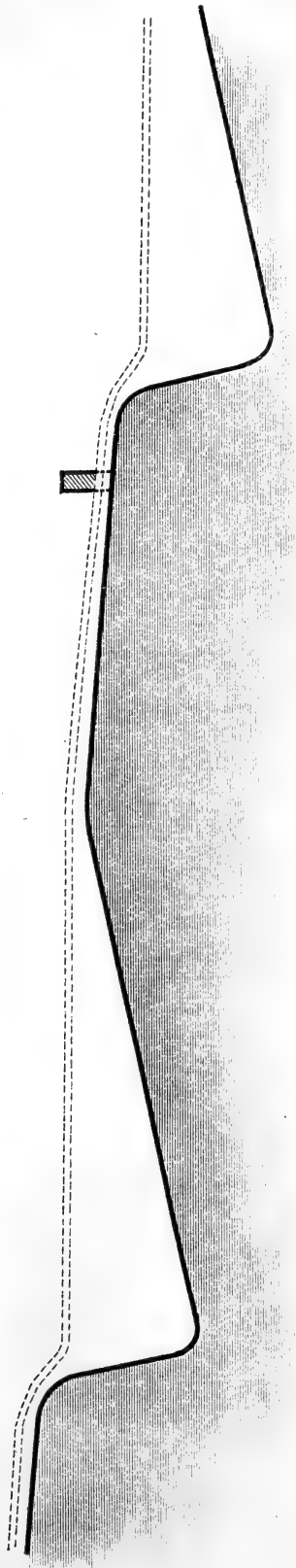
The Kingairloch Pass.—In this structure the pools have a rather special formation. I have already described them as excavated in the floor of the pass. I have now further to describe them as having a slope of floor against the direction of the water, or, in other words, being deeper at the “head” than at the “tail.” Further, they are pools in which the sill is overflowed by the water, which, descending gently into the head of the pool, strikes against the bottom and then has to flow up an inclined plane. The steeper the incline the stronger the check. The uniform gradient is represented by the succeeding sills.

There are 23 pools in continuous succession, each having the upward slope of the floor. A row of cement blocks, similar to the stones used in the pool-less passes of uniform gradient already described, is placed just above the sill of each pool. At this point, in all ordinary levels of water, the current is so easy that the blocks seem to me superfluous. In flooded conditions they may be more serviceable; but then the admirable flood overflow comes into play.

The arrangement of the floor of each pool will be readily understood from the accompanying section plan. It does not show a plan of the particular pass now under review, but is simply intended to show the admirable arrangement. It is an imaginary case of a pass with a gradient of 1 in 24, having two pools with a short run between them, as might be adopted in certain localities. In the section the vertical scale is twice the horizontal for the purpose of emphasising the formation.

The steep slope of the upper end of each pool must have at one point a good deep **V** or **U** cut into it to save the necessity of ascending fish leaping when leaving the pool. In the channel the breaks of upright stones are advisable. If pools follow one another in quick succession, the **V** or **U** cuts should alternate so as to be first at one side of the pass, then at the other. This gives a certain amount of cross water. With pools 25 to 30 feet long, in all ordinary water levels, the water becomes very easy, and aeration practically disappears. In high water the pass is much easier than if no pools were present, and valuable rests are afforded to ascending fish. An objection to allowing fish to rest in pools of this kind is that they are more open to the attacks of poachers. This may be so, but the objection is, in my opinion, not sufficient to counterbalance the advantage of the pools. The pass must be watched or otherwise protected if there is any fear of poaching. If the water is really heavy, fish may lie the greater part of a day in such pools, and only complete the ascent at night.

If a pool be constructed of such length that the drop into it is two feet or so, a valuable assistance to fish leaving the pool may be provided by a “break” projecting from the side of the pass a short distance below the **V** or **U**, which break may conveniently be propped by strong supports from the bottom or side of the pool. The action of such a break is to form a water-cushion by piling up the water which spouts from the **U**, and so raising the level between the **U** and the break. The difference made by a simple contrivance of this kind is most marked. If pools are at all shallow



SECTION OF A POOL PASS.

in a comparatively small pass, such breaks can be made of large boulders. This I have seen done with excellent effect at Mr. Ian Nelson's pass in Glen Etive, and I have since introduced it elsewhere with equally good results.

At the Kingairloch pass already referred to the sills of the pools are slightly trough-shaped in addition to the alternating **U**—the sill at the side opposite the **U** being higher than at the **U**. This seems to give a very agreeable outflow, and I am informed by Mr. Strutt, of Kingairloch, that although the whole structure has been in his opinion unnecessarily costly, the pass works to his complete satisfaction.

The Falls of Tummel Pass.—I may, suitably perhaps, include now a short description of the large pass now almost completed at the Falls of Tummel, and at the same time venture to mention wherein I consider the arrangement might be still further improved. When finished, as I expect it will be by the time this is published, it will rank with the Invermoriston pass as the largest structures of the kind in Scotland.

The height of the fall, as between the extremities of the pass, is 18 feet, and the pass is constructed entirely through solid rock on the left or Bonskied side.

The length of the pass is 140 yards; breadth, 10 feet; gradient, which is uniform throughout, 1 in 23.

A tunnel has been formed, 40 yards long and 6 feet high, in the upstream half of the pass. The tunnel was completed on 23rd March, and I walked through it a few days later. The quartzite rock is of extraordinary hardness opposite the fall, and the open cutting of the lower section of the pass attains a maximum depth of 37 feet. The Tay District Fishery Board, who bear the expense of the pass, and who have decided on its features, arranged that the floor of the pass should be formed without pools, and that provision for the checking of descending water should be adjusted by rows of stones as in the Loch More pass. The rows of four stones are placed at intervals of 14 feet throughout the length of the pass, the spaces between the stones being, roughly, 1 foot 4 inches.

In a pass 140 yards long, as this is, and with a gradient of 1 in 23, water would naturally become unduly rough in the lower half, in spite of the rows of stones. To obviate this, it has been decided to restrict the inlet of water so that a depth of 1 foot 5 inches will constantly descend the pass, this being the depth at which it is considered the pass will best work. The restriction at the inlet is regarded, however, as temporary and experimental, and is being formed of wooden battens. These battens are to be raised to a height of 6 feet 9 inches above the level of the sill, so as to prevent the entrance of flood water. From what I have already said under the heading of "Sluices at Waterfalls," it will be seen that, in my opinion, more favourable conditions for the success of the pass would have been secured if the inlet had been left open, but provided with an outer protecting barrier as in Norwegian passes, and if pools with steep sloping floors had been relied upon to check the flow of the water. I consider that the restricted opening need not now be regarded as in an experimental stage. It is exactly analogous to a partially-closed sluice.

It is, however, matter for great satisfaction that a pass of a substantial sort has been, at last, constructed at this important waterfall. The distance, measuring above the Tummel Fall to the head waters of Loch Ba, and to Loch na-Gannich, is between 50 and 60 miles, about one-half of which consists of river with good spawning ground. Taking the more northerly direction to the head of Loch Ericht, the distance is, practically the same, but only about 26 miles consist of river. With so extensive an area of pure water and good spawning ground, the opening up of the fall in question should, if the pass is successful, be of great value to the Tay district.

Conclusions.

At comparatively low obstructions, such as dam dykes and small falls, a pass may conveniently be of uniform gradient, provided the gradient is easy and the entrance for fish is suitably placed. At the same time, the formation of pools instead of a single chute-like pass is often advisable. At high falls, where the pass requires to be long, the most satisfactory results, in my opinion, will be obtained by the free use of pools. If the gradient requires at any point to be steep, the Torrbol type of pool is to be recommended; where the gradient may be easy, and especially where a large flow of water has to be dealt with, I would advocate the Kingairloch type of pool.

APPENDIX II.

THE SCALES OF SALMON.

BY H. W. JOHNSTON.

[*Fourth Paper.*]

My three previous papers * on the scales of salmon may be supplemented by some notice of more recent developments.

"WIRED" SMOLTS AND MAIDEN SALMON.

In the Twenty-third Annual Report for the year 1904, it was pointed out that the scales showed that some smolts returned as grilse in the year following their migration, and that others prolonged their stay in the sea and came back in later years as mature salmon of various ages. The two papers afterwards published related how the recapture of smolts which had been marked with a wire in 1905, confirmed the deductions from scale examination as far as was possible up to the time of writing, viz., to the stages of summer and autumn fish taken in 1907. Particulars of a few additional recaptures of fish of the same marking, caught as spring salmon in 1908 when also on their first return to the river after approximately three years spent in the sea, have since been published. †

One of these "wired" spring fish, caught in March, 1908, weighed 35 lbs., so that it had approximately gained one pound for each month spent in the sea, thus maintaining the same rate of increase that was shown in the case of the "wired" 27-pounder recaptured in the previous August, one of whose scales was illustrated in the Twenty-sixth Report. I regret I have been unable to obtain any scales of the 35 lb. spring fish (though one is represented in Mr. Malloch's book); but to continue my series a photograph of the scale of another spring salmon of similar weight, age, and history is now given.

It will be understood that there is no doubt that very nearly all the "wired" recaptures hitherto mentioned (including the large spring fish of 1908) were on their first return, or were, as we may term them, maiden salmon. Had they before been in fresh water for spawning purposes, their great rate of growth would have been still more remarkable.

As previously stated, the examination of the scales of still older salmon led me to believe that they were in many cases revisiting fresh water for the first time, and when it is considered that the number of smolts "wired" in 1905 was limited, and that the proportion of the old and heavy fish in the total annual catch is small, it will be apparent that there may be some difficulty in securing a "wired" specimen of a maiden salmon of six, seven, or eight years old. The present seems, therefore, a fitting opportunity to judge how the lessons drawn from scales as stated in the Report for 1904 have been actually borne out by recaptures of smolts

* Twenty-third Annual Report for 1904 (Part II., App. II.).

† Twenty-fourth Annual Report for 1905 (Part II., App. II.).

† Twenty-sixth Annual Report for 1907 (Part II., App. III.).

† "The History and Habits of the Salmon, &c.," by P. D. Malloch. 1910.

“wired” in 1905. For this purpose the following comparative Tables are given:—

TABLE I.—Summary of the examination made in 1902-4 of the Scales of Maiden Salmon. (*Vide Report for 1904.*)

Class of Fish.	Specimens.		Weights. Lbs.	Estimated duration of Smolts' absence in the sea.	Remarks.
	Num-ber.	Season.			
Grilse,	54	May-August	2 $\frac{1}{4}$ -11 $\frac{1}{2}$	1-1 $\frac{1}{2}$ years	} These fish were all on their first return.
Small Spring, ...	14	Nov.-April	6-9	1 $\frac{1}{2}$ -2 ,,	
Summer and Autumn,	42	April-August	7 $\frac{1}{2}$ -28	2-2 $\frac{1}{4}$,,	
Large Spring, ...	66	Nov.-April	12 $\frac{1}{2}$ -32 $\frac{1}{2}$	2 $\frac{1}{2}$ -3 ,,	
	176				

Note.—The figures in the last column are taken from the forecast of my first paper, published in *The Field* of 29th October, 1904.

TABLE II.—Summary of Recaptures of Smolts “Wired” in or about May, 1905. (*Vide Mr. Malloch's book, 1910.*)

Class of Fish.	Specimens.		Weights. Lbs.	Actual duration of Smolts' absence in the sea.	Remarks.
	Num-ber.	Season.			
Grilse	40	June-Aug., 1906	2 $\frac{1}{8}$ -10 $\frac{1}{2}$	1 $\frac{1}{2}$ -1 $\frac{1}{4}$ years	} These fish were all on their first return with perhaps one or two exceptions.
Small Spring, ...	18	Feb.-April, 1907	7-13	1 $\frac{1}{2}$ -2 ,,	
Summer and Autumn,	39	May-Aug., ,,	7 $\frac{3}{4}$ -27	2-2 $\frac{1}{4}$,,	
Large Spring, ...	4	Feb.-March, 1908	13-35	2 $\frac{1}{2}$ -2 $\frac{1}{2}$,,	
	101				
Spawned (once) ...	1	March, 1908	18	?	} Recaptured on their second return
	3	July-Aug., 1909	26 $\frac{1}{2}$ -36	?	

The recaptures of “wired” smolts up to the end of the netting season of 1909 would seem to number 105, of which only four are specially described as being on their second return, though it is possible that a few of the older fish, whose scales I have had no opportunity of examining, may also have been in the river before.

Apart from the irregular periods of the smolts' return as maiden salmon, which subject has already been dealt with, the chief point of interest to be noted in the above Tables is the maximum weight to which fish of certain ages may attain, and it will be seen that there is a remarkable correspondence between those indicated by scale examination and the actual results of marking, more especially in the case of the large autumn and spring fish. In the former class salmon up to 28 lbs. were found to be maiden fish from the scale indications, and a “wired” recapture was made weighing only one pound less. In the latter class a fish of 32 $\frac{1}{2}$ lbs. was the largest maiden salmon of which a scale was examined, and this heavy weight at five years old was surpassed when a “wired” 35-pounder was taken in 1908. The number of recaptures of large spring fish is comparatively small, and I can only look upon this as accidental and in no way

representing the actual proportion of smolts that come back towards the end of their third year in the sea. Probably a repetition of the marking experiment would bring out a larger proportion of spring fish, although many of them may enter the river before the netting season commences and so escape notice.

PARR AND SMOLTS.

In previous papers I have stated that the age at which most of the smolts leave the Tay is a little over two years, with the reservation that a few may go when one or three years. Statistics and photographs of scales with ridges in three divisions, taken from young fish of doubtful age, will be found in the Twenty-fifth Report (pp. 57 and 66), which, with some doubt, I was then inclined to put down as not over two years old. Further investigation now causes me to regard each series of their ridges as representing a whole year or part of that period, so that the July parr referred to would be in their third summer, and the April-May smolts at the end of their third year. So far, however, I have found comparatively few of such examples.

In the early part of the present year (1910) I have received pamphlets, kindly sent by Dr. Knut Dahl (Norway)* and Dr. Hoek (Holland) †, in both of which reference is made to the scales of salmon. Dr. Dahl states he has a more extensive paper in preparation, and meantime it can only be inferred from a diagram he gives, that he considers $3\frac{1}{2}$ years to be the average time that the Norwegian parr remains in the river. Until his promised contribution to the literature on the subject is published, one is not able to know on what grounds his conclusions are based. I have examined too few Norwegian scales to hazard a definite opinion, but those that have passed through my hands have the appearance of a two year old migration, and in one or two exceptional specimens a younger age might doubtfully be read.

Dr. Hoek limits his observations to salmon from the Rhine, and seems to think that the smolts generally leave that river for the sea after the completion of their first or second year, but that a few may delay migration until the end of the third year. From the measurements he gives, the young fish must be of larger size than those of the Tay.

I may mention that scales from the Hampshire Avon sent me by Dr. Kingston Barton rather suggest that warm water and good feeding may accelerate the smolt stage, and that some at least of the young fish in that river possibly migrate when less than eighteen months old, and yet be quite as well developed as Tay smolts that have completed their second year. This is a point that might be better studied by some one in the Avon district who could procure and compare specimens of parr and smolts at different seasons of the year.

It is satisfactory to find that the study of scales is not only assuming larger proportions in this country, but has also been taken up abroad, as by a comparison of results it is hoped that more light will be thrown on the life-history of the fish. Mr. J. Arthur Hutton, ‡ in a very clear and instructive pamphlet, has done much to make known the value of scale indications, and has carefully studied the fish of the Wye and other rivers both in England and Norway. Dr. Turnbull, § of the London Hospital, is one of several investigators who has done good work in the same field.

* "The Assessment of Age and Growth in Fish," by Knut Dahl (Bergen). Leipsig, 1909.

† "On the Age of the Salmon to be derived from the Structure of the Scales," by Dr. P. P. C. Hoek. Amsterdam, 1909-10.

‡ "Salmon Scales as indicative of the Life-history of the Fish," by J. Arthur Hutton. 1909.

§ "The Scales of Salmon," by Hubert M. Turnbull, M.D. (*The Field*, Decr. 11th, 18th, and 25th, 1909).

We are still very ignorant of what happens in the sea, and in which parts of the ocean smolts and kelts increase in weight so rapidly. Dr. Dahl has, I understand, obtained some young salmon in mackerel nets, and the North Sea investigations promise to help us by indicating when and where the food supply is abundant. Any definite knowledge as to the marine haunts of the salmon might not prove an unmixed advantage, as their sanctuary would be sure to be invaded to the probable detriment of our home fisheries. The latter are within territorial limits and subject to our laws, ancient though they be and much in need of amendment; but any attempt to protect salmon in the ocean would be dependent on international agreement, not always easy to arrange and often difficult to enforce.

SALMON THAT HAVE SPAWNED.

Now that we know that many of the older salmon are on their first return to the river, it is evident that, even if they manage to evade the nets and other dangers that threaten to terminate the course of their natural life, their opportunities of reproducing their species must be limited in number. In the Twenty-third Report (p. 77) I gave particulars of the scales of one or two fish that had spawned twice before they were netted, while on their third journey to the redds. So far I have not come across any scale bearing more than two spawning marks, but as this mark is not defined until after the fish descends to sea as a kelt and adds new growth to the circumference of the scale, it follows that a salmon may have spawned three times, and yet only show two indications of having done so. Such a case, however, implies that we lose trace of it after its third appearance as a kelt.

We have confirmation of the possibility of a third spawning in an instance from the Helmsdale, where a kelt marked early in 1905 was recaptured and artificially spawned both in 1906 and 1908, so that it yielded ova in three seasons though the scale only recorded two spawning marks up to the time the fish was last handled. It seems fairly safe to conclude that only a few salmon get the chance of breeding three times.

From the marking experiments on the Tay, it would appear clear that many of the heavier autumn fish which spawn for the first time when in their fifth year, do not repeat the operation until their seventh year, which is probably near the close of their reproductive life. We would expect that a grilse (so-called) spawning in its fourth year might exhibit a greater generative frequency, but there is little evidence on this point. There does not seem any room for doubt that the restocking of our rivers largely depends on the maiden fish of the different seasonal runs, for although some salmon that have previously spawned contribute their share of ova, they are in the minority.

DESCRIPTION OF PLATE.

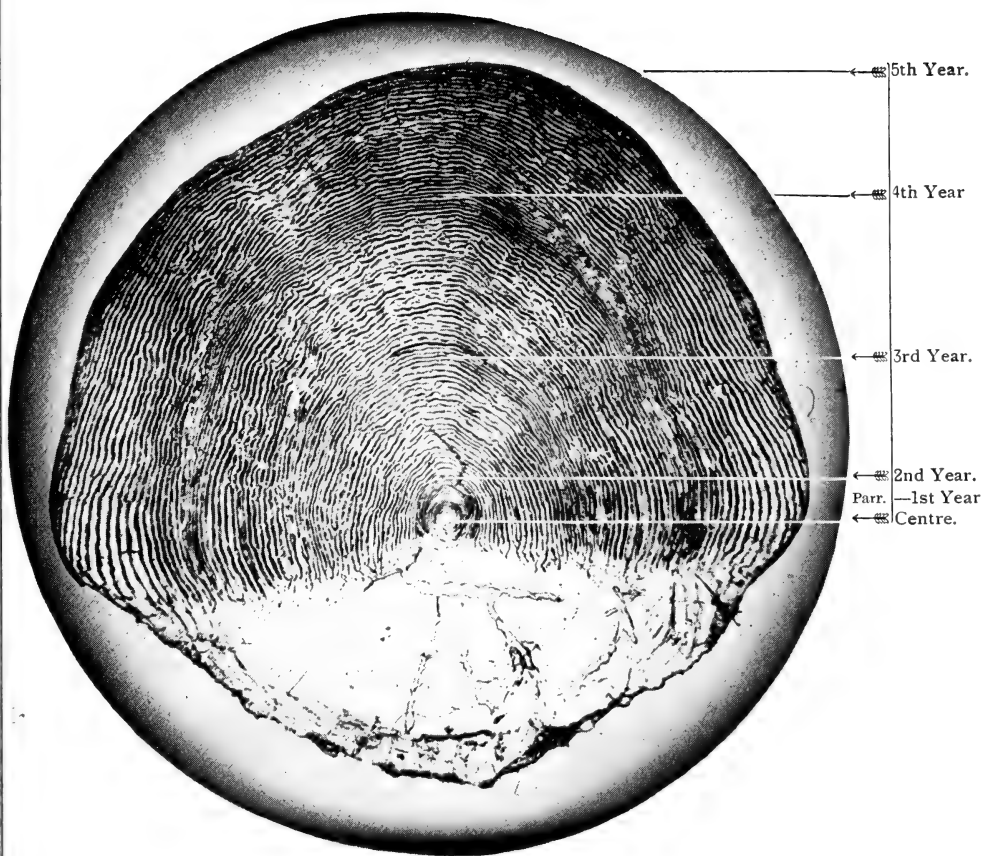
Scale (magnified) of a 35lb. spring salmon (male), captured in March, 1909.

This fish had migrated as a smolt shortly after the completion of its second year, and had remained nearly three years in the sea before returning to fresh water.

Towards the middle of the scale a small point is visible, which is called the centre of growth and marks the initial formation. This is surrounded by the fine lines added in the river during two years of infancy, and these again are bordered on the anterior (or concealed) portion of the scale by the better-developed ridges representing three years' growth in salt water.

During the three summers this fish spent in the sea its scales increased rapidly in size, as denoted by the distance between the numerous ridges; but in the winter months the rate of growth was diminished, and the lines put on were comparatively few and close together, forming a band indicating approximately the end of a year in salt water. Two of the winter bands are distinct, and the third is in course of formation on the periphery of the scale where the ridges approach each other more closely.

The break in the scale outside the second winter band is not a spawning mark, but is caused by the unequal action of the cells on the resumption of activity in the beginning of the last summer.



← 5th Year.
← 4th Year
← 3rd Year.
← 2nd Year.
Parr. — 1st Year
← Centre.

APPENDIX III.

THE "WHITE-FISH NETS" OF THE SOLWAY.

BY W. L. CALDERWOOD.

For very many years salmon fishers in the Solway have complained against a class of nets which closely resemble salmon nets, but which are, by their owners, declared to be white-fish nets. At the beginning of February a case was decided by the Sheriff-Principal at Dumfries in which twelve fishermen were implicated. Interdict against the use of the nets in question was granted, the decision being based upon that of Lord Trayner when an analogous case was heard in the Court of Session in 1886. This has since been appealed to the Second Division.

Other cases of a similar kind have occurred in the past, and I believe I am correct in stating that the decision has in every case been the same. "Paidle-nets," or white-fish nets, placed so as to catch salmon, and which do catch salmon, fished without the consent of the owner of the proper rights, have in every case been put down. A full Court of Session inquiry was conducted with regard to this question in 1879, and an elaborate judgment delivered by Lord Curriehill. In spite of this it has happened that after each case paidle-nets have quietly reappeared.

It is by no means easy to determine, merely by observation, which nets are salmon nets and which "white-fish nets." In other districts in Scotland one has no difficulty. A net stretched on stakes, having an enclosed chamber or "head," and a leader, to guide fish into the head, is at once recognised as a salmon net whether it be erected on a flat tidal shore or floated to moorings where the coast is steep. The type of net has become clearly recognised. On a flat tidal shore the stakes are sunk in the ground, the leader is erected at right angles to the shore, and the head is commonly placed at or near low-water mark. The net ebbs dry, and the fish which may have entered the head when the tide was up are gathered at low-water. This variety of the type is called a "fly net." On a steep coast where this method of fishing salmon is impracticable, the same arrangement of netting is floated and held in position by mooring ropes and guys, and the variety is called a salmon "bag net." No one attempts to set a fly net or bag net of this type except the purpose be to catch salmon.

In the Solway it is not so. Fixed nets, stretched on stakes which are sunk in the ground, and with leaders or "cross arms," and heads similar, though it may sometimes be smaller than the heads of ordinary salmon nets, are set in many localities. But they are given the name of white-fish nets, and protection for their use is sought under the plea that they are for the purpose of catching flounders and other white fish. With the miles of sandy or muddy flats left bare by the tide in the wide bays and estuaries on the Scottish side of the Solway, these nets not infrequently are placed in isolated positions where they are entirely free from casual observation, and where anyone going to inspect them is necessarily seen a long time before the nets can be reached. It is curious, however, that they are commonly set close to the natural tidal bed of some river as it winds seawards through the flats.

To aid one in distinguishing between salmon nets proper and white-fish nets, it is possible to consult the Schedule of the Commissioners appointed in 1879 to inquire into the Solway Salmon Fisheries. These Commissioners

were empowered to examine into the title by which each salmon fixed net was used, and to grant certificates to such persons as proved their right to use fixed nets. As a result, certificates were granted, exclusive of poke nets in the Annan neighbourhood, to 80 fixed engines carrying 209 pockets, and the situation of each net was indicated. One is able, therefore, with a certain amount of confidence to distinguish whether or not in a given locality the full number of certificated engines are being fished, and by further enquiry it is generally possible, in cases where more than the certificated number appear to be present, to identify the salmon nets proper and to determine which nets are called white-fish nets.

In my annual inspection in 1909 I endeavoured to see almost all the salmon nets and white-fish nets of the various Solway districts, and subsequently I communicated with the District Fishery Boards of Annan, Nith, and Dee, and with those in other districts, where Boards do not exist, who might be likely to inform me as to the number of white-fish nets. From the answers received I am able to supply the following list:—

LIST OF STAKE NETS IN SOLWAY, CALLED WHITE-FISH NETS.
[AUTUMN 1909.]

District.	No. of Nets.	No. of Pockets.	Details.
Annan,	10	24	3 with 4 pockets. 1 " 3 " 3 " 2 " 3 " 1 pocket.
Nith,	66	66	26 in Nith Estuary. 40 on Blackshaw Bank.
Dee,	None	—	—
Fleet,	4	4	2 in Carrick Bay. 2 in Fleet Bay.
Cree,	1	1	In Estuary of Cree.
Bladenoch, ..	1	1	

82 nets with 96 pockets.

It therefore appears that there are, or were at the date of this return, rather more white-fish nets than certificated salmon nets. One may presume that, in view of the interdict granted at Dumfries in February of this year, and already referred to, the number of nets in the Nith district has since diminished.

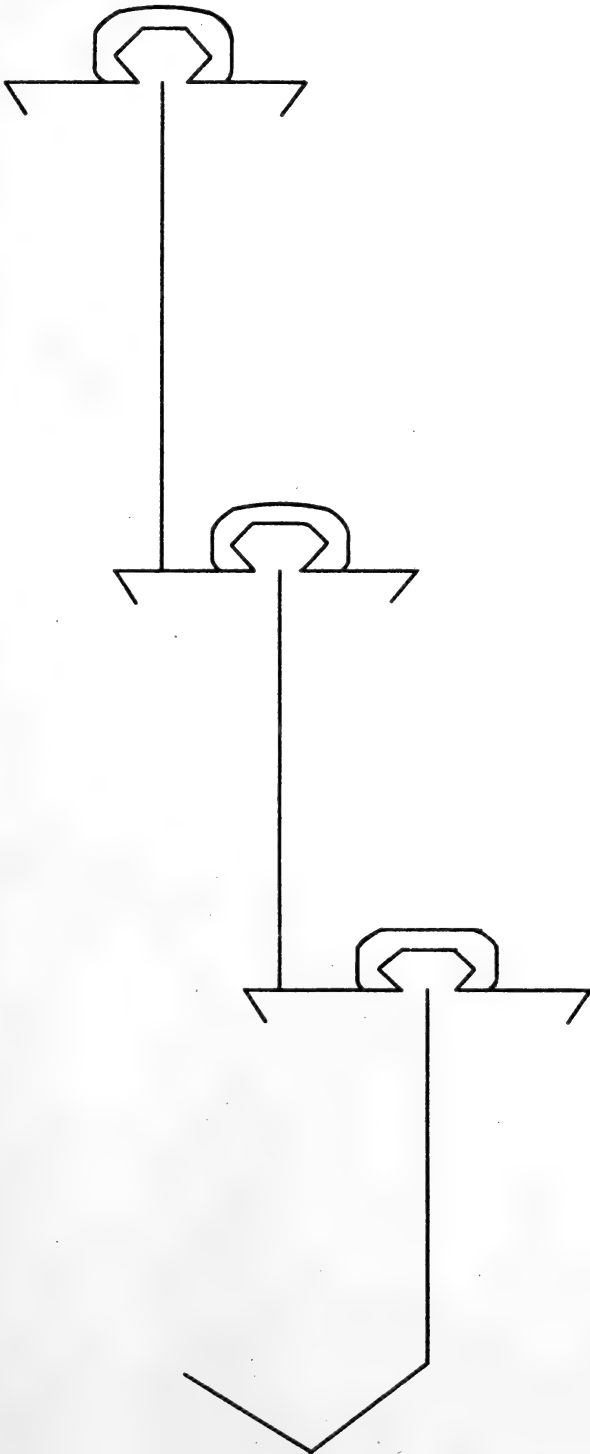
I specially wish to observe that it not infrequently happens that the plan or design of the "white-fish nets" and the plan of the salmon nets in the same district or neighbourhood is identical. As a matter of fact, considerable variation exists amongst salmon nets in neighbouring districts of the Solway. Yet in one district the salmon and the white-fish nets may be and commonly are exactly alike.

The ground-plan of the three salmon nets which project into the tidal section of the river at Creetown is represented in the illustration.

These, together with a single net a short distance further down the river, constitute the four Cassenary nets.

At the time of my visit the Cree was in high flood, and neap tides prevailed. The result was that the furthest out net and all its leader never dried, and could not be visited by the fishermen. Even the central net was to some extent awash, the three or four salmon it contained being

←
Direction of River Cree.



PLAN OF SALMON NETS AT CREETOWN.





“White-fish net” off Craigmere Point.

choked in semi-liquid mud. The Moneypool Burn, which enters just above Creetown, swept through the cross-arm, carrying with it a great quantity of weeds and dirt of all sorts. Opposite the lowest Cassencary salmon net a large "white-fish net" was erected. I could distinguish no difference between the plan of this net and that of the recognised salmon nets, and on asking the head salmon fisher, he replied that there was none. With a recognised salmon net on one side of the river, and a so-called white-fish net on the other, the opinion is irresistible that salmon are caught in the white-fish net. One might almost venture to say that the catching of many white fish is improbable, and that the initial cost and the upkeep of such a net is not likely to be met by the quantity of white fish captured. Some distance away on the mud flats of the Bladenoch district another stake net was visible, and on enquiry this was described as a white-fish net. I understand this net has since been dealt with in the Wigtown Justice of Peace Court. A small fine was imposed upon the fisherman for taking salmon in his net, it being intimated at the same time that power existed to order the forfeiting of the net. The fisherman was asked if he would be willing to remove his net to a situation where it was less likely to catch salmon, but this proposal was strongly resisted by the fisherman's agent, and was not further pressed.

I recollect on two previous occasions inspecting stake nets in this district which were described by their owners as "white-fish nets," one a tidal net like the one just referred to, the other practically a typical salmon bag-net, which, at the moment of my inspection, contained three salmon and no other fish. This net was only removed after an appeal to the Sheriff-Principal.

In the Fleet district I inspected the nets in June, 1909, and found, in addition to the salmon nets, two white-fish nets. One was situated in a position in which it was quite as likely to catch salmon and sea-trout as the certificated engines, being as a matter of fact closer to the river mouth than any of the salmon nets. I considered it somewhat significant also that it was being fished by the same fisherman who worked the salmon nets. The other net was on the opposite or west side, and further down the estuary near Cardoness. The former net has since been moved to another site, and the river has also changed its course. I give a photograph of this net now set on Craigmore Point. Two other nets of a similar kind are set in Carrick Bay, at the mouth of the Fleet estuary.

I desire specially to mention two points in connection with these Bay of Fleet nets. First, being "white-fish nets," they are apparently not regarded as subject to the regulations respecting weekly close time (I purposely made my visit to the Fleet on a Sunday in order to ascertain this point); second, so far as I can learn, there are practically no white fish to catch in the shallow estuary of the Fleet.

It did not further strengthen my belief in the good faith of the local fisherman to learn that a few days before my visit he had been convicted in the Sheriff Court of Kirkcudbright of contravening the Salmon Acts through the non-observance of the weekly close time. I found, indeed, that the pockets of each of his salmon nets had (presumably the evening before) been cut up. There was no arrangement provided for opening them otherwise. The freshly-made cut in the netting was very clear. To anyone familiar with a salmon "fly" net, the net represented in the photograph will, I think, be indistinguishable. In my opinion it is absurd to call these nets "white-fish nets." The possibility of fishing such nets is in some measure due, as in the Fleet district, to the absence of a District Fishery Board, who could supervise locally; but in such districts as that of the Nith it must proceed from a different cause. There is no doubt that, in the repeated renewal of the offence, either the possibility of escaping notice or a spirit of defiance prompts the action.

The excuse that flounders can only be caught by means of large and expensive nets, stretched on stakes, roofed and floored with netting, need scarcely, I think, be considered. From all the evidence of the many cases tried, it appears clear that if more valuable fish than flounders were not taken the outlay for equipment would entirely swamp all possibility of profits.

The peculiar physical conditions under which the fishing is carried on, the wide expanses of mud and sand, render, no doubt, some special features to the case, but flounders really do not require elaborate nets for their capture.

In Morecambe Bay and neighbouring flat shores of the Lancashire and Western district, stake nets are used to catch flounders, the physical conditions being very similar to those which obtain in the Solway. The nets in question are of considerable length, and from 6 to 10 feet high. As in the Solway, the flounders are caught by being retained in the net as the tide recedes, so that ultimately they are left high and dry. But no pockets are used in the nets, and it is clear that no pockets are necessary. The stake net fishing for flounders is regulated by bye-laws of the Lancashire and Western Sea Fisheries Committee. With the view of allowing undersized fish to pass through the nets, a minimum size of mesh is fixed. A gauge of $1\frac{3}{4}$ inches measured across each side of its square, or 7 inches round the mesh, has been selected, and this, curiously enough, corresponds with our salmon net mesh.

The further regulations are as follow :—

“No person shall use in fishing for sea fish any stake net except in accordance with the following regulations :—

- (a) The site of the net shall be marked by poles, perches, or buoys, visible above the surface at any state of the tide, and such poles, perches, or buoys shall be maintained so long as the stakes of the net continue in position. The net shall be legibly marked, with the owner's name affixed to the end stakes, so long as the stakes continue in position.
- (b) No portion of the net shall be nearer the centre of any stream or channel than the edge of such stream or channel at low water of the tide during which the net is fishing.”

A further regulation which affects the matter is :—

“No person shall use in fishing for mackerel, herring, spurling, shrimps, or prawns, any method or instrument of fishing, except at the times and places at which and in the manner in which such method or instrument may be reasonably calculated to take such fish respectively.”

I am indebted to Mr. J. G. Muspratt, the Clerk to the Joint Committee, for the above information.

I now desire to remind the Board that even if all the Solway river districts were provided with District Fishery Boards, such Boards would be unable to deal with the regulation of white-fish nets. District Boards exist for the purpose of administering locally the Salmon Fishery Acts.

In the interests of the salmon fisheries of the Solway, therefore, and without, in my opinion, doing any material damage to the white fishing interests, I would venture to suggest that a suitable bye-law regulating the form which white-fish nets may assume on the wide sandy flats, within a given distance of any river mouth, might with advantage be passed.

APPENDIX IV.

AN ABRIDGED STATEMENT OF REPORTS FROM DISTRICT FISHERY BOARDS AND OTHERS.

REPORT FROM RIVER TWEED DISTRICT.

Take of Fish—

1. State whether the take of fish has been above or below the average of previous years—
 - (a) By fixed engines in the sea—Below the average.
 - (b) By sweep net in tidal or fresh waters—Above the average.
 - (c) By rod and line—Below the average.
2. The actual number of fish caught has been as follows :—
 - (a) By fixed engine, approximately, 7000.
 - (b) By sweep net, actual number, 44,283.
 - (c) By rod and line, approximately, 1573.
3. Expressed as percentages for each month of the season, so as to show the times of greatest run, the figures are :—

	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
By Fixed Engine, ...	...	...	...	...	17	29	4	^{14days} 11	...	...
By Sweep Net, ...	1·81	1·51	2·09	6·43	15·11	24·52	26·43	^{14days} 22·10	...	...
By Rod and Line, ...	4·70	1·74	3·34	1·64	0·99	0·28	0·44	2·36	42·12	42·39

Particulars as to the times grilse and sea trout appeared, as included in the above return, are as follow :—The first grilse caught by net was on 13th April. The first grilse caught by rod and line was on 31st May. The greatest number of sea trout and grilse were caught by net in July and August, and by rod and line in October and November.

4. The weight of the heaviest salmon taken during the season was—By net, 43 lbs. ; by rod and line, 46 lbs.

The particulars of time and place of capture are :—By net, on 21st August, at Meadow Haven Fishery, near Berwick Pier. By rod and line, on 29th October, in Tweed at Sprouston, Roxburghshire; caught by Miss Trotter, Charter Hall.

Protection—

1. The assessable rental for 1909 was £16,092 14s. 4d.
2. The assessment levied was £3218 10s. 9d.
3. The water bailiffs employed are as follows :—9 in July, 9 in August, 19 in September, 46 in October, 54 in November, 52 in December, 47 in January, 27 in February, 22 in March, 16 in April, 16 in May, 9 in June, and 1 engineer all the year.

4. Particulars as to prosecutions instituted are briefly as follow :—Prosecutions were instituted against 192 persons during season 1908-09. Fifty-five persons paid fine or were allowed time to pay, 89 were imprisoned, 14 absconded, 8 were acquitted or admonished, and proceedings were withdrawn in the case of 26 persons.

The principal offences were—Killing salmon by means of illegal nets, cleek and light and rake-hooks, being in illegal possession of salmon and engines for killing salmon, and assaulting and obstructing bailiffs.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect :—Philiphaugh cauld, on the Ettrick, and Deuchar Mill cauld, on the Yarrow, were washed away in January last. Philiphaugh cauld is at present under repair, but Deuchar Mill cauld has not been rebuilt. A small dam is being built on Stobo Burn, in Peeblesshire, to form a pond near Stobo Castle.
2. Are the bye-laws observed in every case ?—Duly enforced and carried out.

Pollutions—

1. The existing pollutions are :—Poisonous matters from mills and dyehouses in Selkirk, Peebles, Innerleithen, Walkerburn, Galashiels, Hawick, Jedburgh, and Chirnside. Household sewage from Biggar, West Linton, Eddleston, Melrose, St. Boswells, Kelso, Coldstream, Sprouston, Ancrum, Lilliesleaf, Earlston, Lauder, &c.
2. Remedial measures :—There are settling tanks connected with all the mills in Peeblesshire which intercept the grosser parts of the mill effluent, but not much good. There are purification works connected with the mills in Galashiels and Selkirk, but those in Galashiels do not appear to be of any use, judging from the appearance of the water flowing from them ; but a new system of drainage and purification is now in the course of being constructed. In Hawick there are irrigating tanks in a field, but they are not worked satisfactorily. A very expensive purifying plant has been recently erected at Chirnside Paper Works with good results.

The Salmon Disease—

1. Disease made its appearance, season 1908-09, in the month of October, and reached its height in January.

The river was free of diseased fish in May.

2. The number of diseased fish taken from the river and destroyed was as follows :—

	Males.	Females.
Kelts, - - - - -	1,008	540
Clean, - - - - -	50	73

The Spawning Season, 1908-09—

1. Fish were first noticed spawning on 19th October (sea trout).
2. The greatest number spawned in December.
3. Spawning ceased end of February.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as good.

Smolts—

1. Smolts were noticed to be migrating seawards in April and May.
2. As a smolt year 1909 was fairly good.

REPORT FROM FORTH DISTRICT.

Take of Fish—

1. State whether the take of fish has been above or below the average of previous years—
 - (a) By fixed engines in the sea—Above the average.
 - (b) By sweep net in tidal or fresh waters—About the average.
 - (c) By rod and line—Below the average.
3. Particulars as to the times grilse and sea trout appeared are as follow :—Grilse, July and August. Trout, all season.
4. The weight of the heaviest salmon taken during the season was 47 lbs. The particulars of time and place of capture are :—Largo Bay, on the coast of Fife.

Protection—

1. The assessable rental for 1909 was £3569 8s. 9d.
2. The assessment levied was 4s. 6d. per £ (£803 2s. 2d.).
3. The water bailiffs employed are 11 in number, including superintendent.
4. Particulars as to prosecutions instituted are briefly as follow:—Nine prosecutions for contraventions of the Salmon Fishing Acts during the year ending 31st December, 1908, implicating 14 men. The cases consisted of taking smolts, putting bag nets in fishing order before the expiry of the weekly close time, and taking salmon during the annual close time. Three men interdicted from drift-net fishing, and one man tried in the Court of Session for breach of interdict and sentenced to 21 days' imprisonment without the option of a fine.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect—None.
2. Are the byè-laws observed in every case?—No. Hecks at the intakes and outlets of the mill lades, on the River Allan, are not kept in proper order.
3. Fish passes built or in prospect—One fish pass built on Airthrey Paper Mill dam dyke.
4. Natural obstructions not yet dealt with are:—Kippenross old cruive.

Pollutions—

1. The existing pollutions are:—Sewage from the towns and villages on the banks of the Forth and its tributaries; chemicals from paper mills, dye-works and distilleries, and coal washings from coal pits.
2. Remedial measures—Steps are being taken to mitigate the pollutions above mentioned.

The Salmon Disease—

1. Disease made its appearance this year in the month of October, and reached its height in January, 1909.
The river was free of diseased fish in April, 1909.
2. The number of diseased fish taken from the river and destroyed was as follows:—284, being 341 less than for 1907-1908.

	Males.	Females.
Kelts,	244	40

The Spawning Season—

1. Fish were first noticed spawning in middle of October (sea trout), 1909.
2. The greatest number spawned December and January.
3. Spawning ceased end of January.
4. Number of breeding fish below the average; state of the water high.

Smolts—

1. Smolts were noticed to be migrating seawards in April, May, June, and July.
2. As a smolt year 1909 was about the average.

REPORT FROM TAY DISTRICT.

Take of Fish—

1. State whether the take of fish has been above or below the average of previous years—
 - (a) By fixed engines in the sea—Average.
 - (b) By sweep net in tidal or fresh waters—Average.
 - (c) By rod and line—Below.
3. Particulars as to times grilse and sea trout appeared are as follow:—Grilse were rather late in making their appearance, but were a fair crop and a much better class of grilse than in the previous year. Sea trout were got from the start of the net fishing, and were above the average in numbers.
4. The weight of the heaviest salmon taken during the season was 56½ lbs.
The particulars of time and place of capture are:—Estuary of Tay, near mouth of Earn, on 27th May, 1909.

Protection—

1. The assessable rental for 1909 was £23,715 12s.
2. The assessment levied was 8 per cent.
3. The water bailiffs employed are 24 in number.
4. Particulars as to prosecutions instituted are briefly as follow:—Since last report 19 cases have been tried in Perth Sheriff Court, involving 29 persons. The offences consisted of salmon in possession in close season, 8; cleeking, 2; stoning, &c., 1; stick and cord, 1; gaff in possession, 2; unclean salmon in possession, 1; fishing with roe, 1; roe in possession, 1; fry in possession, 1; fishing without leave of proprietor, 1. Of the 29 persons involved, all were convicted. Fines ranging from 5s. to £4 1s. were imposed. The total fines imposed amounted to £56, being an average of £1 18s. 7d. for each of the 29 persons convicted. Fines were paid by 10, 15 were imprisoned, and 4 have yet to be dealt with. The alternatives ranged from 1 to 15 days.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect:—Dam dyke at Inveralmond (on Almond) washed away by a spate on 18th January last and not to be replaced.
3. Fish passes built or in prospect:—A salmon pass is in course of construction at the Falls of Tummel (on the River Tummel). This pass is expected to be ready for the ascent of spring fish next season.
4. Natural obstructions not yet dealt with are:—Falls of Keith, on Ericht, and some impossible falls on Upper Isla; Falls of Dunalastair, on the Tummel, above Loch Tummel.

Pollutions—

1. The existing pollutions are:—Chiefly sewage of Perth, Dundee, and Broughty Ferry; also bleaching works at Almondbank, Luncarty, and Stormontfield.
2. Remedial measures:—Purification works are now completed for Crieff sewage which seem to be very effective.

The Salmon Disease—

1. Disease made its appearance this year in the month of October, and reached its height in January. The river was never quite free of disease, but last season it was much less destructive than in previous years.
2. The number of diseased fish taken from the river and destroyed was as follows:—

	Males.	Females.	
Kelts,	200	150	} Estimate.
Clean,	6	6	

The Spawning Season—

1. Fish were first noticed spawning on 20th or 21st October.
2. The greatest number spawned in December.
3. Spawning ceased about 10th January.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as an average one. The number of fish was rather above the average, but the flooded condition of the water was somewhat against good results in the maturing of the ova.

Smolts—

1. Smolts were noticed to be migrating seawards in March.
2. There was great difficulty in judging the smolt crop last season, as the waters were heavy during most of the migrating season; but as far as could be judged they were under the average.

REPORT FROM SOUTH ESK DISTRICT.**Take of Fish—**

1. As compared with previous years, the take of fish generally throughout the district has been a good average.
3. On 16th February, first clean fish taken. Main run of grilse and sea trout, June and July.

4. No particularly heavy fish reported, but a number caught weighing from 35 to 40 lbs.

Protection—

1. The assessable rental for 1909 was £3403.
2. The assessment levied was £306 5s. 4d.
3. The water bailiffs employed are 8 in number during the close season, and generally 3 during the fishing season.
4. Particulars as to prosecutions instituted are briefly as follow :—Five cases, implicating nine persons.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect :—No change.
3. Fish passes built or in prospect :—Fish passes on most of dam dykes on river.
4. No natural obstructions in the river.

Pollutions—

1. The existing pollutions are mostly from town and farm sewage and mills of Brechin.

The Salmon Disease—

1. Disease made its appearance this year about the middle of November, 1908, and reached its height in January, 1909. The river was free of diseased fish about the end of June.
2. The number of diseased and spent fish taken from the river and destroyed was 529. Thirty-six clean fish, all more or less diseased, were removed from the river and destroyed. The clean fish were all got in the dams about Brechin during March, April, and May, 1909.

The Spawning Season—

1. Fish were first noticed spawning during the first week of November, 1908.
2. The greatest number spawned in December.
3. Spawning ceased about the end of January.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as very good.

Smolts—

1. Smolts were noticed to be migrating seawards in April, May, and June.
2. As a smolt year 1909 was very good.

REPORT FROM NORTH ESK DISTRICT.

Take of Fish—

1. State whether the take of fish has been above or below the average of previous years—
 - (a) By fixed engines in the sea—Above average.
 - (b) By sweep net in tidal or fresh waters—Above average.
 - (c) By rod and line—Very much below average.
2. The actual number of fish caught has been :—By rod and line, from 31st August, when net fishing closed, to 30th October, when rod fishing also closed, 139 salmon and 37 grilse, total 176, as recorded by bailiffs. No statistics as to fish caught otherwise.
3. Particulars as to the times grilse and sea trout appeared are as follow :—The first grilse was got in the sea on 8th and in the river on 14th May. Sea trout were plentiful in both the sea and river early in May.
4. The weight of the heaviest salmon taken during the season by rod and line was 38 lbs. The particulars of time and place of capture are :—October, Craigo. A good many of the fish caught were over 30 lbs.

Protection—

1. The assessable rental for 1909 was £6614.
2. The assessment levied was 6 per cent.

3. The water bailiffs employed are 12 in number, including superintendent.
4. Particulars as to prosecutions instituted are briefly as follow :—Four, for dragging for salmon. Convictions obtained in three cases ; the other held not proven.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect—None.
2. Are the bye-laws observed in every case ?—Yes.
3. Fish passes built or in prospect—None.
4. Natural obstructions not yet dealt with are :—“Loups” on North Esk, about 12 miles from mouth. “Loups” on West Water (tributary), about 12 miles from mouth.

Pollutions—

1. The principal existing source of pollution is the effluent from North Esk Distillery, about a mile from the mouth of the river.
2. Remedial measures :—Filtering tanks.

The Salmon Disease—

1. Disease made its appearance this year in the month of December, and reached its height in January.
The river was free of diseased fish in April. Disease appeared again in June and continued until the end of the season.
2. The number of diseased fish taken from the river and destroyed was as follows :—

	Males.	Females.
Kelts,	434	136
Clean,	20	23

The Spawning Season—

1. Fish were first noticed spawning on 20th November.
2. The greatest number spawned in December and January.
3. Spawning ceased early in February.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as rather above average.

Smolts—

1. Smolts were noticed to be migrating seawards in April, May, and June.
2. As a smolt year 1909 was very good.

Note.—By a clerical error 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. This was proposed to be amended by Sub-Section (ii.) of Section 29 of the Salmon Fisheries (Scotland) Bill, 1905. It is now proposed to alter it, by Clause 28 of the Provisional Order which is being applied for by the Town Council of Montrose, with the view of obtaining an additional supply of water for the town.

REPORT FROM BERVIE DISTRICT.

Take of Fish—

1. State whether the take of fish has been above or below the average of previous years—
 - (a) By fixed engines in the sea—Salmon and sea trout above ; grilse slightly below.
 - (b) By sweep net in tidal or fresh waters—Above.
 - (c) By rod and line—Above.
2. Cannot give statistics of the actual number of fish caught.
Particulars as to the times grilse and sea trout appeared are as follow :—
The first grilse was taken in the sea on 18th May ; sea trout were got in abundance about the 28th of June—both dates being about the same as in previous years.
4. The weight of the heaviest salmon taken during the season was 46 lbs.
The particulars of time and place of capture are :—On 16th July, in a bag-net at West Shield Hill.

Protection—

1. The assessable rental for 1909 was £1095 13s.
2. The assessment levied was 14 per cent.
3. The water bailiffs employed are 5 in number.
4. Particulars as to prosecutions instituted are briefly as follows:—Two prosecutions for taking smolts, 1 conviction obtained, and fine of 10s. imposed, besides £2 15s. 6d. of expenses; other charge not proven. Two prosecutions for taking fish by clip, convictions obtained, and fines of 9s. 6d. imposed in both cases, besides £2 3s. and £2 10s. 6d. of expenses.

Obstructions to the Passage of Fish—

1. Dam dyke at Upper Mill of Allardice, which has now ceased working.
2. Are the bye-laws observed in every case?—Yes.

The Salmon Disease—

1. Disease made its appearance this year in the month of November, and reached its height in February.

The river was free of diseased fish in the middle of March.

2. The number of diseased fish taken from the river and destroyed was as follows:—

	Males.	Females.
Kelts, - - - - -	9	8
Clean, - - - - -	—	1

The Spawning Season—

1. Fish were first noticed spawning on 2nd November.
2. The greatest number spawned in November, December, and January.
3. Spawning ceased about the end of February.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as having been very good. Fish were plentiful, and the river ran slightly in flood during most of the spawning season.

Smolts—

1. Smolts were noticed to be migrating seawards in the first week of April up to the end of June.
2. As a smolt year 1909 was very good.

REPORT FROM DEE DISTRICT.

Take of Fish—

1. State whether the take of fish has been above or below the average of previous years—
 - (a) By fixed engines in the sea—A good average.
 - (b) By sweep net in tidal or fresh waters—Above an average.
 - (c) By rod and line—Below the average, chiefly owing to the exceptionally low state of the river during the month of September.
3. Particulars as to the times grilse and sea trout appeared are as follow:—*Grilse*—First grilse got early in May. The chief run was in July, but then it ceased rather suddenly, so that the grilse fishing for the year was decidedly below the average. *Sea Trout* were got from the commencement of the fishing season. The chief takes were in July.
4. The weight of the heaviest salmon taken during the season was 48 lbs. The particulars of time and place of capture are:—48 lbs., by fixed engine, at Aberdeen Harbour fishings, on 22nd July; 35 lbs., by sweep net, at Pot and Ford's fishings, Lower Dee, on 4th August; 38 lbs., by rod and line, at Drum (8 to 9 miles up river), on 25th October.

Protection—

1. The assessable rental for 1909 was £18,335 14s. 5d.
2. The assessment levied was at the rate of 5½ per cent., yielding £1008 9s. 5d.
3. The water bailiffs employed are 23 in number; of these, 6 were for short periods during spawning season, and 4 for the whole year.

- Particulars as to prosecutions instituted are briefly as follow:—Four cases, implicating 7 men; two of these cases implicated 5 men. Complaints were for being in possession of nets of small mesh and with sea trout in bags. Fines ranged from 5s. to £5, besides expenses; 3 men paid fines, &c., and 2 went to prison. The other two cases implicated 2 men; complaints were for having smolts in their possession. Both cases settled out of Court.

Obstructions as to the Passage of Fish—

- Dam dykes disused, built, or in prospect. State particulars of any such:—
No dam dykes.
- Are the bye-laws observed in every case?—No cause for complaint. Bye-laws have generally been properly observed.
- Fish passes built or in prospect:—No fish passes, and none in prospect so far as is known.
- Natural obstructions not yet dealt with are:—In tributaries—one in the Feugh, near Banchory, and the other in the Luie, in the Braemar district. Both are referred to in previous reports, and remain unchanged.

Pollutions—

- The existing pollutions are:—1, Sewage from the City of Aberdeen; 2, discharge from Culter Paper Mills, about eight miles up the river; and 3, sewage discharges from several drainage districts, country villages, and mansion-houses, &c., along course of river.
- Remedial measures:—The evil which long arose from the sewage of the town of Aberdeen has been greatly lessened since the large sewer was completed last year. At Culter Paper Mills, also, it is understood that a process has been adopted of submitting refuse (which formerly found its way into the river) to high pressure, which has the effect of converting it into a solid substance resembling oil cake, but of a lighter colour. This substance is sent south to mills where it is useful in the making of a strong, though coarse, grey paper, for which there is a market. The pollution is, however, still serious.

The Salmon Disease—

- The river has not been free of diseased fish during the whole year, and may be said to have reached its height in December.
- The number of diseased fish taken from the river and destroyed was as follows:—

	Males.	Females.
Kelts,	595	111
Clean,	97	(sex not known).

The Spawning Season—

- Fish were first noticed spawning on 10th October, 1909.
- The greatest number spawned in upper reaches of Dee and tributaries in the end of October and first two weeks of November.
- Spawning ceased practically in first week of January, 1910.
- As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as fairly satisfactory.

Smolts—

- Smolts were noticed to be migrating seawards early in April.
- As a smolt year 1909 was a good average both as to numbers and size. It was remarked that the smolts appeared to be better grown than usual, and altogether a very promising breed.

REPORT FROM DON DISTRICT.

Take of Fish—

- State whether the take of fish has been above or below the average of previous years—
 - By fixed engines in the sea—Above the average.
 - By sweep net in tidal or fresh waters—Above the average.
 - By rod and line—About average; perhaps rather under.

3. Particulars as to the times grilse and sea trout appeared are as follow :—
Grilse.—First grilse caught on 8th May. Chief run was in July, but, on the whole, the grilse season was a good deal under average. *Sea Trout* were got at the opening of the fishing season, and were caught occasionally up to the end of the season. They were most plentiful in July.
4. The weight of the heaviest salmon taken during the season was 42 lbs.
5. The particulars of time and place of capture are :—42 lbs., by fixed engine at river's mouth ; 36 lbs., by sweep nets at Cruives of Don ; 33 lbs., by rod and line at Cruives of Don.

Protection—

1. The assessable rental for 1909 was £3842 10s.
2. The assessment levied was at 14 per cent., yielding £537 19s.
3. The water bailiffs employed are 16 in number, including inspector. Of these, 8 are employed for 9 months in the year, 5 for 4 months, and 3 for whole year.
4. Particulars as to prosecutions instituted are briefly as follows :—Eight prosecutions, implicating 15 men. Five of these cases, implicating 11 men, were for taking salmon by means of gaff or snigger, or having gaff in possession with intent ; one, implicating 2 men, for having unseasonable salmon in possession ; two, implicating 2 men, were for fishing with net of small mesh (one of the men having several finnocks in his possession). All convicted on evidence. Fines ranged from 5s. to £5, besides expenses, or alternatives of imprisonment from 5 days to 60 days. Three men paid fines, 11 went to prison, and one was simply admonished and dismissed.

Obstructions to the Passage of Fish.

1. Dam dykes disused, built, or in prospect. State particulars of any such :—
No new dam dykes built, and none of the old dykes have been disused.
2. Are the bye-laws observed in every case ?—Practically so.
3. Fish passes built or in prospect :—There are prospects of considerable alterations for the better upon the passes both at Mugiemoss and Stoneywood.
4. Natural obstructions not yet dealt with are :—Practically no natural obstructions exist in the river or tributaries.

Pollutions—

1. The existing pollutions are :—Sewage from Bucksburn, Bankhead, and Stoneywood, at each of which places a considerable population is located. Also mill refuse from paper mills and manufactories along lower portion of river.
2. Remedial measures :—Some of the manufactories have, it is understood, adopted remedial measures with a view to lessening the pollution, and others are considering at present as to same.

The Salmon Disease—

1. Disease made its appearance this year in the month of October, and reached its height in December.
The river was not quite free of disease, but greatly diminished by end of January.
2. The number of diseased fish taken from the river and destroyed was as follows :—

	Males.	Females.
Kelts,	197	110

The Spawning Season—

1. Fish were first noticed spawning on 14th October.
2. The greatest number spawned about middle of December.
3. Spawning ceased practically at latter end of January.
4. As regards numbers of breeding fish, and state of the water, the numbers of breeding fish observed were about the usual average, but, for nearly a fortnight of what should have been the most productive weeks of the breeding season, the river was icebound, which no doubt acted detrimentally, so that, on the whole, the breeding season is considered to have been rather disappointing.

Smolts—

1. Smolts were noticed to be migrating seawards in the middle of April.
2. As a smolt year 1909 was a very good average.

REPORT FROM YTHAN DISTRICT.**Take of Fish—**

1. State whether the take of fish has been above or below the average of previous years—
 - (a) By fixed engines in the sea—About average in number, but above average in weight.
 - (b) By sweep net in tidal or fresh waters—About average.
 - (c) By rod and line—Below average, but better than in 1907 and 1908.
2. The actual number of fish caught has been as follows :—

(a) By fixed engine—	}	This information cannot be obtained.
(b) By sweep net—		
(c) By rod and line—About 130 salmon.		
3. Particulars as to the times grilse and sea trout appeared are as follow :—
Sea trout appeared in Ythan in July, and grilse in August.
4. The weight of the heaviest salmon taken during the season was 42 lbs.
The particulars of time and place of capture are :—July, at Port Erroll fishings, in a bag-net.

Protection—

1. The assessable rental for 1909 was £1352.
2. The assessment levied was £167 15s. 6d., being a little over 2s. 5½d. per £.
3. The water bailiffs employed are 5 in number—1 all the year, and 4 extra during close time.
4. Particulars as to prosecutions instituted are briefly as follow :—Three cases of prosecution, implicating three persons—two against lessees of salmon fishings for failing to remove leaders from bag-nets during weekly close time. One paid £19 and the other £17. The third complaint was against a man for contravention of Section 15 (1) of "The Salmon Fisheries (Scotland) Act, 1868." Fined 10s., with £1 2s. of expenses.

Pollutions—

1. The existing pollutions are :—Ellon Burgh sewage.
2. Remedial measures :—None.

The Salmon Disease—

1. Disease made its appearance this year in the month of December, and reached its height in February.
The river was free of diseased fish in April.
2. The number of diseased fish taken from the river and destroyed was as follows :—

	Males.	Females.
Kelts,	62	10
Clean,	1	—

The Spawning Season—

1. Fish were first noticed spawning on 3rd December, 1908.
2. The greatest number spawned from 1st to 14th January.
3. Spawning ceased in February.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as favourable.

Smolts—

1. Smolts were noticed to be migrating seawards in April and May.
2. As a smolt year 1909 was very good.

REPORT FROM UGIE DISTRICT.

Take of Fish—

1. As compared with the average results of previous years, the take of fish generally throughout the district has been under the average of former seasons, especially grilse, which were reported to be very scarce, but the salmon has been better than season 1908.
2. The actual number of fish caught has been as follows :—
 - (a) By fixed engine—1000 salmon and 800 grilse.
 - (b) By sweep net—2000 sea trout.
 - (c) By rod and line—1300 finnock, 150 sea trout, and 40 salmon.
3. Particulars as to the times grilse and sea trout appeared are as follow :— Grilse made their appearance in this district about the middle of June, and went off about the end of July. Sea trout made their appearance about the end of June, and continued during July, August, September, and October. There was a very good run of sea trout, much better than in season 1908.
4. The weight of the heaviest salmon taken during the season was (1) 46 lbs. by fixed engines, and (2) 22 lbs. by rod and line.
The particulars of time and place of capture are :—(1) By fixed engines at the mouth of the river Ugie, in September 1909; (2) by rod and line in the river Ugie, in October 1909.

Protection—

1. The assessable rental for 1909 was £757.
2. The assessment levied was £58 7s. 2d., being at the rate of 1s. 6½d. per £.
3. The water bailiffs employed are 5 in number—1 regular man, who has the assistance of 4 gamekeepers of Colonel Ferguson of Pitfour, when on their beats.
4. Particulars as to prosecutions instituted are briefly as follow :—There was one prosecution, which was against George M'Rae, baker, Longside, Aberdeenshire, for fishing for and killing sea trout on Colonel Ferguson's water without having a license to do so. The accused was fined a nominal penalty of 2s. 6d.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect—None.
2. Are the bye-laws observed in every case?—Yes.
3. Fish passes built or in prospect—None. The existing fish passes afford a free and natural passage to fish at all times.

The Salmon Disease—

1. Disease made its appearance this year in the month of November 1908, and reached its height in the beginning of January 1909.
The river was free of diseased fish in the beginning of May 1909.
2. The number of diseased fish taken from the river and destroyed was as follows :—

	Males.	Females.
Kelts,	6	12

The Spawning Season—

1. Fish were first noticed spawning on 17th November 1908.
2. The greatest number spawned during the period between 26th November and 18th December 1908.
3. Spawning ceased between the last week of December 1908 and the first week of January 1909.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as a very satisfactory one. There was a good stock of spawners forward, the river being favoured with little spates to take them on to the spawning ground.

Smolts—

1. Smolts were noticed to be migrating seawards in the beginning of April 1909.
2. As a smolt year 1909 was very good. The tidal portion was full from the end of April up to the end of May 1909.

REPORT FROM DEVERON DISTRICT.**Take of Fish—**

1. State whether the take of fish has been above or below the average of previous years :—
 - (a) By fixed engines in the sea—Above the average.
 - (b) By rod and line—Above the average.
 - (c) By rod and line—Above the average.
2. The actual number of fish caught has been as follows :—By rod and line, over 1000.
3. Particulars as to the times grilse and sea trout appeared are as follow :—
First grilse of the season killed 11th May, and the principal run of grilse and sea trout was July.
4. The weight of the heaviest salmon taken during the season was 53 lbs.
The particulars of time and place of capture are :—15th July, in a bag-net at Whitehills.

Protection—

1. The assessable rental for 1909 was £2707.
2. The assessment levied was £756.
3. The water bailiffs employed are 12 in number, and superintendent.
4. Particulars as to prosecutions instituted are briefly as follow :—One prosecution for being in possession of salmon fry.

Pollutions—

1. The existing pollutions are :—Seven distilleries discharge their refuse into the tributaries ; also the towns of Turriff, Huntly, and Keith.

The Salmon Disease—

1. The river was free of diseased fish in April ; disease was very slight.
2. The number of diseased fish taken from the river and destroyed was as follows :—

	Males.	Females.
Kelts,	199	47
Clean, . . . . .	...	1

The Spawning Season—

1. Fish were first noticed spawning on 16th October.
2. The greatest number spawned in November and December.
3. Spawning ceased on 20th January.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as one of the best for a number of years.

Smolts—

1. Smolts were noticed to be migrating seawards on 19th April.
2. As a smolt year 1909 was good.

REPORT FROM SPEY DISTRICT.**Take of Fish—**

1. (a) By fixed engines in the sea-- Below the average.
- (b) By sweep net in tidal or fresh waters—Below the average.
2. (c) By rod and line—Much increase over the middle reaches of the river during spring and summer months. Of course, no numbers can be got.
3. Expressed as percentages, the take is :—

Month, 1909.	By Net and Coble.			By Fixed Engine.		
	Salmon.	Grilse.	Trout.	Salmon.	Grilse.	Trout.
Feb. 11th to 28th,	6·9	—	0·2	3·3	—	0·2
March,	11·8	—	0·6	4·1	—	0·3
April,	8·0	—	5·8	6·8	—	4·0
May,	14·3	0·2	45·1	21·7	0·1	23·4
June,	15·8	8·8	19·6	24·7	11·2	26·1
July,	19·3	75·5	23·9	18·6	69·3	43·3
August, to 26th,	23·9	15·5	4·8	20·8	19·4	2·7
	100·0	100·0	100·0	100·0	100·0	100·0

Particulars as to the times grilse and sea trout appeared, as included in above return, are as follow :—Grilse, 15th May ; trout, 11th February.

Protection—

1. The assessable rental for 1909 was £9396 15s.
2. The assessment levied was £1223 10s. 8d., being at 2s. 7½d. per £.
3. The water bailiffs employed are 47 in number.
4. Particulars as to proceedings instituted are briefly as follow :—Two persons were brought before the Sheriff of Inverness charged with poaching offences. They were convicted and sentenced to fines and expenses amounting to £3 7s.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect—No change during the year.
2. Are the bye-laws observed in every case ?—Not always as well as could be wished.

The Salmon Disease—

1. Disease made its appearance this year in the month of October, and reached its height in December.
The river was free of diseased fish in May.
 2. The number of diseased fish taken from the Fiddich and destroyed was 298, as follows :—51 male and 8 female sea trout, 177 male and 40 female grilse, 15 male and 7 female salmon ; mostly all spawned,
- | | Males. | Females. |
|------------------|--------|----------|
| Kelts, | 243 | 55 |

The Spawning Season—

1. Fish were first noticed spawning on 26th September 1908.
2. The greatest number spawned in November 1908.
3. Spawning ceased at end of March 1909.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as one of the best.

Smolts—

1. Smolts were noticed to be migrating seawards in April 1909.
2. As a smolt year 1909 was good.

REPORT FROM LOSSIE DISTRICT.

Protection—

1. Contribution by His Grace the Duke of Richmond and Gordon, K.G., £76 18s. 7d.; contribution by Captain J. Brander Dunbar of Pitgaveny, £15.
3. The water bailiffs employed are 3 in number, superintended by the Spey District superintendent.
4. Particulars as to prosecutions instituted are briefly as follow :—No case taken before the Court during the year.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect—No change.
2. Are the bye-laws observed in every case ?—Pretty well.
3. Fish passes built or in prospect :—No change.
4. Natural obstructions not yet dealt with are :—Kellas rocks or falls.

Pollutions—

2. Remedial measures :—Elgin City sewerage purification works.

The Salmon Disease—

1. Disease made its appearance this year in the month of November, and reached its height in December.
The river was free of diseased fish in May and June.
2. The number of diseased fish taken from the river and destroyed was 27, as follows :—

	Males.	Females.
Kelts,	15	12

The Spawning Season—

1. Fish were first noticed spawning on 8th October 1908.
2. The greatest number spawned in November 1908.
3. Spawning ceased on 1st of January 1909.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as fair.

Smolts—

1. Smolts were noticed to be migrating seawards in April 1908.
2. As a smolt year 1909 was fair.

*REPORT FROM FINDHORN DISTRICT.***Take of Fish—**

1. State whether the take of fish has been above or below the average of previous years—
 - (a) By fixed engines in the sea—About an average.
 - (b) By sweep net in tidal or fresh waters—Above the average.
 - (c) By rod and line—Above the average.
2. The actual number of fish caught has been as follows :—
 - (a) By fixed engine, 11,724.
 - (b) By sweep net, 4872.
3. First grilse caught by fixed engine, 20th May, by net and coble, fresh water, 7th June; main run in July. Sea trout, main run in June.
4. The weight of the heaviest salmon taken during the season was 40 lbs. The particulars of time and place of capture are :—Burghead, by bag net; time, end of July.

Protection—

1. The assessable rental for 1909 was £3661.
2. The assessment levied was £300.
3. The water bailiffs employed are 3 in number yearly; 12 extra during spawning season.
4. Particulars as to prosecutions instituted are briefly as follows :—None.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect—None.
2. Are the bye-laws observed in every case?—Strictly adhered to.
3. Fish passes built or in prospect—None.

Pollutions—

1. Existing pollutions are—None.
Salmon disease is absent.

The Spawning Season—

1. Fish were first noticed spawning on 18th October.
2. The greatest number spawned between 20th October and 20th November.
3. Spawning ceased on the upper reaches on the 27th November; on the lower reaches on 29th January, 1909.
4. For number of breeding fish the past season was very good. The state of the water during the spawning season was not good for spawning purposes.

Smolts—

1. Smolts were noticed to be migrating seawards in April, May, and June.
Main run between 15th May and 15th June.
2. As a smolt year 1909 was about the average.

*REPORT FROM NAIRN DISTRICT.***Take of Fish—**

1. State whether the take of fish has been above or below the average of previous years—
 - (a) By fixed engines in the sea—Above average.
 - (b) By sweep net in tidal or fresh waters—Average.
 - (c) By rod and line—Above average.

3. Sea trout run in June and July ; salmon and grilse, August and September
Particulars as to the times grilse and sea trout appear are as follow :—
Grilse appeared on 22nd May. Clean sea trout can be got in this river at any period of the open season.
4. The weight of the heaviest salmon taken during the season was 45 lbs.
The particulars of time and place of capture are :—Caught during August in the sea nets at Easter Delnies.

Protection—

1. The assessable rental for 1909 was £1205 8s.
2. The assessment levied was 1s. 6d. per £.
3. The water bailiffs employed are two in number, one being permanent, and the other being engaged during the close season.

Obstructions to the Passage of Fish—

2. Are the bye-laws observed in every case ?—Yes.
3. Fish passes built or in prospect—None.

The Salmon Disease—

1. No disease.

The Spawning Season—

1. Fish were first noticed spawning on 3rd November.
2. The greatest number spawned 10th November to 12th December.
3. Spawning ceased in middle of January.
4. Number of breeding fish above average ; state of water (half flood on average) good ; spawning good.

Smolts—

1. Smolts were noticed to be migrating seawards in April, and disappeared on 18th June.
2. As a smolt year 1909 was above average.

REPORT FROM NESS DISTRICT.

Take of Fish—

1. State whether the take of fish has been above or below the average of previous years—
(a) By fixed engines in the sea—Above average.
(c) By rod and line—855 (about average).
3. Particulars as to the times grilse and sea trout appeared are as follow :—
Sea trout appeared in the month of March. Grilse appeared in the month of May.
4. The weight of the heaviest salmon taken during the season was 52 lbs.
The particulars of time and place of capture are :—Cromarty, March, in bag-net.

Protection—

1. The assessable rental for 1909 was £3532 15s.
2. The assessment levied was £323 16s. 8d.
3. The water bailiffs employed are 4 in number.
4. Particulars as to prosecutions instituted are briefly as follow :—George Paterson, Cromarty fishings, breach of weekly close time ; case found not proven. Roderick Paterson, pilot, Kessock, taking 87 sea trout in Beaulay Firth by means of illegal net ; boat and net forfeited, and expenses. John Jack, fisherman, Avoch, taking 7 sea trout with four hang nets in Moray Firth at Avoch ; fined £2 10s.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect—None.
2. Are the bye-laws observed in every case ?—Yes.
3. Fish passes built or in prospect—None.

The Salmon Disease—

1. Disease made its appearance this year in the month of January, and reached its height in February.

The river was free of diseased fish in March.

2. The number of diseased fish taken from the river and destroyed was 129, as follows :—

	Males.	Females.
Kelts,	115	14

The Spawning Season—

1. Fish were first noticed spawning on 28th October.
2. The greatest number spawned in the month of November.
3. Spawning not ceased.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as very good.

Smolts—

1. Smolts were noticed to be migrating seawards in the month of April.
2. As a smolt year 1909 was very good.

*REPORT FROM CONON DISTRICT.***Take of Fish—**

1. State whether the take of fish has been above or below the average of previous years—
 - (a) By fixed engines in the sea—Above the average.
 - (b) By sweep net in tidal or fresh waters—During the spring months in the Brahan waters with net and coble, above the average ; otherwise about an average.
 - (c) By rod and line—About the average.
3. Expressed as percentages for each month of the season, so as to show the times of greatest run, the figures are :—

	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.
By Fixed Engine, . . .	3	7	8	15	15	40	12	...
By Sweep Net, . . .	4	10	12	9	13	36	16	...
By Rod and Line, . . .	9	12	14	9	13	19	14	10

Particulars as to the times grilse and sea trout appeared, as included in the above return, are as follow :—The main run of sea trout was in March and April. Clean sea trout in the tidal waters at all seasons. The first run of grilse was about the last week in May.

4. The weight of the heaviest salmon taken during the season was 58½ lbs. The particulars of time and place of capture are—July, Castlecraig bag net fishery. Several salmon were caught in all the bag net fisheries in the Conon district varying in weight from 30 lbs. to 40 lbs.

Protection—

1. The assessable rental for 1909 was £2967 10s.
2. The assessment levied was 1s. 4d. per £.
3. The water bailiffs employed are 3 in number—1 permanent inspector and 2 temporary watchers.
4. Particulars as to prosecutions instituted are briefly as follow :—The only prosecution during the year 1909 was one for angling in the Blackwater without permission from the proprietor. The accused person was tried at Dingwall on 11th November, 1909, and a plea of guilty was tendered on his behalf. The Sheriff ordered him to pay £1 1s. of modified expenses.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect—No dam dykes have been disused or built, nor are any in prospect.
2. Are the bye-laws observed in every case?—All the bye-laws have been strictly observed.
3. Fish passes built or in prospect—No fish passes have been built, nor are there any in prospect.
4. Natural obstructions not yet dealt with are—Falls of Orrin, Falls of Scatwell, Falls of Conon, Falls of Rogie, and Falls of Garve.

The Spawning Season—

1. Fish were first noticed spawning about the last week in October.
2. The greatest number spawned between 6th November and 19th November.
3. Spawning ceased about the last week of December.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as a good one. Spawning fish seen on the redds were above the average.

Smolts—

1. Smolts were noticed to be migrating seawards in the first week of April.
2. As a smolt year 1909 was a fairly good one.

REPORT FROM ALNESS DISTRICT.

Take of Fish—

1. The take of fish has been as follows :—
 - (a) By fixed engines in the sea—No fixed nets in the district.
 - (b) By sweep net in tidal or fresh water—Slightly below the average all over, but some of the stations show much improvement.
 - (c) By rod and line—Below the average of previous years, but better than last year.
2. The actual number of fish caught is not known.
3. Sea trout begin to run about the middle of June, and the greatest run of sea trout is from about the 10th to 15th July. The best run of grilse is from about 1st July to 11th August. A few salmon are to be found running along with grilse throughout the whole summer. A few salmon were also observed entering the Alness River during the spring months. The past season was remarkable for the numbers of large salmon observed in the district.
4. The weight of the heaviest salmon taken during the season was—By sweep net, 35 lbs. ; by rod, 24 lbs.
The particulars of time and place of capture are :—The 35 lbs. salmon on Teaninich fishing in July ; the 24 lbs. salmon on Novar waters in May.

Protection—

1. The assessable rental for 1909 was £451.
2. The assessment levied was 4s. 6d. per £.
3. The water bailiffs employed are 1 permanent water bailiff and an assistant in the spring months and again in the autumn months.
4. No prosecutions.

Obstructions to the Passage of Fish.

1. No change as regards obstructions.
2. Are the bye-laws observed in every case?—Yes, as regards the Alness River ; but the Board is endeavouring to arrange for an improvement as regards the Balnagown River.
3. No change as regards fish passes.
4. There are no natural obstructions.

Pollutions—

1. There is not much pollution except the sewage from the village of Alness and the mansion and other houses near the river. The District Committee of the County Council, however, are taking steps to have the sewage of the village conveyed direct into the sea by means of a pipe.

The Salmon Disease—

1. There was no diseased fish noticed in the district.

The Spawning Season—

1. Sea trout were first noticed spawning about first week of October 1908, grilse about the end of October, and salmon in November and December 1908.
2. The greatest number spawned in November and the first fortnight of December 1908.
3. Spawning ceased about the end of December 1908.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as a good deal below the average as regards the number of spawning fish other than sea trout, in consequence of the flooded state of the river. The numbers of sea trout spawning were, however, above the average.

Smolts—

1. Smolts were noticed to be migrating seawards in April, but the greatest run was in the month of May.
2. As a smolt year 1909 was good.

*REPORT FROM KYLE OF SUTHERLAND DISTRICT.***Take of Fish—**

1. State whether the take of fish has been above or below the average of previous years—
 - (a) By fixed engines in the sea—Above the average.
 - (b) By sweep net in tidal or fresh waters—Above the average.
 - (c) By rod and line—Above the average.
4. The weight of the heaviest salmon taken during the season was 43 lbs. The particulars of time and place of capture are :—Month of August, by bag-nets, in this district.

Protection—

1. The assessable rental for 1909 was £4315 7s. 6d.
2. The assessment levied was at 1s. 6d. per £—£323 13s.
3. The water bailiffs employed are 8 in number.
4. Prosecutions—None.

The Salmon Disease—

1. Disease made its appearance this year in the month of June, and reached its height in July.
The river was free of diseased fish in August.
2. The number of diseased fish taken from the river and destroyed was 4, as follows :—

	Males.	Females.
Kelts,	1	3

The Spawning Season—

1. Fish were first noticed spawning on 10th October.
2. The greatest number spawned between 5th and 28th of November.
3. Spawning ceased in January.
4. As regards numbers of breeding fish, and state of the water the past spawning season is regarded as a very good one.

Smolts—

1. Smolts were noticed to be migrating seawards in April.
2. As a smolt year 1909 was fair ; about average.

*REPORT FROM THE DISTRICTS OF EAST AND WEST SUTHERLAND.***Take of Fish—**

1. State whether the take of fish has been above or below the average of previous years—
 - (a) By fixed engines in the sea—Above average.
 - (b) By sweep net in tidal or fresh waters—Above average.
 - (c) By rod and line—Above average.

2. The actual number of fish caught has been as follows :—
 - (a) By fixed engine—Salmon, 896 ; grilse, 2444 ; trout, 158—West Coast bag-nets.
 - (b) By sweep net—Salmon, 859 ; grilse, 751 ; trout, 667—Brora sweep nets.
 - (c) By rod and line—River Helmsdale, 1375 (lower, 822 ; upper, 553) ; Fleet, 172 salmon and grilse and over 200 seat trout ; Brora, 380 ; Inchard, 64.
3. Expressed as percentages for each month of the season, so as to show the times of greatest run, the figures are :—

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.
*By Fixed Engine { Salmon, Grilse, Trout,	-	-	.8	5.0	38.4	36.0	12.8	7.0	-
	-	-	-	-	.6	54.1	44.0	1.3	-
	-	-	.6	2.4	10.7	32.6	51.0	2.7	-
††By Sweep Net { Salmon Grilse, Trout,	-	-	-	43.0	25.0	19.0	13.0	-	-
	-	-	-	-	.6	35.0	64.4	-	-
	-	-	-	-	3.0	45.0	52.0	-	-
§By Rod and Line { Salmon, Grilse, }	.8	4.6	12.1	15.6	16.2	15.8	16.5	11.5	6.9

* West Coast bag nets.

† Brora sweep nets.

†† Fishing on river suspended till 1st May ; figures shown for April arrived at by including fish netted in Loch Brora.

§ River Helmsdale.

Particulars as to the times grilse and sea trout appeared, as included in the above return, are as follow :—First salmon caught in West Coast bag-nets, 13th March ; first trout, 18th March ; and first grilse, 3rd May. Main run of grilse and trout on West Coast in June and July, and same on East Coast.

4. The weight of the heaviest salmon taken during the season was—On Helmsdale, 27 lbs. ; Brora, 23½ lbs. ; Fleet, 20½ lbs. ; Inchard, 17 lbs. ; Kirkaig, 28½ lbs. ; Inver, 19½ lbs. ; Laxford, 27½ lbs.

The particulars of time and place of capture are :—Helmsdale fish caught on Lower Torrish Pool, No. 3 beat, on 26th February ; Brora fish caught by Major Burnell Milnes on 24th February in the small pool above Cliff Pool ; Fleet fish caught in Rovie Poll in September ; and Inchard fish caught on Garbetbeg on 21st August.

Protection—

1. The assessable rental for 1909 was—East Coast £2160, West Coast £1317 ; but angling mostly let with shootings, and value not fully apportioned.
2. Assessment levied—None.
3. The water bailiffs employed are 5 in number, but all the estate keepers undertake watching as part of their duty.
4. Particulars as to prosecutions instituted are briefly as follow :—None.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect—No additional dams to those already reported on.
2. Are the bye-laws observed in every case ?—Yes.
3. Fish passes built or in prospect—No additional ones.
4. Natural obstructions not yet dealt with are—Too numerous to give in detail.

Pollutions—

1. No pollutions exist in this district.

The Salmon Disease—

1. No disease on Helmsdale or West Coast rivers. One diseased fish taken from Brora at Carroll.

The Spawning Season—

1. Fish were first noticed spawning on 26th October on Helmsdale, 16th October on Laxford, 19th October on Brora, 20th October on Inchar, beginning November on Inver and Kirkaig.
2. The greatest number spawned 4th to 10th November.
3. Spawning still continuing (14th November).
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as moderately good. On East Coast the number of spawning fish was above the average, but owing to high floods season cannot be regarded as too good. On West Coast the season may be taken as a good average one as far as number of breeding fish are concerned, but rivers being in high spate, some of spawning beds must have been shifted and a lot of spawn washed away.

Smolts—

1. Smolts were noticed to be migrating seawards in the second and third weeks of April.
2. As a smolt year 1909 was a very good season on East and average season on West Coast.

Most pleasing feature of season's fishing was fine appearance of grilse. The rivers have remained exceptionally high during year, which was very favourable to rod-fishing. The high catch of salmon and grilse on the River Fleet will be noted, and this year was the earliest on which salmon have been taken on the River Inchar (15th June). The Laxford has done better than it has for 15 years.

COUNTY OF SUTHERLAND—NORTH COAST (RIVERS HALLA-DALE, NAVER, BORGIE, KINLOCH, AND HOPE).

Take of Fish—

1. State whether the take of fish has been above or below the average of previous years—

(a) By fixed engines in the sea,	}	Slightly above the average.
(b) By sweep net in tidal or fresh waters,		
(c) By rod and line,		
2. The actual number of fish caught has been as follows:—

(a) By fixed engine—666 salmon, 1740 grilse.
(b) By sweep net—1014 salmon, 2866 grilse.
(c) By rod and line—684 salmon and grilse.
3. Expressed as percentages for each month of the season, so as to show the times of greatest run, the figures are:—

	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.
By Fixed Engine, . . .	...	...	...	9	50	36	5	...
By Sweep Net, . . .	...	...	...	9	41	50	...	...
By Rod and Line, . . .	2	14	24	17	8	14	7	14

Particulars as to the times grilse and sea trout appeared, as included in the above return, are as follow:—First grilse caught 11th May, by bag-net; first sea trout caught 22nd May, by sweep net.

4. The weight of the heaviest salmon taken during the season was 39 lbs. The particulars of time and place of capture are:—Caught 9th August 1909, in bag-net, east from Bighouse Head.

Protection—

1. The assessable rental for 1909 was £1300 per Valuation Roll, but angling mostly let with shootings and not apportioned at full value.
2. No assessment levied.

3. The water bailiffs employed are 5 in number, in addition to keepers who assist in the watching.
4. Prosecutions—None.

The Spawning Season—

1. Fish were first noticed spawning on 22nd October.
2. The greatest number spawned* between 28th October and 15th November.
3. Spawning ceased about the end of November.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as favourable. Rivers of medium size during the spawning season.

Smolts—

1. Smolts were noticed to be migrating seawards in the first week of May, and continued till the 20th.
2. As a smolt year 1909 was fairly good.

REPORT FROM BALGAY DISTRICT.

Take of Fish—

1. State whether the take of fish has been above or below the average of previous years :—About the average catch with rod and line.
3. Particulars as to the times grilse and sea trout appeared are as follow :—Sea trout began to show at mouth of the Kinloch and Balgay rivers after the middle of June ; began to ascend said rivers on the first and second week of July. First shoal of sea trout gone up to Loch Doule on the 6th July last.
4. The weight of the heaviest salmon taken during the season was 15 lbs., by Lady Anne Murray.
The particulars of time and place of capture are :—The River Balgay.

Protection—

1. The assessable rental for 1909 was £40.
2. All expenses paid by Mr. Murray and Earl of Lovelace.
3. The water bailiffs employed are 1 in number, by Mr. Murray.

The Spawning Season—

1. Sea trout on the Kinloch were seen spawning on the second week of October last.
3. Numbers of sea trout are still in the act of spawning.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as fairly good.

REPORT FROM SKYE DISTRICTS (EAST AND WEST COASTS).

Take of Fish—

2. The number of fish caught has been below the average.

Protection—

1. The assessable rental for 1909 was £540.
2. The assessment levied was for a sum of £17 18s., paid in equal proportions by the several proprietors.
3. The water bailiffs employed are 18 in number.
4. Prosecutions—Nil.

Note.—The sea fishings on the East Coast of the island have been let to Mr. Powrie, Gairloch, &c. These fishings were previously let to Messrs. Johnston & Son, Montrose, whose lease expired at Martinmas last. The rent payable by the new tenant is considerably less than the previous rent.

REPORT FROM LOCHY DISTRICT.

Take of Fish—

1. State whether the take of fish has been above or below the average of previous years—
 - (c) By rod and line—Below.
3. Expressed as percentages for each month of the season, so as to show the times of greatest run, the figures are :—

	April.	May.	June.	July.	Aug.	Sept.	Oct.
By Rod and Line. { Salmon and grilse, Sea trout, ...	2 0	3 0	11 1	34 44·4	16 20·3	17 13·1	17 21·2

Particulars as to the times grilse and sea trout appeared, as included in the above return, are as follow :—About 15th June.

Protection—

1. The assessable rental for 1909 was £1900.
2. No assessment levied.
3. The water bailiffs employed are 11 in number.
4. Particulars as to prosecutions instituted are briefly as follow :—One prosecution for night poaching for salmon ; fine of £1 and 10s. of expenses imposed on each offender.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect—None.
3. Fish passes built or in prospect—None.
4. Natural obstructions not yet dealt with are :—Monessie Falls.

The Spawning Season—

1. Fish were first noticed spawning on 1st November.
2. The greatest number spawned from 24th November till 20th December.
3. Spawning ceased at end of December.
4. Breeding fish few and river mostly high.

Smolts—

1. Smolts were noticed to be migrating seawards on 18th May.
2. As a smolt year 1909 was poor.

REPORT FROM AWE DISTRICT.

Take of Fish—

1. State whether the take of fish has been above or below the average of previous years—
 - (a) By fixed engines in the sea—Above the average.
 - (b) By sweep net in tidal or fresh waters—Much above last year's average.
 - (c) By rod and line—About last season's average.
3. Particulars as to the times grilse and sea trout appeared are as follow :—

The first appearance of large sea trout up to 7 lbs. was on May 19th.
The first appearance of grilse was on June 3rd (5½ lbs.).
4. The weight of the heaviest salmon taken during the season was 57 lbs.
The particulars of time and place of capture are :—Caught on River Awe by rod on October 8th (Syndicate waters).

Protection—

1. The assessable rental for 1909 was £1565.
2. The assessment levied was 1s. 3d. per £.
3. The water bailiffs employed are 1 in number.
4. Particulars as to prosecutions instituted are briefly as follow :—One case, fishing for fish of the salmon kind with an illegal net having no right. Not proven.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect—One, not yet dealt with.
2. Are the bye-laws observed in every case?—Fairly observed.

Pollutions—

1. The existing pollutions are :—One at South Connel River—refuse of dye and other matter from woollen mill entering river. The above has not yet been dealt with.

The Salmon Disease—

1. No disease was seen in the River Awe or district this season.

The Spawning Season—

1. Fish were first noticed spawning on October 15th (sea trout); on November 29th (salmon).
2. The greatest number spawned on November 29th (sea trout); late.
3. Spawning ceased about the beginning of January.
4. As regards numbers of breeding fish, and state of the water, there was a very good show of breeding fish, above the average for some years back. Rivers were high at commencement of spawning, and a heavy spate came on about the middle, but considering the heavy show of spawning fish seen in the beds, this should be the best spawning season in the Awe district that has been for years.

Smolts—

1. Smolts were noticed to be migrating seawards on April 19th.
2. As a smolt year 1909 was fairly good.

The number of ova secured locally during the past season was 60,000, 150,000 ova was got from Germany, making in all 210,000. Regarding local ova, twenty-nine salmon were got, to enable ova of male and female to be equal.

The average weight of salmon caught during the net season was heavier than for some years back.

Note.—Rod fishing in Syndicate's water closes on October 14th.

*REPORT FROM CLYDE AND LEVEN DISTRICT, INCLUDING
LOCH LOMOND.*

Take of Fish—

1. State whether the take of fish has been above or below the average of previous years—
 - (a) By fixed engines in the sea—There are none in the district.
 - *(b) By sweep net in tidal waters of the Clyde—Rather below the average.
 - (c) By rod and line (approximately) in Loch Lomond :—(1) Salmon and grilse, far above the average; (2) sea trout, average to July, after which weather conditions ruined sport.

**Note.*—See special remarks on netting at end of report.
2. The actual number of fish caught has been as follows :—
 - (a) By fixed engine—None.
 - (b) By sweep net in the Clyde—(1) 243 salmon, (2) 357 grilse, (3) 4075 sea trout.
 - (c) By rod and line (approximately) in Loch Lomond—(1) Salmon and grilse, 142; (2) sea trout, 448. Rod-caught salmon in 5 years since 1905, showing increase, 38, 39, 95, 97, 142.

3. Expressed as percentages for each month of the season, so as to show the times of greatest run, the figures are :—

		April.	May.	June.	July.	Aug.	Sept.	Oct.
*By Sweep Net	{ Salmon,	...	23	35	42	...	...	...
	{ Grilse,	...	0	6	94	...	...	...
	{ Sea trout,	...	4	11	85	...	...	...
By Rod and Line,	{ Salmon and	6	9	34	45	5	1	0
	{ Grilse,	0	7	6	38	42	6	1
	{ Sea trout,							

* The Clyde nets only work during May, June, and July, so that data of early-running estuary fish are not obtainable.

Particulars as to the times salmon, grilse, and sea trout appeared in Loch Lomond, as included in the above return, for rod and line, are as follow :—(1) salmon, 19th April; (2) grilse, 14th June; (3) sea trout, 24th April.

4. The weight of the heaviest salmon taken during the season was 24 lbs. The particulars of time and place of capture are :—In Loch Lomond, on May 1st, trolling with minnows on Endrick Bank.

Protection—

1. The assessable rent for 1909 was nil, there being no District Board. The district is conserved by the Loch Lomond Angling Improvement Association, whose income from voluntary contributions amounted to £338 14s. 6d. This income is supplemented from other sources.
3. The water bailiffs employed vary in number with the season. There are 3 permanent men. As the season advances the staff is increased to 7 men. A motor boat now patrols Loch Lomond.
4. Particulars as to prosecutions instituted are briefly as follows :—There were several of no great importance.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect—None.
2. Are the bye-laws observed in every case?—Yes.
3. Fish passes built or in prospect :—None.
4. Natural obstructions not yet dealt with have been fully detailed in former reports.

Pollutions—

1. The existing pollutions were fully stated in reports for years 1906 and 1908.
2. Remedial measures are as formerly stated. The litigation regarding new sewers at Alexandria between the fishing proprietors and their lessee, the said Association, as pursuers, and the Western District Committee of the County Council of Dumbarton, as defenders, which has been for five years before the Sheriff, is now concluded with payment by defenders of a proportion of the pursuers' expenses. The net result of the case has been the installation by defenders of a complete system of modern sewage purification works in connection with these sewers.

The Salmon Disease—

1. There has been no evidence of disease seen in the district.

The Spawning Season—

1. Fish were first noticed spawning as follows :—Sea trout, 6th October; salmon, 30th November.
2. The greatest number spawned as follows :—Sea trout, in November; salmon, in January.
3. Spawning ceased as follows :—Sea trout, in December; salmon, in January.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as having been particularly favourable. The redds were occupied by a very plentiful supply of salmon and an average number of sea trout.

Smolts—

1. Smolts were noticed to be migrating seawards in May.
2. As a smolt year 1909 was an average year.

Note.—The following summary of netting rights may be of value :—

1. *Loch Lomond.*—The netting rights belong to the Duke of Montrose, Sir A. W. Leith-Buchanan, Bart., and Sir Alan John Colquhoun, Bart. The Duke of Montrose leases his rights to three tenants, each of whom regularly works one net. A fourth net, belonging to the Duke, is also occasionally worked. Sir A. W. Leith-Buchanan's net is only worked at rare intervals during each season. Sir Alan John Colquhoun's rights are leased to the said Association, and are not exercised by the tenants, but the landlord occasionally works one net at intervals to conserve his rights.

2. *The River Leven.*—The netting rights belong to Sir Alan John Colquhoun, are leased to the said Association, and are not exercised by the tenants.

3. *The River Clyde.*—The known netting rights belong to the Burgh of Renfrew and Sir Alan John Colquhoun. The former rights are leased to Sir Michael Hugh Shaw-Stewart, Bart., who sub-leases that section of the river lying above Newark Castle to the said Association. These rights are not exercised. Sir Alan John Colquhoun's rights are leased on long lease to the Trustees of the Clyde Navigation, who sub-lease them to the said Association. Three nets are worked on one out of seven shots, for four days each week during May, June, and July only.

4. *The Gareloch.*—The netting rights belong to Sir Alan John Colquhoun on the east side, except Row Point, and to the Duke of Argyll on the west side and on Row Point on the east side. The former rights are leased to the said Association, and are not exercised by them. The Duke of Argyll's rights are leased to a tenant or tenants.

With regard to netting rights in the Gareloch, which lies within the estuary of the river Clyde, it is submitted that netting by fixed engines is illegal above "a straight line drawn east from Toward Point Light." Stake nets are, therefore, nowhere used. In a recent trial, the Duke's tenant explained, in giving evidence, that the only method practicable, and which he used, was splash netting.

REPORT FROM AYR DISTRICT.**Take of Fish—**

1. The take of fish generally throughout the district has been increased. The sea fishings are not let by the proprietor, and, as there is no netting employed in any part of the river, the fish have all been taken by rod and line.
2. The actual number of fish caught so far as officially known was 266, but there is ample reason for believing that the actual number killed was far in excess of that figure.
3. As most of the proprietors do not keep an accurate record, or any record at all, of the times when, and the actual number of fish caught, it is impossible to give reliable information on the subject. The majority of the fish are killed in October.

Particulars as to the times grilse and sea trout appeared are as follow :—
The run of grilse took place in June. The first run of sea trout took place in May. The first salmon was caught on 3rd June. The principal runs of salmon took place in July and August.

4. The weight of the heaviest salmon taken during the season was 24½ lbs. The particulars of time and place of capture are :—It was caught on the Craigie stretch of the river, about one mile from the sea.

Protection—

1. The assessable rental for 1909 was £159 10s.
2. The assessment levied was £159 10s.
3. The water bailiffs employed are two in number. During a part of the season an extra bailiff was employed to assist in the watching of the river at Ayr Mills and Overmills, which places are much frequented by the public.

4. Particulars as to prosecutions instituted are briefly as follow :—
- One man was interdicted after being caught on various occasions fishing without leave of the proprietors of the fishing.
 - One man was convicted and fined for salmon poaching.
 - One man was convicted and fined for dragging for salmon by means of a heavy metal minnow.
 - One man was convicted and fined for a similar offence.
 - One man was convicted and fined for using set lines.
 - One man was convicted and fined for dragging for salmon by means of a heavy metal minnow.
 - Four men were convicted and fined for poaching by means of a net.
 - One man was convicted and fined for taking salmon at a fish pass by means of a gaff.
 - One man was convicted and fined for fishing with roe.
- There was a serious case of netting in the river Lugar, a tributary of the Ayr, during the season, but as one of the men implicated lost his life, the Board did not consider it advisable in the circumstances to prosecute.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect :—The dam dyke at Ballochmyle, which the Board consider an obstruction, has not yet been remedied, but it is hoped the matter will be remedied early in the coming season.
2. The bye-laws are generally observed.

The Salmon Disease—

1. Disease made its appearance this year in the month of January, and reached its height in February.
- The river was free of diseased fish in the end of February.
2. The number of diseased fish taken from the river and destroyed was as follows :—

	Males.	Females.
Kelts,	149	23

The Spawning Season—

1. Fish were first noticed spawning on 5th November, 1908.
2. The greatest number spawned in November.
3. Spawning ceased in the end of January.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as beyond the average of previous years.

Smolts—

1. Smolts were noticed to be migrating seawards in April and May.
2. As a smolt year 1909 was a good year.

REPORT FROM DOON DISTRICT.

Take of Fish—

1. As compared with the results of previous years, the take of fish generally throughout the district was about the average. The sea nets for some years have been entirely removed, with the consequence that the stock of fish in the river has enormously increased. The number of fish caught during the season would probably have been much greater, but owing to the abnormal rainfall it was impossible for many days during the season to angle with any hope of success.
2. The actual number of fish caught has been as follows :—

(b) By sweep net in fresh water, 30.

As many of the proprietors do not keep an accurate, or any record at all, of the times when, and the actual number of fish caught, it is impossible to give reliable information on the subject. The majority of fish were killed in October, but a very considerable number were killed in July. There were also a considerable number of spring fish killed towards the end of April and beginning of May.

Particulars as to the times grilse and sea trout appeared are as follow :—
The first run of spring fish took place on 11th December, 1908. The first run of sea trout took place during the first week in April. The main runs of grilse took place towards the end of July. The main runs of salmon took place in July, August, and October. During September the river was very low. The first spring fish was killed on 13th March.

4. The weight of the heaviest salmon taken during the season was 26½ lbs.
The particulars of time and place of capture are :—Caught on the Mount Charles stretch, about one mile from the sea.

Protection—

1. The assessable rental for 1909 was £511 sterling.
2. The assessment levied was £229 19s.
3. The water bailiffs employed are two in number. During a part of the season an extra bailiff was employed to assist in the watching of the river where it enters the sea. There it crosses a long gravelly bar, and when going over this the fish are easily captured.
1. Particulars as to prosecutions instituted are briefly as follow :—One man paid a sum to avoid a prosecution for using set-lines. Two men were convicted and fined for a similar offence. Two men were convicted and fined for a similar offence. Three men were convicted and fined for salmon poaching at the mouth of the river. One man was convicted and fined for salmon poaching by rod and line. Two men paid a sum to avoid a prosecution for salmon poaching by rod and line. One man was convicted and fined for a similar offence. Four men were convicted and fined for salmon poaching by means of a net.

Obstructions to the Passage of Fish—

1. Dam-dykes disused, built, or in prospect—None.
2. Are the bye-laws observed in every case?—The bye-laws are generally observed.
3. Fish passes built or in prospect—None.

Pollutions—

1. The existing pollutions are :—The blanket mill at Skeldon has been shut down for some time, and during the season there was no pollution.

The Salmon Disease—

1. Slight disease made its appearance in the month of January, and reached its height during that month.
The river was free of diseased fish early in February.

The Spawning Season—

1. Fish were first noticed spawning in the first week in November.
2. The greatest number spawned during the month of November.
3. Spawning ceased early in January.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as beyond the average. There was a very large number of breeding fish in the river.

Smolts—

2. As a smolt year 1909 was good.

REPORT FROM GIRVAN DISTRICT.

Take of Fish—

1. State whether the take of fish has been below or above the average of previous years—
(a) By fixed engines in the sea—Owing to the fact that the fishings in this district have shown results for the season far beyond the usual, tacksmen cannot be induced to give any figures, but it may be taken that at least four or five times last year's numbers of salmon and grilse were captured. Last year's figures were 720 salmon and 880 grilse.

2. The actual number of fish caught has been as follows:—The first fish was caught as soon as the nets were out—26th March.
 - (c) By rod and line—The rod and line results also showed improvement, over 50 salmon and grilse having been taken instead of the usual 8 or 12.
4. The weight of the heaviest salmon taken during the season was 28 lbs. The particulars of time and place of capture are:—Bargany fishery, south of pier, about 15th July.

Protection—

1. The assessable rental for 1909 was £533 10s.
2. The assessment levied was £28 18s.
3. The water bailiffs employed are 1 in number.
4. Particulars as to prosecutions instituted are briefly as follow:—Two tacksmen were prosecuted for failing to observe the weekly close time and were fined, one £7 and £3 expenses, the other £7 and £1 expenses.

Obstructions to the Passage Fish—

2. Are the bye-laws observed in every case?—Some of the mill lades do not conform to the statutory requirements with regard to hecks and sluices, but an effort is being made to have this state of matters remedied.

Pollutions—

1. The existing pollutions are:—Polluted water is now flowing from the Dalquharran Pit, which was shut down after the fire. The proprietor of the pit was prevented from pumping out the polluted water and running it into the river, and failed in Court proceedings which he raised to assert his right. The water now escaping to the river is oozing through the ground and overflowing at the old day levels, but it has not yet acquired sufficient volume to be destructive to fish life. There is also objectionable water being pumped from the new Killochan Coal Coy.'s pit. It has been analysed and found to contain deleterious salts of iron and other matters in solution and in suspension, and would be fatal to fish if discharged in sufficient quantity.
1. Remedial measures:—The Board have had the matter under consideration, but no measures have yet been resolved upon.

The Spawning Season—

1. Fish were first noticed spawning about the end of November.
2. The greatest number spawned in December so far as observed.
3. Spawning still going on (15th December).
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as no better than average according to the watchers' reports, though from outside sources it was believed that the stock of fish in the river was much beyond the average.

Note.—It is admitted by the tacksmen that the season of 1909 has been the best for a period of over 20 years at least. They believe that the fish may have come from the adjoining Doon district, where the nets have been removed for some years back. A suggestion has been made to buy up and remove the sea nets in this district. The matter is now being considered by the Board, and if a difficulty as to the existing leases can be overcome, some practical result may follow.

REPORT FROM STINCHAR DISTRICT.**Take of Fish—**

1. State whether the take of fish has been above or below the average of previous years—
 - (c) By rod and line—Much above the average of previous years.
3. Grilse and sea trout appeared about the 1st of June.
4. The weight of the heaviest salmon taken during the season was 28 lbs.

Protection—

1. The assessable rental for 1909 was £400.
2. The assessment levied was £15.
3. The water bailiffs employed are 2 in number.

The Spawning Season—

1. Fish were first noticed spawning on 20th November.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as good.

Smolts—

1. Smolts were noticed to be migrating seawards about 15th May.
2. As a smolt year 1909 was about an average season.

REPORT FROM CREE DISTRICT.

Take of Fish—

1. State whether the take of fish has been above or below the average of previous years—
 - (a) By fixed engines in the sea—Much worse than last year.
 - (b) By sweep net in tidal or fresh waters—Much worse than last year.
 - (c) By rod and line—Above the average of previous years.
2. The actual number of fish caught has been as follows :—
 - (a) By fixed engine } Not known.
 - (b) By sweep net }
 - (c) By rod and line—161.
3. Expressed as percentages for each month of the season, so as to show the times of greatest run, the figures are, from April onwards :—By rod and line, 14, 2½, 10½, 25, 24, 24.
Particulars as to the times grilse and sea trout appeared are as follow :—
Grilse and sea trout did not appear till July in season 1909, as June was abnormally dry.
4. Fish from this river by rod and line average 9 lbs. There was no specially heavy fish taken in 1909.

Protection—

1. The assessable rental for 1909 was £862 10s.
2. The assessment levied was 9½d. per £, or £34 2s. 10d.
3. The water bailiffs employed are 3 in number all the year round and four in June, July, August, and September.
4. Particulars as to prosecutions instituted—None.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect.—None. There is still the obstruction reported previously, and referred to last year, of water for timber merchant's mill at Minnigaff from the dam dyke on Penkilm Burn.
2. Are the bye-laws observed in every case?—Regular.
3. Fish passes built or in prospect—None.
4. Natural obstructions not yet dealt with are :—On High Cree, on Bargrennan Lynn, and on Minnoch (tributary of Cree) at Glencaird Lynn.

The Salmon Disease—

Salmon disease proper was not experienced in 1909.

The Spawning Season—

1. Fish were first noticed spawning on 7th October.
2. The greatest number spawned during October and first week of November.
3. Spawning ceased 15th November or thereabouts.
4. As regards numbers of breeding fish, and state of the water, the number of breeding fish was well above the average. Severe flooding in mid October would militate against successful results; still 1909 may be regarded as a good spawning season.

Smolts—

1. Smolts were noticed to be migrating seawards in June and July.
2. As a smolt year 1909 was excellent.

No change in office-bearers.

There is a great desire on the part of most of the proprietors and fishermen to have the annual fishing time extended to the same period as the Annan and Luce and some other districts on the Solway. It is not thought that this would affect the fishing in the rivers, as the back-end salmon, which are caught late in the season, are never seen up the rivers. An equal time would, of course, be taken off the open time at the beginning of the season. This change, it is thought, would be advantageous to all concerned.

*REPORT FROM DEE (SOLWAY) DISTRICT.***Take of Fish—**

2. The actual number of fish caught has been as follows :—
(c) By rod and line—215, which is well above the average.
3. Particulars as to the times grilse and sea trout appeared are as follow :—
First grilse was caught on 3rd June, 10 days earlier this year than usual.
The first sea trout was caught in the end of June; they were very scarce.
4. The weight of the heaviest salmon taken during the season was 32 lbs.
Taken by draft net.

Protection—

1. The assessable rental for 1909 was £1231.
2. The assessment levied was 5 per cent.
3. The water bailiffs employed are 13 in number.

The Salmon Disease—

No diseased fish were seen in the river this year.

The Spawning Season—

1. Fish were first noticed spawning on October 26th.
2. The greatest number spawned—A record for over twenty years.

Smolts—

1. Smolts were noticed to be migrating seawards in the last week in April and first 10 days in May.
2. As a smolt year 1909 was very poor.

*REPORT FROM NITH DISTRICT.***Take of Fish—**

2. The number of fish caught :—
(a) By fixed engine—Cannot be ascertained.
(b) By sweep net—Cannot be ascertained.
(c) By rod and line—Cannot be ascertained correctly, but, so far as known, 47 salmon and grilse. This is above last year's take.
3. Particulars as to the times grilse and sea trout appeared are as follow :—
Grilse about beginning of June; sea trout early in March. Grilse much under the average of last year in number; sea trout about the average.
4. The weight of the heaviest salmon taken during the season was 30 lbs.
The particulars of time and place of capture are :—On 11th November, by rod and line, one each in Carnsalloch and Lincluden waters respectively.

Protection—

1. The assessable rental for year to 15th May, 1909, was £506 19s. 4d.
2. The assessment levied was 5s. per £.
3. The water bailiffs employed are 1 in number.

4. Particulars as to prosecutions instituted are briefly as follow :—Five cases, involving nine persons, seven of whom were convicted, and the charge against two of them withdrawn. The offences were contravention of Sections 15 (4), 17, and 21 of Salmon Act, 1868. Fines varied from 30s. to £3.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect—The saw mill caul at Dalgonar, Dunscore parish, has been removed.
2. Are the bye-laws observed in every case?—Observed except in regard to Dalgonar meal mill, Dunscore parish. The caul there is not in a good state to allow fish to pass. No fish pass is constructed. The stream is divided by an island, and the dam only extends to the island. When the water is not very low fish may ascend on the other side.
3. Fish passes built or in prospect—None.
4. Natural obstructions not yet dealt with are :—In river Cairn, at Gribton saw mill, Holywood parish, known as “Cluden Rocks,” which are an obstruction in low water.

Pollutions—

1. The existing pollutions are :—The effluents from the mills at Dumfries containing dye, which are still unconnected with the sewage system.

The Salmon Disease—

1. Disease made its appearance this year in the month of January, and disappeared in May.
2. The number of diseased fish taken from the river and destroyed was as follows :—

	Males.	Females.
Kelts,	1	4

The Spawning Season—

1. Fish were first noticed spawning in first week of January.
2. The greatest number spawned about third week of January.
3. Spawning ceased about second week of February.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as very good.

Smolts—

1. Smolts were noticed to be migrating seawards in May and June.
2. As a smolt year 1909 was very good.

Note.—Drift net fishing in Arbigland waters, at the estuary of the Nith, has been discontinued. In the action for interdict in the Sheriff Court, Dumfries, against the white-fish fixed (paidle) nets in the estuary of the Nith, judgment has been issued by the Sheriff-Substitute granting interdict as craved. This judgment has been confirmed by the Sheriff-Principal, but is at present under appeal to the Second Division of the Court of Session.

REPORT FROM ANNAN DISTRICT.

Take of Fish—

1. State whether the take of fish has been above or below the average of previous years—
 - (a) By fixed engines in the sea—About the average of previous years.
 - (b) By sweep net in tidal or fresh waters—No sweep nets used.
 - (c) By rod and line—Generally thought to be slightly above the average of previous years.
3. Particulars as to the times grilse and sea trout appeared are as follow :—
First sea trout taken on 10th March in Annan Burgh fishings. Grilse appeared in first week in June in Newbie fishings.
4. The weight of the heaviest salmon taken during the season was 38 lbs.
The particulars of time and place of capture are :—In last week in July, in Newbie fishings, by stake net. The first salmon taken was on 26th February in Annan Burgh fishings.

Protection—

1. The assessable rental for 1909 was £2917.
2. The assessment levied was 3s. per £.
3. The water bailiffs employed are 4 in number.
4. Particulars as to prosecutions instituted are briefly as follow :—(1) Thomas Rule was, at Sheriff Court, Dumfries, on 28th May, 1909, fined £1 and £1 of expenses, or 30 days' imprisonment, for contravention of Salmon Act, viz., having an unclean salmon in his possession. Fine paid. (2) Richard Davidson, retired grocer, Lochmaben, contravention of Salmon Fisheries Act, two charges, killing salmon fry, Sheriff Court, 3rd June, 1909. Admonished. (3) Jacob Robinson, Richard Woodhouse, (4) James Woodhouse, and John Woodhouse were, at Sheriff Court, Dumfries, on 15th July, 1909, fined 2s. 6d. and 19s. 6d. expenses each, for contravention of Annan Fisheries Act (whammelling). Fines paid. Case taken for appeal and not yet settled.

Obstructions to the Passage of Fish—

1. Dam dykes disused, built, or in prospect—None.
2. Are the bye-laws observed in every case?—Yes.
3. Fish passes built or in prospect—None.
4. Natural obstructions not yet dealt with—None.

Pollutions—

1. The existing pollutions—None.
2. Remedial measures—Nil.

The Salmon Disease—

1. Disease made its appearance this year in the month of January, and reached its height in April.
The river was free of diseased fish in the second week of May.
2. The number of diseased fish taken from the river and destroyed was as follows :—

	Males.	Females.
Kelts,	6	21

The Spawning Season—

1. Fish were first noticed spawning on 15th December 1908.
2. The greatest number spawned in January 1909.
3. Spawning ceased in first week in March 1909.
4. As regards numbers of breeding fish, and state of the water, the past spawning season is regarded as good.

Smolts—

1. Smolts were noticed to be migrating seawards in May (about 15th).
2. As a smolt year 1909 was fair.

River was in heavy flood from 13th October till the end of the month, and during that period a great number of salmon went up the river. The heaviest salmon caught by rod and line was 29 lbs., by John Halliday, fisherman to E. J. Brook, Esq., in Hoddam water, about the end of October. During the month of August the most salmon were caught in the stake nets and poke nets.

APPENDIX V.

NOTE ON CROSSING OF SALMON STOCK BY TRANSPORTING
RIPE MILT.

BY W. L. CALDERWOOD.

The custom of transporting fertilised salmon eggs from one river to another has now become very familiar, and by this means many attempts have been made to introduce entirely new stock to rivers. An experiment, which is an alternative of this, was made during last winter (1909-1910) and is worthy of note. This consisted in transporting ripe milt from two rivers in Scotland to the Cheshire Dee. It not infrequently happens that, when ova-fishing for hatchery purposes, ripe males are not as plentiful as ripe females, and I have known of men putting the ripe milt in a bottle and carrying it about with them during the day. So far as I am aware, however, no attempt to transport milt from one river to another has been carried out, or, if carried out, has been made public. For purposes of crossing fish stock, it now appears to be possible to send or carry ripe milt from one district to another.

Major Leadbetter, of the Dee Board of Conservators, Cheshire, who instituted these experiments, has kindly given me the particulars.

The first trial was rather severe, the milt being carried all the way from Conon, in Ross-shire, to the Welsh Dee. Arrangements having been made with the Conon district authorities, that river was netted on 8th December, and of 13 males caught, 9 were placed in a floating cage for future use. Similarly two female salmon ready for spawning were secured and kept in a sort of cage in the Dee, before the Superintendent started for the Ross-shire river. He arrived there on the morning of 21st December, and a quantity of ripe milt was secured without delay from the Conon fish. This was placed in bottles and carefully sealed, and the bottles were then packed in moss to minimise shaking. By 1.15 p.m. the return journey was commenced, Chester being reached on the morning of 23rd December. By 10 o'clock on that date 22,000 eggs were fertilised and laid down in the Dee Hatchery. The actual time taken on the journey was 21 hours.

In the case of the other experiments, the attempt was made to transmit the milt by post from the Tweed. Although the time necessary for the journey is only 10 hours, very considerable delay occurred owing to the New Year holidays intervening. Three attempts were made, the first taking 18 hours, the second 40 hours, and the third no less than 63½ hours. These Tweed experiments appear to have been unsuccessful, but it is thought that the shaking which the milt received when in the hands of the parcels post authorities may in some measure have accounted for the loss. In any case, the result is that the length of time during which milt will remain fertile when carried in this way has not been determined. Fertilisation appeared to have taken place to some extent even in the case of the 63 hours' experiment, but subsequent results have shown these trials to be failures. In transporting pheasant eggs for rearing purposes

much shaking or jolting addles the eggs, and the same infertility may result in the case of milt of fishes. It should be noted also that the males were held up in the cage for 13 days, and that the females were similarly treated, though for a shorter period. From experience of confining salmon in this way, I believe that the success of the experiment was considerably jeopardised. The ripening of the genitalia is materially retarded by confining salmon.

In the *Conon Experiment*, the eggs began to hatch out in 48 days, although the number of dead eggs after the second week was marked. Of the 22,000 eggs laid down, 11,490 remained to hatch out, and up to the time of writing, 35 of the alevins have died, so that the total result is 11,455 fry. Last reports I have received go to show that the fry are quite strong and healthy.

First Tweed Trial.—The milt was received at Chester Fishery Office on 31st December, 1909, and 28,000 eggs were fertilised. Transit in this case took 18 hours. The first hatching out commenced in 50 days. Unfortunately the “dry” method of fertilisation was not followed in this case. In seven weeks the death rate had amounted to 13,371.

Second Tweed Trial.—The milt was received in 40 hours, and 7000 eggs were fertilised on 1st January, 1910. In seven weeks the death rate amounted to 411, a much better result than in the first trial. I have not received particulars as to the subsequent development, and am therefore unable to state why the result came to be considered a failure.

Third Tweed Trial.—The milt was received on 3rd January, 1910, having been $63\frac{1}{4}$ hours on the way. Only 4000 eggs were treated, and 2000 of these were regarded as fertilised. The eggs do not appear to have “eyed” well, and the death rate during the first four weeks was respectively 11, 24, 81, 156. I understand that all subsequently died.

The result of the Conon-Dee experiment is, however, sufficient to show that this mode of crossing can be successfully accomplished.

APPENDIX VII.

RATEABLE VALUE OF SALMON FISHERIES, IN DISTRICTS WHERE BOARDS HAVE BEEN FORMED, FOR THE YEARS 1881 TO 1909 INCLUSIVE.

YEAR.	Alness.		Annan.		Awe.		Ayr.		Balgay.		Bervie.		Conon.		Cree.		Dee (Aberdeen).		Dee (Solway).	
	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.
Average for 5 years, 1881 to 1885	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -
Average for 5 years, 1886 to 1890	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -	£ -
1891	579	2,778	701	2,112	586	2,099	586	2,112	40	2,112	586	2,112	530	11,968	530	10,127	530	11,968	1,463	1,391
1892	579	2,778	718	2,112	586	2,099	586	2,112	40	2,112	586	2,112	530	11,968	530	10,127	530	11,968	1,463	1,391
1893	579	2,778	723	2,112	586	2,099	586	2,112	40	2,112	586	2,112	530	11,968	530	10,127	530	11,968	1,463	1,391
1894	579	2,778	723	2,112	586	2,099	586	2,112	40	2,112	586	2,112	530	11,968	530	10,127	530	11,968	1,463	1,391
1895	584	2,793	896	2,793	752	2,389	752	2,793	20	2,793	536	2,540	2,755	14,593	542	13,461	542	14,593	1,633	1,497
1896	584	2,793	896	2,793	752	2,389	752	2,793	20	2,793	536	2,540	2,755	14,593	542	13,461	542	14,593	1,633	1,497
1897	614	3,182	878	3,182	896	3,182	896	3,182	20	3,182	1,071	2,455	2,455	15,820	571	15,820	571	15,820	1,603	1,603
1898	608	3,182	878	3,182	896	3,182	896	3,182	20	3,182	1,071	2,455	2,455	15,820	571	15,820	571	15,820	1,603	1,603
1899	609	3,182	870	3,182	870	3,182	870	3,182	42	3,182	871	2,554	2,554	17,468	696	17,468	696	17,468	1,603	1,603
1900	610	3,182	870	3,182	878	3,182	878	3,182	20	3,182	871	2,504	2,504	17,427	696	17,427	696	17,427	1,603	1,603
1901	606	3,196	936	3,196	878	3,196	878	3,196	20	3,196	871	2,504	2,504	18,989	646	18,989	646	18,989	1,603	1,609
1902	601	3,197	936	3,197	936	3,197	936	3,197	20	3,197	910	3,142	3,142	19,419	696	19,419	696	19,419	1,596	1,596
1903	617	3,197	1,052	3,197	936	3,197	936	3,197	40	3,197	910	3,108	3,108	19,455	691	19,455	691	19,455	1,557	1,557
1904	617	3,197	1,129	3,197	936	3,197	936	3,197	40	3,197	911	3,047	3,047	18,393	695	18,393	695	18,393	1,556	1,556
1905	735	3,256	1,208	3,256	911	3,256	911	3,256	40	3,256	911	3,047	3,047	19,079	728	19,079	728	19,079	1,556	1,553
1906	531	3,006	1,208	3,006	911	3,006	911	3,006	40	3,006	911	3,047	3,047	19,333	700	19,333	700	19,333	1,570	1,553
*1907	530	3,256	1,467	3,256	911	3,256	911	3,256	40	3,256	910	3,004	3,004	19,068	868	19,068	868	19,068	1,570	1,570
*1908	455	2,947	1,565	2,947	1,565	2,947	1,565	2,947	40	2,947	910	2,967	2,967	18,940	885	18,940	885	18,940	1,566	1,566
*1909	451	2,917	1,565	2,917	1,565	2,917	1,565	2,917	40	2,917	1,095	2,967	2,967	18,893	862	18,893	862	18,893	1,231	1,231

* Assessed Rentals.

APPENDIX VII.—continued.

RATEABLE VALUE OF SALMON FISHERIES, IN DISTRICTS WHERE BOARDS HAVE BEEN FORMED, FOR THE YEARS 1881 TO 1909 INCLUSIVE.

YEAR.	Devercn.		Don.		Doon.		Esk (North).		Esk (South).		Findhorn.		Forth.		Girvan.		Kyle of Sutherland.		Lochy.		Nairn.					
	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.				
Average for 5 years, 1881 to 1885 ...	2,477	3,247	—	—	—	6,211	—	2,431	—	3,617	—	3,868	—	571	—	2,496	—	1,658	—	—	—	—	—			
Average for 5 years, 1886 to 1890 ...	1,807	3,806	—	—	—	6,673	—	3,055	—	3,570	—	4,261	—	547	—	2,598	—	1,719	—	—	—	—	—			
1891 ...	2,047	3,646	—	—	6,476	—	3,012	—	3,541	—	3,890	—	542	—	2,640	—	1,895	—	—	—	—	—	1,543			
1892 ...	2,071	3,623	—	—	6,519	—	3,012	—	2,501	—	3,704	—	542	—	2,665	—	1,961	—	—	—	—	—	—	1,343		
1893 ...	2,073	3,964	—	—	6,609	—	3,012	—	3,491	—	3,765	—	554	—	2,613	—	1,961	—	—	—	—	—	—	1,343		
1894 ...	2,138	3,743	—	—	6,812	—	3,002	—	3,501	—	3,806	—	554	—	2,558	—	2,122	—	—	—	—	—	—	1,343		
1895 ...	2,383	3,583	3,711	—	6,812	—	6,645	3,037	3,501	3,507	3,786	544	544	544	2,611	2,637	2,122	2,012	—	—	—	—	—	1,341		
1896 ...	2,360	3,390	—	—	6,519	—	3,149	—	3,446	—	3,617	—	500	—	2,634	—	2,094	—	—	—	—	—	—	1,136		
1897 ...	2,469	3,383	—	—	6,540	—	3,149	—	3,436	—	3,616	—	524	—	2,731	—	2,115	—	—	—	—	—	—	1,135		
1898 ...	2,658	3,374	—	—	6,579	—	3,507	—	3,436	—	3,738	—	524	—	2,771	—	2,115	—	—	—	—	—	—	1,136		
1899 ...	2,979	3,430	—	—	6,523	—	3,424	—	3,436	—	3,792	—	524	—	2,838	—	2,030	—	—	—	—	—	—	1,136		
1900 ...	3,078	3,336	3,382	—	6,414	—	6,515	3,342	3,511	3,453	3,712	544	544	544	2,845	2,763	2,338	2,130	—	—	—	—	—	1,136		
1901 ...	3,186	3,691	—	473	6,510	—	3,492	—	3,527	—	3,925	—	514	—	2,890	—	2,992	—	—	—	—	—	—	—	1,136	
1902 ...	3,048	3,700	—	473	6,466	—	3,567	—	3,527	—	3,928	—	528	—	3,132	—	2,306	—	—	—	—	—	—	—	1,136	
1903 ...	3,105	3,646	—	486	6,494	—	3,552	—	3,587	—	3,731	—	553	—	2,923	—	2,300	—	—	—	—	—	—	—	1,139	
1904 ...	3,387	3,863	—	498	6,494	—	3,565	—	3,607	—	3,510	—	544	—	3,517	—	2,238	—	—	—	—	—	—	—	1,141	
1905 ...	3,369	4,153	3,810	485	6,489	—	6,490	3,553	3,661	3,581	3,721	549	537	549	3,515	3,415	2,231	2,413	—	—	—	—	—	—	1,154	
1906 ...	3,425	4,173	—	498	6,486	—	3,600	—	3,681	—	3,274	—	544	—	3,458	—	2,231	—	—	—	—	—	—	—	1,204	
*1907 ...	3,351	4,035	—	490	6,490	—	3,351	—	3,681	—	3,178	—	541	—	3,408	—	2,231	—	—	—	—	—	—	—	—	1,205
*1908 ...	3,381	3,945	—	511	6,474	—	3,674	—	3,661	—	3,569	—	533	—	3,333	—	2,880	—	—	—	—	—	—	—	—	1,205
*1909 ...	2,707	3,842	—	511	6,614	—	3,403	—	3,661	—	3,569	—	533	—	4,315	—	1,900	—	—	—	—	—	—	—	—	1,205

* Assessed Rentals.

APPENDIX VII.—continued.
RATEABLE VALUE OF SALMON FISHERIES IN DISTRICTS WHERE BOARDS HAVE BEEN FORMED, FOR THE YEARS 1881 TO 1909 INCLUSIVE.

YEAR.	Ness.		Nith.		Skye.		Spey.		Stinchar.		Tay.		Thurso.		Tweed.		Ugie.		Ythan.	
	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.
Average for 5 years, 1881 to 1885	£	3,093	£	520	£	-	£	9,165	£	-	£	19,596	£	-	£	13,600	£	335	£	746
Average for 5 years, 1886 to 1890	-	3,203	-	464	-	-	-	10,207	-	-	-	20,504	-	-	-	14,158	-	314	-	834
1891	3,366	-	443	-	-	-	9,669	-	-	-	17,820	-	-	-	14,414	-	-	-	-	931
1892	3,254	-	423	-	-	-	9,687	-	-	-	17,227	-	-	-	14,746	-	-	-	-	1,004
1893	3,253	-	756	-	-	-	9,687	-	-	-	19,008	-	-	-	14,573	-	-	-	-	1,004
1894	3,468	-	775	-	-	-	9,316	-	-	-	21,763	-	-	-	15,583	-	-	-	-	1,004
1895	3,209	3,310	771	633	-	-	9,588	9,589	-	-	19,587	19,079	-	-	15,803	15,023	402	366	-	1,024
1896	3,085	-	815	-	-	-	8,671	-	-	-	17,091	-	-	-	15,084	-	-	-	-	1,024
1897	3,503	-	780	-	-	-	9,638	-	-	-	17,211	-	-	-	15,444	-	-	-	-	1,294
1898	3,667	-	781	-	-	-	10,634	-	-	-	17,905	-	-	-	15,239	-	-	-	-	1,299
1899	3,510	-	775	-	-	-	11,683	-	-	-	21,048	-	-	-	15,000	-	-	-	-	1,299
1900	3,647	3,482	676	765	424	-	10,122	10,119	200	-	22,482	19,147	-	-	15,032	15,159	845	625	-	1,317
1901	3,582	-	654	-	540	-	8,608	-	400	-	22,549	-	-	-	15,005	-	-	-	-	1,398
1902	3,636	-	545	-	540	-	8,052	-	400	-	22,608	-	-	-	15,005	-	-	-	-	1,398
1903	3,516	-	564	-	540	-	8,147	-	400	-	22,648	-	-	-	15,338	-	-	-	-	1,389
1904	3,404	-	584	-	540	-	7,397	-	400	-	22,902	-	-	-	15,389	-	-	-	-	1,359
1905	3,646	3,556	583	583	540	540	8,365	8,113	400	400	23,069	22,794	-	-	15,450	15,247	778	809	-	1,369
1906	3,503	-	619	-	540	-	8,741	-	400	-	22,676	-	-	-	15,732	-	-	-	-	1,354
*1907	3,502	-	510	-	540	-	8,990	-	400	-	23,202	1,799	-	-	15,732	-	-	-	-	776
*1908	3,532	-	506	-	540	-	9,243	-	400	-	23,508	-	-	-	16,093	-	-	-	-	809
*1909	3,532	-	506	-	540	-	9,396	-	400	-	23,715	1,638	-	-	16,092	-	-	-	-	757

* Assessed Rentals.

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 (<i>Loch Hourn</i>),	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 (<i>Kinloch</i>),	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 (<i>Gairloch</i>),	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.
Beaully,	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 (<i>in Cantyre</i>),	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, Avenangeren, Strathgravat, North Lacastile, Scalladale and Mawrig (<i>East Harris</i>),	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 (<i>Island of Lews</i>),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Creran (<i>Loch Creran</i>),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Croe and Shiel (<i>Loch Duich</i>),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Dee (<i>Aberdeenshire</i>),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Dee (<i>Kirkcudbright</i>),	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 (<i>Isle of Bute</i>),	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. 21 to Feb. 4.	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 (<i>West Harris</i>),	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Findhorn,	From Aug. 27 to Feb. 10.	From Oct. 11 to Feb. 10.
Fleet (<i>Sutherlandshire</i>),	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Fleet (<i>Kirkcudbrightshire</i>),	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Forss,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 24.
Forth,	From Aug. 27 to Feb. 10.	From Oct. 16 to Jan. 14.
Fyne, Shira, and Aray (<i>Loch Fyne</i>),	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, 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. 11.
Helmsdale,	From Aug. 27 to Feb. 10.	From Oct. 1 to Jan. 10.
Hope and Polla or Strathbeg, Howmore,	From Aug. 27 to Feb. 10.	From Sept. 11 to Jan. 11.
Inchard,	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 (<i>in Jura</i>),	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 (<i>in Arran</i>),	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.
Kannaird,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Kilchoan or Inverie (<i>Loch Nevis</i>),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Kinloch (<i>Kyle of Tongue</i>),	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 Oct. 16 to Feb. 10.
Laggan and Sorn (<i>Island of Islay</i>),	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 (<i>Island of Mull</i>),	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 (<i>North Uist</i>),	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.
Naver and Borgie, <i>see</i> Halladale,		
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. 1.
Nith,	From Sept. 10 to Feb. 24.	From Nov. 15 to Feb. 24.
Orkney Islands (<i>River from Loch of Stenness, &c.</i>),	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Ormsary (<i>Loch Killisport</i>), Loch Head, and Stornoway (<i>Mull of Cantire</i>),	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.

Name of River.	Annual Close Time for Net-fishing.	Annual Close Time for Rod-fishing.
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.
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 (<i>River of Sandwater, &c.</i>),	From Sept. 10 to Feb. 24.	From Nov. 16 to Jan. 31.
Shiel (<i>Loch Shiel</i>),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Sligachan, Broadford, and Portree (<i>Isle of Skye</i>),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Snizort, Orley, Oze, and Drynoch (<i>Isle of Skye</i>),	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. 15 to Feb. 24.
Tay (except Earn),	From Aug. 21 to Feb. 4.	From Oct. 16 to Jan. 14.
Thurso,	From Aug. 27 to Feb. 10.	From Oct. 6 to Jan. 10.
Torridon, Balgay, and Shieldag,	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Tweed,	From Sept. 15 to Feb. 14.	From Dec. 1 to Jan. 31.
Ugie,	From Sept. 10 to Feb. 24.	From Nov. 1 to Feb. 24.
Ullapool (<i>Loch Broom</i>),	From Aug. 27 to Feb. 10.	From Nov. 1 to Feb. 10.
Urr,	From Sept. 10 to Feb. 24.	From Nov. 30 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, - -	Andrew Mackenzie, Esq., Dalmore House, Alness.	William J. Duncan, Solicitor, Dingwall.
Annan, - -	A. Johnstone Douglas, Esq., Comlongan Castle, Ruthwell.	John F. Cormack, Solicitor, Lockerbie.
Awe, - -	The Duke of Argyll, Inveraray Castle, Inveraray.	Alex. MacArthur, Solicitor, Oban.
Ayr, - -	Richard A. Oswald, Esq., of Auchincruive, Ayr.	Wilfrid C. Macrorie, Commercial Bank, Ayr.
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.	W. C. Walls, Solicitor, Montrose.
Broom, - -	W. Ewing-Gilmour, Esq., of Inverlael, per A. W. G. Aitken, Esq., S.S.C., Edinburgh.	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), -	Col. W. J. M. Baillie of Cally, Gatehouse.	W. Nicholson, Sheriff-Clerk, Kirkcudbright.
Deveron, - -	C. R. Sellar, Esq., Boddam, Peterhead.	James Morrison, Solicitor, Banff.
Don, - -	George Davidson, Esq., Wellwood, Aberdeen.	Alex. Duffus, Advocate, Aberdeen.
Doon, - -	Marquis of Ailsa, Culzean Castle, Maybole.	Wilfred C. Macrorie, Solicitor, Ayr.
Esk (North), -	The Rev. J. More Gordon of Charleton and Kinnaber, per H. More Gordon, Esq., Charleton, Montrose.	J. R. Findlay, Solicitor, Montrose.
Esk (South), -	William Douglas Johnston, Esq., Montrose.	D. S. Campbell, Solicitor, Montrose.
Findhorn, - -	R. C. Munro Ferguson, Esq., of Novar, M.P., per J. J. Meiklejohn, Esq., factor.	William Grant, National Bank Buildings, Forres.
Forth, - -	Mandatory of Commissioners of Woods and Forests.	Henry Robb, 11 Barnton Street, 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, Little Broom, -	Sir Charles Lockhart Ross, Bart., of Balnagowan.	John M'Crone, Solicitor, Dornoch.
	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, - -	Thomas Allison, Factor and Mandatory for the Trustees of the late Lord Abinger, Inverlochy Castle, Fort-William.	N. B. Mackenzie, Solicitor, Fort-William.

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.
Lossie, - -	The Duke of Richmond and Gordon, Gordon Castle, Fochabers, per George Muirhead, Esq., Commissioner.	T. R. Mackenzie, Solicitor, Elgin.
Nairn, - -	Brodie of Brodie, Brodie Castle, Forres.	H. T. Donaldson, Solicitor, Nairn.
Ness, - -	Captain E. C. Ellice of Glengarry, Fort-Augustus.	Anderson & Shaw, Solicitors, Inverness.
Nith, - -	John Henderson, Esq., Solicitor, Dumfries.	C. Steuart Phyn, Procurator-Fiscal, Dumfries.
S l i g a c h a n , Broadford, & Portree (Skye)	The Hon. Godfrey MacDonald, Portree.	Kenneth Macrae, Sheriff-Clerk, Portree.
Snizort, Orley, Oze, and Dry- nock (Skye),	The Hon. Godfrey MacDonald, Portree.	Kenneth Macrae, Sheriff-Clerk, Portree.
Spey, - -	The Duke of Richmond and Gordon, Gordon Castle, Fochabers, per George Muirhead, Esq., Commissioner.	T. R. Mackenzie, Solicitor, Elgin.
Stinchar, - -	The Earl of Stair, Lochinch, Wigtownshire.	Stair M'Harrie, Rephad, Stranraer.
Tay, - -	The Earl of Moray, Kinfauns Castle, Perth.	Condie, Mackenzie, & Co., Solicitors, Perth.
Thurso, - -	Peter Keith, Esq., mandatory for Sir J. G. Tollemache Sinclair, Bart., of Ulbster.	David Keith-Murray, Solicitor, Thurso.
Torridon, - -	C. R. Manners, Esq., C.E., 12 Lombard Street, Inverness.	Duncan Shaw, W.S., 15 High Street, Inverness.
Tweed (Police Committee of the Commis- sioners),	Sir Richard John Waldie-Griffith, Bart., of Hendersyde Park, Kelso.	David W. B. Tait, W.S., Kelso.
Ugie, - -	Lieut.-Col. Ferguson, of Pitfour, Mintlaw.	Robert Gray, Solicitor, Peterhead.
Ythan, - -	Earl of Errol, Slains Castle, Aberdeenshire.	D. M. A. Chalmers, Advocate, Aberdeen.

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, Naver, Borgia, and Kinloch (under the charge of his factor, Mr. John Morrison, Tongue); W. E. Gilmour, Esq., of Rosehall, etc., is proprietor of the rivers Dionard, Polla, Strathy, and Armadale, also in the north of Sutherland, and part owner, with the Duke of Sutherland, of the river Hope; Lord Lovat has practically sole right of fishing in the river Beaully (Mr. J. T. Garrioch, Beaully, factor); and the Countess of Cromartie is sole proprietrix of the district of the river Kinnaird (under the charge of her factor, Mr. George Wetherspoon, Cromartie Estate Office, Kildary).

Fishery Board for Scotland,
Edinburgh, April 1910.

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Being for the Year 1909.

IN THREE PARTS.

PART I.—GENERAL REPORT.

PART II.—REPORT ON SALMON FISHERIES.

PART III.—SCIENTIFIC INVESTIGATIONS.

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TWENTY-EIGHTH ANNUAL REPORT.

TO THE RIGHT HONOURABLE
LORD PENTLAND,

His Majesty's Secretary for Scotland.

OFFICE OF THE FISHERY BOARD
FOR SCOTLAND,
EDINBURGH, 15th December, 1910.

MAY IT PLEASE YOUR LORDSHIP,

In continuation of our Twenty-eighth Annual Report we have the honour to submit—

PART III.—SCIENTIFIC INVESTIGATIONS.

GENERAL STATEMENT.

This part of the Twenty-eighth Annual Report deals with the scientific investigations which have been conducted by the Board in 1909 in connection with the sea fisheries of Scotland, so far as they have been completed, by means of the Parliamentary Vote granted for the purpose.

The scientific work has, as usual, been carried out under the supervision of Dr. T. Wemyss Fulton, the Scientific Superintendent under the Board, the researches having been undertaken chiefly at the Board's Marine Laboratory, Bay of Nigg, Aberdeen, and partly in the Clyde, in connection more particularly with the herring fishery there. The hatchery for sea fishes is also situated at the Bay of Nigg, Aberdeen, and a statement of the work done at it during the year will be found below.

As was explained in previous Reports, the investigations into the condition of the fishing-grounds in the Moray Firth and Aberdeen Bay, which were conducted for a number of years by means of commercial steam trawlers engaged for the purpose, have not been continued, for reasons formerly stated; but the statistics of the catches of line fishermen within the Moray Firth are regularly collected, and the old trawling stations of the "Garland" are now being periodically examined with a beam-trawl by the "Goldseeker," and a report dealing with the investigations is in course of preparation.

In the Firth of Clyde, and in particular in Loch Fyne, the investigation into the herring fishery which has been in progress for the last few years was continued, and observations on the temperature of the water and the relative abundance of plankton were made as frequently and regularly as circumstances allowed. This subject is dealt with more fully below.

Among the researches in progress, but not yet completed, may be mentioned the relation between the salmon fishery and the herring fishery in Loch Fyne, the destruction of immature herrings by sea birds, and the reproduction of fishes.

THE HATCHING OF PLAICE.

During the season of 1909 the hatching-work was continued at the Bay of Nigg as in previous years. The methods employed have been fully described in some previous Reports, the essential features being the retention of the adult fishes in a large tidal pond, where the eggs are shed and fertilised in a natural way during the spawning season; the collection of the floating eggs from the pond and their transference to the hatching apparatus, where also the larval fishes are kept for some time after hatching occurs.

In the course of the previous autumn considerable numbers of live plaice were obtained by the "Goldseeker" in the Moray Firth and added to the stock already existing in the spawning pond. In consequence of the increased supply of spawners, the number of eggs collected in the course of the season was larger than in the previous year, amounting to about 19,749,000, as compared with 15,332,000 in 1908—the increase thus being about 4,417,000. The first eggs were collected on 21st January, and collections were made thereafter almost daily till 26th May, when a few thousands were obtained. The spawning in the pond thus extended over eighteen weeks, but, as usual, by far the greater proportion of the eggs were shed in March, and particularly just after the middle of the month. The number of eggs obtained in each month of the season, and the percentages, were as follows:—

	Number of Eggs.	Percentage.
January, - - - -	87,000	0·44
February, - - - -	2,890,000	14·6
March, - - - -	10,860,000	55·0
April, - - - -	5,387,000	27·2
May, - - - -	525,000	2·6

The number of dead eggs which were removed from the hatching apparatus was estimated at 3,134,000, or a little under 16 per cent., which is a lower proportion than usual. The specific gravity of the water during the season varied from 26·2 to 27·4, and the temperature from 2·6° C. to 11·4° C.

The number of living fry of the plaice obtained from the hatching apparatus in the course of the season was estimated at about 16,615,000, as compared with 12,296,000 in the previous year—an increase of 4,319,000. They were liberated in the sea in nine lots, between 25th February and 12th June. About half of them were

taken to the waters off the northern part of the coast of Aberdeenshire and liberated in the neighbourhood of Fraserburgh, while the remainder were liberated in the waters of Aberdeen Bay and off Girdleness. It is satisfactory to be able to state that the hatching operations are much appreciated by the fishermen along the coast of Aberdeenshire. Petitions on their behalf for the liberation of the fry have been received from many of the fishing villages from Roseheartly to Newburgh, and these have as far as possible been given effect to.

The number of the eggs of the plaice collected from the spawning pond, and the number of fry hatched out and liberated in the sea, since the hatchery was established at the Bay of Nigg, are as follows:—

Year.	Eggs Collected.	Fry Liberated.
1900	43,290,000	31,305,000
1901	65,377,000	51,800,000
1902	72,410,000	55,700,000
1903	65,940,000	53,600,000
1904	39,600,000	34,780,000
1905	40,110,000	24,500,000
1906	7,486,000	4,406,000
1907	1,627,000	1,282,000
1908	15,332,000	12,296,000
1909	19,749,000	16,615,000
	370,921,000	286,284,000

The decrease after 1905 was due to the fact that the services of steam trawlers in the Moray Firth and Aberdeen Bay was then abandoned, large supplies of living plaice for the spawning pond having previously been obtained in this way. It may be added that the cost of the fish-hatching work as carried on at the Bay of Nigg, in conjunction with the laboratory, is small, amounting to an estimated sum of about £80 per annum, representing the extra expenditure for coals, oils, &c., and for occasional assistance.

INVESTIGATIONS ON THE HERRING FISHERY OF THE FIRTH OF CLYDE.

Since the latter part of 1904 investigations have been carried on with reference to the herring fishery in the Firth of Clyde, and in Loch Fyne in particular, as far as the means at disposal allowed. These investigations were initiated in consequence of a failure of the fishery in Loch Fyne, a failure which unfortunately still continues. The following figures show the quantity of herrings taken in the loch during the last ten years:—

Year.	Herrings Caught.	Year.	Herrings Caught.
1900, - -	24,743 crans.	1905, - -	4,672 crans.
1901, - -	29,117 "	1906, - -	5,258 "
1902, - -	26,339 "	1907, - -	3,914 "
1903, - -	21,198 "	1908, - -	4,070 "
1904, - -	7,827 "	1909, - -	3,684 "

The statistics of the Loch Fyne herring fishery extend back to the year 1854, and only in one year in that period was the quantity of herrings caught less than in 1909, and then only by a few crans—namely, in 1873, when 3,648 crans were landed. The poor results of the fishing in recent years is not equalled in the history of the fishery, so far as known, for in the last great depression there were only three years—1872–1874—when the quantity was less than 10,000 crans. Towards the end of June last year there were indications that a considerable shoal of herrings had entered Lower Loch Fyne, and in the month of July a fair fishing was carried on—the aggregate catch for that month being 2,966 crans, as compared with 3,684 crans for the whole year. The herrings, however, did not penetrate far up the loch, and they very soon left it altogether.

Similar and apparently unaccountable fluctuations in the herring fishery, more especially in lochs or arms of the sea, are of not infrequent occurrence, and have been attributed to various causes; but no explanation that has yet been given can be regarded as altogether satisfactory. Variations in the temperature of the sea and in the quantity of floating food upon which the herring subsists are believed by many to be the principal factors in producing fluctuations in the fishery. The investigations now being made are designed to show whether or not this explanation is the right one. Periodic observations are taken of the temperature of the water and of the abundance of the floating herring-food, and these will be continued until the herrings have returned to Loch Fyne in something like their former abundance. There is no good reason to suppose that the present scarcity will not be followed by years of good fishing, such as have succeeded to the periods of depression in the past.

THE INFLUENCE OF TEMPERATURE ON THE DEVELOPMENT OF THE EGGS OF THE HERRING.

At the request of the Government of New Zealand, a series of experiments on the retardation of the development of the eggs of the herring has been carried on at the Marine Laboratory during the last two seasons. The object of the New Zealand Government is to ascertain whether it is possible to delay the development, and thus the hatching, of the ova of the herring for a period sufficiently prolonged to enable them to be carried to New Zealand and dealt with there—a period which is estimated at about 50 days. In last year's Report an account of the first series of experiments was given by Dr. H. C. Williamson, the general result being that it was shown to be possible to delay the development of the eggs for the period required, though the great proportion of them died at an earlier date. The main cause of the mortality was deficient aeration of the water, as it was difficult to secure a sufficient flow cooled to the necessary temperature. The further experiments which were made by Dr. Williamson are described in the present Report, other forms of apparatus having been made use of. The cooling of the water was successfully attained and a much more even temperature secured, but the difficulties of the aeration of the water were not overcome, and although a few of the eggs survived for a period of fifty days, none of them hatched. Check experiments with uncooled water showed that

the mortality was owing, not to the low temperature, but to deficient aeration. At the request of the New Zealand authorities, these experiments are being continued, and it is hoped that it will be possible to devise an apparatus which will enable the difficulties referred to to be surmounted.

THE FOOD OF THE HALIBUT.

An extensive research on the nature of the food of this important fish was made by Dr. Thomas Scott, who contributes a paper to the present Report setting forth the results of the investigation. The stomachs of 1076 halibut were examined, the fish ranging in length from 18 inches to five feet; they were caught at various parts of the North Sea and North Atlantic and landed at Aberdeen. About one-third of the stomachs, or nearly 34 per cent., were found to be empty, or contained food in such a condition that identification of the organisms composing it could not be made. A very considerable proportion of the food of the halibut was shown to consist of fishes, of which twenty species were determined, the most common being the haddock and the whiting, and it was found that the larger halibuts were more prone to a fish diet than the smaller ones. Crustaceans, and in particular the Norwegian lobster (*Nephrops*) and hermit crabs, were common in many of the stomachs examined, and cuttle-fishes of several species were not infrequent, but echinoderms were sparingly represented, and annelids hardly at all.

DISEASES OF FISHES.

The subject of the diseases to which fishes are liable is now receiving more attention than was the case previously. In the present Report, Dr. A. G. Anderson, now the Medical Officer of Health of Rochdale, describes a bacteriological investigation which he made of an outbreak of disease among the fishes at the Marine Laboratory. Some haddocks and whittings which were caught in the neighbourhood of a sewer were conveyed to the Laboratory to replenish the tanks, and a few of them were observed to have small ulcerations on the skin. Within a few days the healthy fish which were previously in the tank became affected in like manner, and shortly afterwards they all died. The outflow from those tanks was into the large pond, in which live plaice were contained, and later on a number of these fish became also affected and subsequently died. The bacteriological investigations made at Marischal College by Dr. Anderson revealed the presence of various bacteria, including bacillus coli communis, which made it probable that the fish had died from a form of septicæmic poisoning, possibly caused by infection from the sewage-borne micro-organisms. A few years ago a similar outbreak of disease was observed to have occurred among the fishes in the pond at the Marine Laboratory, Port Erin. It appears that marine fishes are not so susceptible to microbial attacks as are fresh-water fishes, and that amongst the former flat-fishes are less susceptible than round fishes, as haddocks and whittings. The evidence, moreover, indicates that fish do not suffer readily from

the ingestion of bacteria, nor from the presence of sewage in the water, so long as the gills are not clogged; but, on the other hand, such outbreaks of disease are of some significance to Health Authorities in whose sanitary areas sewage is being deposited in rivers, estuaries, or on the seashore.

ABNORMAL AND DISEASED CONDITIONS OF FISHES.

Dr. Williamson contributes a paper to this Report, in which he describes various abnormalities and diseased conditions which he has observed among fishes, such as tumours in the cod, the lemon dab, the viviparous blenny, and other forms, and also cases of hermaphroditism in the cod, a species in which that condition is not uncommon. He also describes and figures the larvæ of the angler (*Lophius*), and gives an account of its eggs and those of the halibut, the conger, and the tusk. The ripe egg of the conger has not yet been identified with certainty: the largest yolked eggs observed by Dr. Williamson were 0·6 millimetres in diameter, and were found in fishes captured at the end of October and the beginning of November. The same gentleman has also written a paper, illustrated with five plates, describing the larval stages of various species of crabs. The study of these larvæ is important with reference to the general question of development and the discrimination of the forms which go to make up the plankton. This paper is not included in the present Report, but is published separately as a Stationery Office publication.

PARASITES OF FISHES.

Several papers dealing with the parasites of fishes have appeared in previous Reports of the Board, and to the present one Dr. T. Scott contributes a description, illustrated with two plates, of four parasitic trematodes, one of which is now described for the first time. One of them was obtained from the gills of the gar-fish, and the others from the non-edible *Chimæra monstrosa*.

We have the honour to be,

Your Lordship's most obedient Servants,

ANGUS SUTHERLAND, *Chairman.*

D. CRAWFORD, *Deputy-Chairman.*

D'ARCY W. THOMPSON.

W. R. DUGUID.

L. MILLOY.

D. MEARNS.

H. WATSON.

DAVID T. JONES, *Secretary.*

SCIENTIFIC REPORTS.

I.—REPORT ON LARVAL AND LATER STAGES OF CERTAIN DECAPOD CRUSTACEA (WITH FIVE PLATES). By H. CHAS. WILLIAMSON, M.A., D.Sc., F.R.S.E., Marine Laboratory, Aberdeen.

Issued separately as Stationery Office Publication, price 2s. 3d.

II.—REPORT ON THE OPERATIONS AT THE MARINE FISH HATCHERY, BAY OF NIGG, ABERDEEN, IN 1909. By Dr. T. WEMYSS FULTON, F.R.S.E., Scientific Superintendent.

In the course of the autumn of 1908 several hundreds of live plaice were added to the stock of adults in the spawning-pond, the fish having been caught by the Fishery Investigation steamer *Goldseeker* in the Moray Firth and brought to Aberdeen. The mortality among these fishes, owing often to the rough passage from the fishing-grounds, was sometimes considerable after they had been placed in the pond, and, as the fact is not without importance with reference to the methods adopted in the "marking experiments" (to ascertain the migrations of fishes), it may be mentioned that of 193 placed in the pond on 12th September, 55 had died before the 29th of that month, and of 267 put in on 23rd October, 30 had succumbed by the next day, and other 36 within a week.

In consequence of the increased supplies of spawners, the number of eggs collected from the spawning-pond in the course of the season was larger than in the previous year, amounting to about 19,749,000, as compared with 15,332,000 in 1908, the increase thus being about 4,417,000.

The first eggs were collected on 21st January, which is about the usual time for them to appear, and collections were made thereafter almost daily until 26th May, when a few thousands were obtained. The spawning of the plaice thus extended over eighteen weeks, but, as usual, by far the greater proportion of the eggs were shed in March, and particularly just after the middle of the month. It will be observed from the appended table that the spawning was considerable at the end of February, when the temperature of the water was unusually high for the season, and that it was checked later when the temperature fell several degrees lower. The numbers of eggs obtained in each month of the season, and the percentages, are given in the subjoined table:—

Month.	Number of Eggs. Collected.	Per- centage.
January	87,000	0·44
February	2,890,000	14·6
March	10,860,000	55·0
April	5,387,000	27·2
May	525,000	2·6
	19,749,000	

The number of dead eggs which were removed from the hatching apparatus (including, however, the shells of those which had hatched) was estimated at 3,134,000, or a little under 16 per cent., which is, a very low

proportion, attributable for the most part to a fuller supply of water and better filtering arrangements, and to the utilisation of the filtered water again during the occurrence of storms, as described in last report.

The number of living fry obtained in the course of the season was estimated at about 16,615,000, as compared with 12,296,000 in the previous year. They were put out into the sea in nine lots, the first on the 25th February, and the last on the 12th June, as described in Table II. appended. About half of the fry were taken to the northern part of the coast of Aberdeenshire and liberated off Sandhaven, near Fraserburgh, Mr. W. J. Caird, of Sandhaven, kindly rendering much assistance in making the arrangements. The remainder were liberated off Aberdeen Bay and Girdleness.

The fishermen on the coast of Aberdeenshire have petitioned on several occasions for fry to be "planted" in the locality of their fishing grounds, requests of the kind having been received from many of the villages from Rosehearty to Cruden. Their plaice-fishing has recently been very much better than it was before, and they attribute the improvement to the planting of the fry along the coast during the last five or six years. In such cases it is not an easy matter to obtain convincing evidence, but inquiries at other parts of the coast show that the plaice-fishing had not improved in the same way at other localities, and from the results of the extensive experiments carried on for thirteen years in Lochfyne, and described in the Annual Report for 1907, it is quite likely the fishermen are right in their opinion, namely, that their increased catch of plaice is due to the operations of the hatchery.

The number of the eggs of the plaice collected from the spawning-pond, and the number of the fry hatched out and liberated in the sea, in the various years since the hatchery was established at the Bay of Nigg, are as follows:—

		Eggs Collected.	Fry Produced.
1900	.. ..	43,290,000	31,305,000
1901	.. ..	65,377,000	51,800,000
1902	.. ..	72,410,000	55,700,000
1903	.. ..	65,940,000	53,600,000
1904	.. ..	39,600,000	34,780,000
1905	.. ..	40,110,000	24,500,000
1906	.. ..	7,486,000	4,406,000
1907	.. ..	1,627,000	1,282,000
1908	.. ..	15,332,000	12,296,000
1909	.. ..	19,749,000	16,615,000
		370,921,000	286,284,000

It will be seen that, although the numbers in the last two years are greater than they were in 1906 and 1907, they fall far short of what they were a few years earlier, when large supplies of adult fish were being obtained by means of the trawlers whose services were secured for work in the Moray Firth.

It has to be added that the cost of the fish-hatching work as carried on at the Bay of Nigg, in combination with the Marine Laboratory, is comparatively small, amounting to about £80 per annum, so far as it can be estimated, the amount representing extra coals, oils, etc., food for the fishes, and occasional assistance to the attendant.

The appended Tables show the progress at the hatchery from day to day; the temperature and specific gravity of the water on the beach, in the pond, and in the hatching apparatus; and also the particulars referring to the liberation of the fry:—

TABLE I.—Showing the Daily Progress at the Hatchery, and the Temperature and Specific Gravity of the Water.

DATE.	Eggs Collected.	Dead Eggs Removed.	BEACH.		POND.		HATCH-ERY.
			Temp. °C.	Specific Gravity.	Temp. °C.	Specific Gravity.	Temp. °C.
1909.							
Jan. 21	} 10,000 {	..	6·6	27·4	4·0	27·4	6·0
" 22		..	6·6	27·4	3·8	27·4	6·0
" 23		7·0	27·4	4·2	27·4	5·6
" 25	10,000	..	5·0	27·4	2·8	27·4	3·4
" 26	27,000	..	5·4	27·2	3·0	27·2	3·8
" 27	10,000	..	4·8	27·2	2·6	27·0	3·8
" 28	10,000	..	5·4	27·2	2·6	27·2	3·2
" 29	20,000	..	5·4	27·2	2·4	27·2	4·0
" 30	..	..	4·2	27·4	1·5	27·4	3·0
Feb. 1	40,000	..	4·8	27·4	1·6	27·2	2·6
" 2	10,000	..	5·0	27·2	2·0	27·2	2·8
" 3	..	..	5·2	27·2	4·2	27·2	5·0
" 4	10,000	20,000	5·0	27·4	3·2	27·4	4·6
" 5	13,000	..	5·2	27·4	3·2	27·2	4·4
" 6	10,000	..	6·0	27·2	2·8	27·2	4·0
" 8	30,000	..	6·0	27·4	4·2	27·4	4·8
" 9	10,000	..	6·6	27·2	4·2	27·4	5·0
" 10	10,000	..	6·0	27·2	4·0	27·2	5·0
" 11	27,000	20,000	6·2	27·4	4·6	27·4	5·6
" 12	20,000	..	5·4	27·2	4·2	27·2	5·0
" 13	10,000	..	6·4	27·4	5·0	27·4	6·8
" 15	20,000	..	5·8	27·2	5·4	27·2	6·0
" 16	20,000	..	6·6	27·4	6·0	27·4	6·6
" 17	160,000	..	7·0	27·4	6·6	27·4	6·8
" 18	100,000	..	8·0	27·4	7·0	27·4	6·8
" 19	120,000	..	7·6	27·4	7·0	27·4	6·8
" 20	160,000	80,000	7·8	27·4	6·8	27·4	7·0
" 22	240,000	..	7·0	27·4	7·0	27·2	7·2
" 23	240,000	..	7·2	27·4	6·6	27·4	7·0
" 24	320,000	..	7·0	27·4	5·6	27·4	6·8
" 25	400,000	100,000	6·6	27·4	5·6	27·4	7·0
" 26	440,000	..	7·4	27·4	6·0	27·4	7·2
" 27	480,000	..	6·2	27·4	5·4	27·4	7·0
Mar. 1	480,000	..	6·4	27·4	4·6	27·4	6·8
" 2	400,000	200,000	6·2	27·4	4·6	27·2	7·0
" 3	480,000	..	6·0	27·4	3·0	27·2	7·0
" 4	360,000	..	5·8	27·4	4·0	27·2	6·6
" 5	240,000	..	5·0	27·4	4·0	27·2	6·6
" 6	280,000	..	5·6	27·2	4·2	27·2	4·2
" 8	360,000	120,000	4·0	27·2	3·8	27·2	6·0
" 9	320,000	..	5·0	26·8	2·8	27·2	3·4
" 10	320,000	..	4·0	26·6	2·6	27·0	3·0
" 11	320,000	80,000	4·8	26·6	3·6	27·0	3·8
" 12	320,000	..	5·2	27·4	3·6	27·0	4·6
" 13	480,000	..	4·2	27·4	3·2	27·2	4·0
" 15	600,000	100,000	4·2	27·0	3·2	27·2	3·4

TABLE I.—continued.

DATE.	Eggs Collected.	Dead Eggs Removed.	BEACH.		POND.		HATCH-ERY.
			Temp. °C.	Specific Gravity.	Temp. °C.	Specific Gravity.	Temp. °C.
1909.							
Mar. 16	480,000	160,000	3·6	27·2	2·8	27·2	3·6
" 17	480,000	..	3·4	27·2	2·4	27·2	3·6
" 18	400,000	120,000	4·8	27·4	3·2	27·2	4·2
" 19	480,000	..	4·8	27·4	4·0	27·2	5·0
" 20	480,000	..	4·6	27·2	3·8	27·2	5·0
" 22	400,000	187,000	4·2	27·4	4·0	27·2	5·0
" 23	440,000	..	4·6	27·4	3·2	27·4	4·8
" 24	400,000	..	5·0	27·4	4·0	27·4	5·0
" 25	480,000	120,000	6·0	27·2	4·0	27·2	5·2
" 26	360,000	..	6·0	27·2	4·4	27·4	5·2
" 27	320,000	120,000	5·6	27·4	4·0	27·4	4·8
" 29	420,000	..	6·0	27·2	4·2	27·0	4·8
" 30	440,000	200,000	6·6	27·0	4·6	27·0	5·0
" 31	320,000	..	5·0	27·2	3·8	27·2	5·0
April 1	360,000	..	6·0	27·2	4·0	27·2	5·0
" 2	280,000	180,000	6·6	27·0	3·6	27·0	4·6
" 3	320,000	..	6·8	27·0	4·4	26·8	5·0
" 5	320,000	120,000	6·8	27·2	4·0	27·0	5·2
" 6	400,000	160,000	7·6	27·0	5·2	27·0	5·8
" 7	280,000	..	6·6	27·2	4·6	27·2	5·8
" 8	240,000	..	7·0	27·4	5·0	27·2	5·8
" 9	240,000	107,000	6·4	27·4	4·6	27·2	6·6
" 10	260,000	..	7·0	27·2	5·6	27·4	6·6
" 12	240,000	120,000	6·6	27·0	5·4	27·2	6·4
" 13	240,000	160,000	8·0	26·8	5·4	27·0	6·2
" 14	200,000	..	7·6	27·2	4·8	27·0	6·8
" 15	180,000	80,000	8·0	27·2	4·8	27·2	6·0
" 16	160,000	..	6·6	27·4	6·0	27·0	7·0
" 17	180,000	80,000	7·0	27·4	6·0	26·8	7·8
" 19	160,000	..	8·0	27·4	5·0	27·2	6·8
" 20	160,000	..	7·6	27·2	5·0	27·4	6·0
" 21	160,000	100,000	7·4	27·2	5·0	27·4	6·0
" 22	160,000	..	6·2	27·0	7·0	27·0	6·4
" 23	160,000	120,000	7·0	26·8	7·8	27·0	8·0
" 24	107,000	..	5·8	27·0	7·0	27·0	8·0
" 26	200,000	80,000	5·8	27·0	8·4	27·0	7·0
" 27	160,000	40,000	6·0	26·8	8·0	26·8	6·4
" 28	60,000	40,000	6·2	27·0	7·6	26·4	6·4
" 29	80,000	..	6·4	27·2	7·4	26·4	6·2
" 30	80,000	..	5·4	27·2	7·4	26·2	6·0
May 1	40,000	..	5·8	27·2	6·6	26·8	5·0
" 3	..	..	6·2	27·2	7·0	27·2	5·4
" 4	120,000	..	7·4	27·2	7·2	27·2	7·4
" 5	40,000	..	6·8	27·2	7·0	27·2	7·0
" 6	40,000	80,000	7·2	27·4	7·4	27·2	7·2
" 7	40,000	..	8·2	26·8	10·0	27·0	9·8
" 8	40,000	..	9·0	27·0	9·8	27·0	9·6

TABLE I.—continued.

DATE.	Eggs Collected.	Dead Eggs Removed.	BEACH.		POND.		HATCH-ERY.
			Temp. °C.	Specific Gravity.	Temp. °C.	Specific Gravity.	Temp. °C.
1909.							
May 10	20,000	..	8·8	26·8	9·6	26·8	8·2
" 11	20,000	20,000	9·0	24·0	10·0	27·0	9·0
" 12	5,000	..	8·6	25·4	9·6	26·4	8·4
" 13	..	..	8·0	26·0	9·0	27·0	7·0
" 14	40,000	..	6·6	26·6	8·2	27·0	6·6
" 15	20,000	..	6·6	27·2	7·6	27·0	6·2
" 17	20,000	5,000	7·8	27·0	8·6	27·0	7·4
" 18	20,000	..	7·0	27·2	8·8	27·0	7·8
" 19	10,000	..	7·4	27·2	9·0	27·0	8·2
" 20	15,000	5,000	8·4	27·0	9·0	27·0	8·8
" 21	10,000	..	8·4	27·2	9·4	27·0	9·2
" 22	..	..	10·0	27·2	10·8	27·0	10·8
" 24	10,000	10,000	10·4	26·8	12·2	27·2	11·4
" 25	5,000	..	8·4	26·8	11·8	26·8	10·4
" 26	10,000	..	8·4	27·0	11·2	26·8	9·8
" 27	..	..	8·4	27·4	11·2	27·2	9·0

TABLE II.—Showing Particulars in connection with the Distribution of Fry.

Date.	LOCALITY.	Depth. Fms.	Surface Temperature of Sea. ° F.	Specific Gravity.	WEATHER.	No. of Fry.
1909 Feb. 25	About 2 miles off Girdleness.	16	39·2	27·2	—	480,000
Mar. 5	About 2½ miles off Girdleness.	16	42·8	27·4	—	1,520,000
" 22	About 3 miles off Sandhaven, near Fraserburgh.	22	44·6	27·2	Fine; wind N.W.	3,800,000
Apr. 6	About 3 miles off Sandhaven, near Fraserburgh.	20	43·0	27·0	Fine; wind S.E.	4,095,000
" 27	About 1¾ miles east of Girdleness.	14	43·0	26·8	Fine; wind N.E.	2,200,000
May 5	About 1¾ miles east of Girdleness.	14	44·0	27·0	Fine; wind S.E.	1,600,000
" 14	About 1¼ miles off Aberdeen Bay.	14	43·9	26·6	Showery; wind N.W.	1,600,000
" 22	About 1 mile off Aberdeen Bay.	12	50·0	27·0	Fine; wind S.	800,000
June 12	About 1½ miles off Aberdeen Bay.	16	53·6	26·6	Fine; wind N.E.	520,000

III.—EXPERIMENT IN RETARDING THE DEVELOPMENT OF THE EGGS OF THE HERRING. By H. CHAS. WILLIAMSON, M.A., D.Sc., F.R.S.E., Marine Laboratory, Aberdeen.

In the spring of 1908 I carried out some experiments on the retardation of the eggs of the herring.* A certain amount of success was achieved in prolonging the period of incubation to 50 days. At the request of the Government of New Zealand, the experiment has been continued this spring, unfortunately without success.

On the previous occasion the difficulties which were specially met with were:—(1) To cool the water and keep it at a steady temperature; (2) to aerate the eggs properly.

This year these difficulties remained to be solved. The cooling of the water was successfully attained by means of a series of iron pipes which were covered with ice. A much more even temperature was in this way obtained. The quantity of water which was lowered to the desired temperature was small, and averaged about one pint in a minute.

The second problem of the aeration of the eggs seemed to be solved by the adoption of a mechanical system, which is shown in the accompanying sketch, viz., Incubating tank. (Plate I.)

The apparatus consisted of a galvanised sheet-steel box T, measuring 35 inches in length, 16 inches in breadth, and 15 inches in depth. Inside this tank there were two revolving frames, A and B. Four glass plates bearing herring eggs were fixed on the outside surfaces of A, while five plates were set in grooves inside B. The frames revolved in consequence of the motion imparted to them by the little water-wheel. The frames were always entirely covered with water.

Two glass plates stood on edge at the lower end of the tank. The tank contained 30 gallons of water.

The tank was surrounded with crushed ice.

The water, already cooled, flowed in on to the surface at one end, and found exit from the bottom of the other end. The quantity of water varied slightly from time to time, as will be seen from the table, p. 17. It averaged one pint in a minute. For a short time during the day the flow was often increased to a pint in 30 seconds. The water never ceased running except for a few minutes at a time.

Air was blown into the water on March 31, and thereafter till the end of the experiment.

The water-wheel rotated slowly. The frame A required about 6 minutes and the frame B 10 to 15 minutes to make a complete revolution.

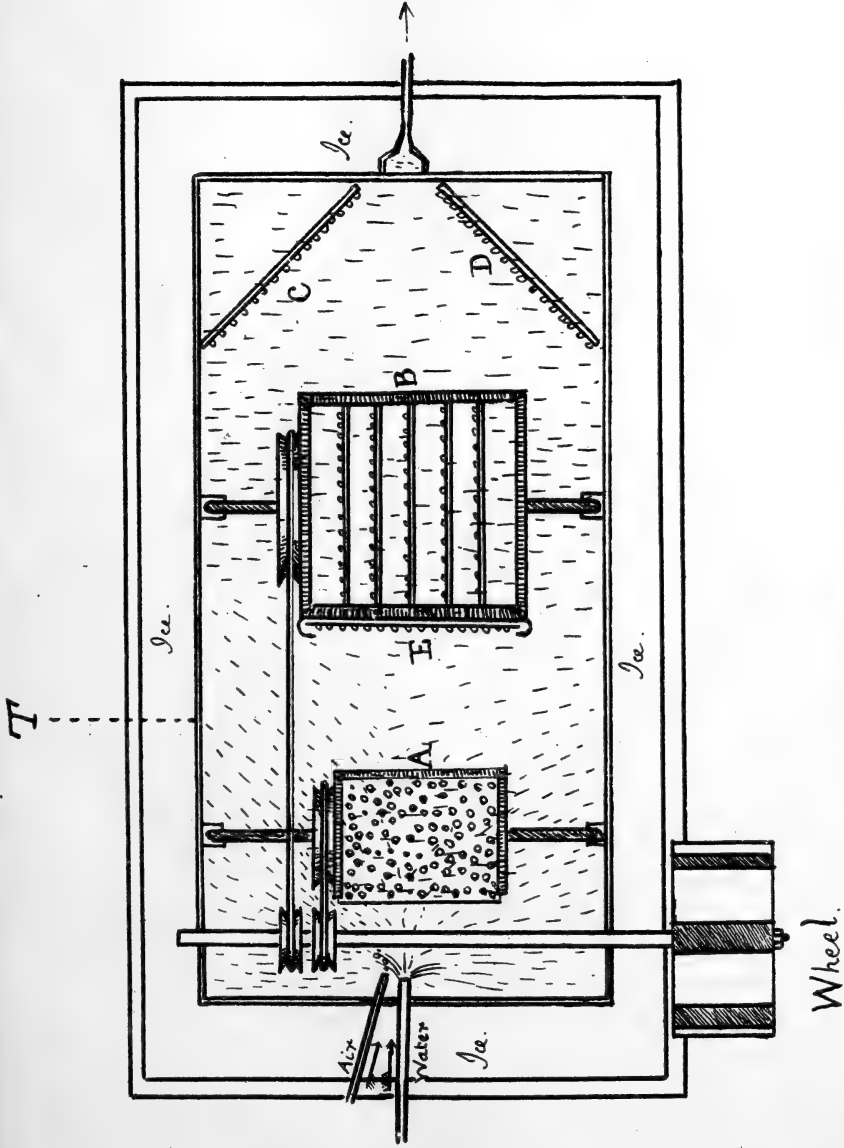
As on the former occasion, the spawn was divided into two portions, part being kept in uncooled water, while the remainder was treated with the cooled water. The temperature of the water is given in the following Tables.

The temperatures were read by myself and by the attendants. Readings were taken during both day and night. These are given in Centigrade. The range in Fahrenheit is deduced† from the highest and lowest Centigrade readings up till March 21st. From March 22nd onwards a Fahrenheit maximum and minimum thermometer was also employed. It was set during the forenoon usually. The readings given cover, therefore, portions of two days, whereas the Centigrade readings refer to one date.

The water before being cooled was filtered through sand.

* "Experiments to show the influence of Cold in Retarding the Development of the Eggs of the Herring (*Clupea harengus*), etc." *Twenty-seventh Report of the Fishery Board for Scotland for 1908*. 1910, p. 100.

† A table of Fahrenheit equivalents to Centigrade readings, drawn up by Dr. T. Scott, was employed for this purpose.



SCALE—1 inch=1 inch.

INCUBATING TANK.

Wheel.

TEMPERATURE OF THE UNCOOLED WATER.

DATE. 1910.	Temperature Observations. ° C.		Tempera- ture. ° F.	DATE. 1910.	Temperature Observations. ° C.		Tempera- ture. ° F.
	Plates.				Plates.		
	7, 8, 9.	12, 13, 16, 18, 20.			7, 8, 9, 12, 13, 16, 18, 20.		
Feb. 25	**3·3, 3·6		37·9, 38·5	Mar. 16	4·7		40·5
" 26	2·6	3·5, 3	36·7-38·3	" 17	5·6		42·1
" 27	2·8		37	" 18	..		..
" 28	3·2		37·8	" 19	..		..
Mar. 1	3·1		37·6	" 20	4·9		40·8
" 2	4·3		39·7	" 21	5·8		42·4
" 3	5·4		41·7	" 22	..		..
" 4	5·2		41·4	" 23	5·6		42
" 5	4·7		40·5	" 24	6·1		43
" 6	4·8		40·6	" 25	6·7, 5·6		44, 42
" 7	5·2		41·4	" 26	6·7, 5·6		44, 42
" 8	5·3		41·5	" 27	6·7, 5·0		44, 41
" 9	6		42·8	" 28	6·7, 5·0		44, 41
" 10	5·4		41·7	" 29	6·7, 5·0		44, 41
" 11	5·1		41·2	" 30	7·2, 5·0		45, 41
" 12	4·8		40·6	" 31	8·4, 5·6		47, 42
" 13	..		..	Apr. 1	7·8, 6·1		46, 43
" 14	3·7		38·7	" 2-4	..		..
" 15	4·4		39·9	" 5	8·4, 5·0		47, 41

** Air about freezing point.

TEMPERATURE OF THE COOLED WATER.

DATE. 1910.	Temperature Observations.—° C.				Range of Temperature. ° F.	Average Quantity of Running Water supplied† during the 24 hours.
	Plates.					
	1, 2, 3, 4	6, 10.	11.	14, 15, 17, 19.		
Feb. 24	**	..	..	..	..	..
" 25	3·6	*3·3, 3·6	*3·3, 3·6	..	37·9, 38·5	..
" 26	2·6		2·6	3·5, 3	36·7, 38·3	..
" 27	2·8, †1·8, 2·0		2·8		35·2, 37	..
" 28	2, 2·4 2·6		3·2, †2·4, 2·6		35·6, 37·8	..
Mar. 1	2·4, 2·5				36·3, 36·5	..
" 2	2·6, 2·0, 1·7				35·1, 36·7	..
" 3	2·6, 2·5, 2, 1·9, 2·0				35·4, 36·7	..
" 4	1·0, 1·0, 1·3, 1·3, 1·4				33·8, 34·5	About 30 secs.
" 5	1·4, 1·3, 1·3, 0·6, 1·2				33·1, 34·5	40 "
" 6	1·0, 1·1, 1·3, 1·2, 1·4, 1·4				33·8, 34·5	52 "
" 7	2, 1·4, 1·3, 1·1, 1·2, 0·6				33·1, 35·6	73 "
" 8	1·6, 0·8, 0·8, 1·0, 1·8, 1·5, 0·5				32·9, 35·2	70 "
" 9	0·6, 0·6, 1·0, 0·8, 0·7, 0·8, 0·6, 0·4				32·7, 33·8	87 "
" 10	1·4, 1·2, 0·8, 0·7, 0·9, 0·6, 1·1, 1·0, 0·8				33·1, 34·5	60 "

** Weather cold ; sleet.

* Air about freezing point.

† First introduction into cooled water.

‡ The amount of running water is indicated by the time (seconds) required to fill a one-pint measure (= .6 litre).

TEMPERATURE OF THE COOLED WATER—*continued.*

DATE. 1910.	Temperature Observations.—° C.	Range of Temperature. F.	Average Quantity of Running Water supplied‡ during the 24 hours.
Mar. 11	0.5, 0.4, 0.6, 1.0, 1.0, 0.2	32.4, 33.8	68 secs.
" 12	0.4, 0.4, 0.3, 0.5, 0.5, 0.8, 0.8	32.5, 33.4	58 "
" 13	0.6, 0.8, 0.7, 0.7	33.1, 33.4	57 "
" 14	0.6, 0.6, 0.6, 0.9, 0.7, 0.6	33.1, 33.6	59 "
" 15	0.6, 0.7, 0.7, 0.7, 1.0, 1.2, 1.1, 1.6	33.1, 34.9	52 "
" 16	1.9, 1.3, 1.4, 1.3, 0.9, 0.8, 0.7	33.3, 35.4	62 "
" 17	1.0, 0.9, 1.0, 0.7, 0.5, 0.6	32.9, 33.8	60 "
" 18	0.7, 0.7, 0.6, 0.8, 1.0, 0.7	33.1, 33.8	56 "
" 19	0.5, 0.5, 0.6	32.9, 33.1	65 "
" 20	1.2, 1.0, 0.9, 1.0, 1.0	33.6, 34.2	57 "
" 21	0.9, 0.8, 1.1, 1.2, 0.6	33.1, 34.2	58 "
" 22	1.0, 0.9, 1.1, 1.2, 1.0, 1.0, 0.9, 0.6	33, 35	59 "
" 23	0.7, 0.6, 0.7, 0.9, 0.9	33, 34	47 "
" 24	1.0, 1.2, 1.2, 1.2, 1.2, 0.9, 0.8	33, 34	58 "
" 25	0.6, 0.8, 1.0, 0.7	33, 34	66 "
" 26	0.7, 0.6, 0.7, 0.8, 0.9, 0.6	33, 33.5	58 "
" 27	0.8, 0.6, 1.0, 0.7, 0.6	33, 33.5	59 "
" 28	1.0, 0.5, 0.8, 1.0, 0.9	33, 34	60 "
" 29	0.6, 0.6, 1.0, 1.0, 1.0, 0.8	33, 33.5	61 "
" 30	0.5, 0.6, 0.6, 0.6, 0.6, 0.9, 1.0, 1.2, 1.0	33, 34	53 "
" 31	1.5, 1.8, 1.8, 1.9, 0.9	33.5, 35.5	58 "
April 1	0.6, 0.5, 0.6, 0.6, 0.7	33, 35	60 "
" 2	0.6, 0.6, 0.4	33, 33.5	60 "
" 3	0.4, 0.6, 0.9, 0.8	32.5, 33.5	54 "
" 4	1.0, 1.0, 0.8, 0.8, 0.6, 1.0, 0.8, 0.6	33, 34	52 "
" 5	0.8, 0.6, 0.6, 1.0, 1.0, 1.0, 0.9	33, 34	56 "
" 6	1.0, 1.0, 1.0, 1.2	33, 34.2	54 "
" 7	0.6, 0.6, 1.0, 1.2	33, 34	47 "
" 8	2.2, 2.3, 1.6, 1.0	33.5, 36	46 "
" 9	0.8, 1.2, 1.2, 1.0	33.5, 34	44 "
" 10	2.6, 1.2, 1.0, 1.0, 1.3, 1.2, 1.0, 0.8	33.5, 36.2	44 "
" 11	0.8, 0.9, 0.8, 1.2	33, 34	46 "
" 12	0.8, 0.8, 0.6, 0.6, 0.9, 1.2, 1.0	33, 34	46 "
" 13	1.2, 1.0	33, 34	51 "
" 14	0.8, 1.2	33, 34	47 "
" 15	0.6, 0.7, 0.8	33, 34	54 "
" 16	0.8, 0.6	33, 33.5	43 "
" 17	2.0	33, 36	30 "
" 18	3.6	36, 39	30 "
" 19	4.9	39, 41	30 "
" 20	5.7	41, 44	30 "
" 21	..	41, 42	30 "

‡ The amount of running water is indicated by the time (seconds) required to fill a one-pint measure (= .6 litre).

Although one or two of the eggs remained alive for a period of 50 days, none hatched. They showed a good appearance a few days after they were spawned, but they died off gradually.

Now this great death-rate occurred in the uncooled eggs as well as with the cooled. Some of the uncooled eggs hatched out.

The death of the eggs was not due, in my opinion, to any great extent to deficiency in the spawn itself. There are no doubt the risks of non-fertilization and slight injury which the eggs may receive when the spawn is being pressed from the fish. If the roe is quite ripe the pressure required to expel it is very slight. The extent to which these contingencies affect the eggs is not known.

Very few of the eggs escaped fertilization, if the swelling-out of the zona to form a peri-vitelline space is to be regarded as a sign that fertilization has taken place.

It is evident, however, that if there is only one micropyle by which the sperm can enter the egg, the mode in which the eggs are obtained from the fish would almost of necessity preclude a quantity of the eggs from being fertilized. The eggs flow out in a continuous ribbon, *i.e.*, each egg is in contact with an egg before and with one behind. They fall immediately on to a glass plate and adhere to it. It does not seem likely that the sperm will be able to penetrate the egg at any of its planes of contact with other eggs, or with the glass. It would follow, then, that there are several points at which the sperm may enter, or the eggs run a risk of not being fertilized. According to Jousset de Bellesme, "the robustness of an organism would depend in great measure on the number of fecundating elements which entered the egg."

In my previous paper I referred to the presence of crystals inside the zona, of the cooled eggs especially. I regarded these crystals as indicating an insufficient aeration. They are evidently excretory products which are not being properly expelled.

The crystals were prevalent during the present experiment, but they were not found in all the cooled eggs.

The death of the eggs may perhaps be ascribed in part to deficient aeration.

The uncooled eggs were in a large tank containing a sufficient supply of water. But the crowded condition of the eggs probably required some sort of strenuous movement of the plates in order to secure a continual change of the water in contact with the ova.

In the case of the cooled eggs, however, I think that neither the amount of running water nor the movement of the revolving frames was much at fault. I have no doubt that a larger current of water, and possibly a quicker movement, would be an advantage from the point of view of aeration. Death there, however, was, in my opinion, mainly due to too low a temperature. The development of the eggs was apparently arrested for a time.

May a slightly deficient aeration inhibit development without killing the egg?

It is probably the case that as the embryo grows an increased aeration may become necessary.

RECOMMENDATIONS.

I think that it would be advisable to get the eggs, as soon as possible after spawning, into running water, or water kept in motion. The eggs are so crowded together on the plates that injury is almost certain to result from leaving the water quiescent.

During the period of incubation I believe a mechanical aeration is necessary, unless a strong current of water be available. Where the quantity of water is limited, as in the case of cooled water, mechanical aeration seems necessary.

There appears to be a risk of retarding the eggs too much by exposing them to a very low temperature.

The tank in which the eggs are kept should not be in direct contact with ice.

THE SPAWN.

The methods adopted for obtaining the eggs of the herring were similar to those of February 1908. I shall give a short description of each lot of eggs, and shall indicate their treatment and history.

Three lots of spawn were secured. The eggs were attached to glass plates.

The first lot, consisting of Plates 1-4, was obtained at Anstruther on February 24th, 1910. The herrings had been captured in anchored nets shot close to the harbour. The milt was coherent, and it was taken from both live and dead males. Plates 1, 2, and 4 were filled with eggs from a live female. Plate 3 received the eggs that were pressed out of a dead female. The plates were kept till next day in a herring-barrel filled with water. The water of the harbour was very dirty, and in consequence the eggs received a coating of fine sand. The spawn arrived at Aberdeen on the evening of the 25th. It was transferred to a tank (No. 2) supplied with running filtered water. Two days later the plates were put into the frame A in the cooled water. At this time the eggs looked alright, but a few were dead. Eleven days after fertilization the eggs were in the stage of the closure of the blastopore. I found no crystals in the eggs. Three days later, however, some crystals were observed. At 32 days the egg examined showed an embryo, the tail of which almost reached the head. No crystals were made out. Two days later the plates were not looking well, and on the 37th day the dead eggs were very noticeable. At 46 days some live eggs were almost ready to hatch, and they showed no crystals inside the zona. On the following day a sample which was examined consisted almost entirely of dead eggs; some had died quite recently: they were still translucent.

On the 50th day the plates were removed to uncooled water. Only one live egg was found. Some of the eggs had advanced embryos. Some of the more recently dead eggs were next the glass and protected by an outer layer of eggs. The live egg, which was about ready to hatch, lived till the 58th day, but it was found dead unhatched on the 61st day. The eggs had died off steadily during the period of incubation.

SECOND LOT OF SPAWN.

The second lot of spawn was procured on 25th February from herrings which had been brought ashore in a barrel, and also from some herrings which were taken from the hold of a fishing-boat. The females were all dead; one male was alive.

Plates 6, 7, 8 were filled with spawn from the herrings of the shot. Plates 10 and 11 received the ova from the herrings brought in the barrel. They arrived at Aberdeen on the evening of the 25th and were put into tank No. 2.

Two days later Plates 6 and 10 were transferred to frame B in cooled water. The eggs looked well; a good deal of sand was present about the eggs. They showed a large blastodisc. Some of the eggs had not expanded to form a peri-vitelline space.

The next day Plate 11 was put in the cooled water. It was placed on edge in the bottom of the tank of cooled water, *e.g.*, C and D in sketch. There were some unfertilized eggs on this plate. They were small, slightly opaquish, and showed no peri-vitelline space. An irregular disorganised blastodisc was present in some cases. The fertilized eggs looked very well; they were very clean.

At 9 and 10 days after fertilization Plates 6, 10, and 11 showed a fair sprinkling of dead eggs. The live eggs were at the stage of the closure of the blastopore. There were crystals on the inside of the zona of both live and dead eggs.

On the 21st day a good proportion of the eggs was dead. Two live eggs on Plate 11 were in stages where (a) the blastopore was closed, or (b) the tail of the embryo nearly reached the head. Eggs of a similar stage of development had been found 12 days previously. During that period, *viz.*, from March 6th to 18th, the temperature of the water was very low, often

below 1°C. It would seem in this case as if development was practically stopped at this temperature. There were lots of crystals in both live and dead eggs. Some of the eggs on Plate 6 looked very well. The zona was well distended. In the furthest advanced larva of Plate 11 no pulsation of the heart was detected.

At 52 days the eggs of Plate 11 all appeared to be dead. Some had died at the stage of the closure of the blastopore, although some had apparently died in the disc stage. I saw no embryo with pigmented eyes. The crystals were numerous inside the eggs. The eggs which were arranged singly, or in little groups of two or five, separate from other eggs, had died early. The eggs which had developed furthest were those that were shielded by other eggs. This seems to indicate that cold had been the cause of death. I did not see a live egg.

53 days.—Plates 6 and 10 had no live egg. What embryos were visible were in the stages (a) in which the blastopore has just closed, and (b) where the tail of the embryo reaches nearly to the head. None seemed to have passed the latter stage. Where the eggs are in a single layer there are many empty shells; where they are two or more layers thick, dead embryos are still present in the inside layers. Plate 6 had comparatively few eggs.

No fry hatched from Plates 6, 10, 11.

Plates 7 and 8.

On February 28, Plates 7 and 8 were put on the outside of a cubical wooden frame which was floating in tank No. 2. The frame was quite free to move about.

Eleven days after fertilization the eggs of one of the plates were in good condition, in the stage where the tail of embryo nearly reached the head. The embryo moved; the heart was beating. I could see no crystals in the eggs. Some of the eggs were dead, but they did not appear to be numerous. On the 25th day some fry were observed in tank No. 2.

26 days.—The most of the eggs were dead and covered with fungus. Some eggs had hatched out, and a few live eggs were ready to hatch. Most of the eggs seemed to have died after the blastopore had closed.

Plate 9.

This plate carried ova which were not perfectly ripe. The spawn ran out on pressure, but it was not perfectly translucent. The majority did not swell up, and did not stick well to the plate. On February 28 it was put into a metal box supplied with running unfiltered water. At that date only a few eggs remained attached. They were in good condition. One or two dead eggs were present. On the 25th day the plate was found to be covered with a thick layer of mud. Most of its small quantity of eggs was alive. The embryos were advanced; some were ready to hatch. None had apparently so far hatched. Some of the eggs had died after the embryo was formed. I made out one crystal attached to the zona.

THIRD LOT OF SPAWN.

Plates 12 to 20 were coated with spawn on the morning of February 26 by Mr. T. Smith, St. Monans. Live herrings were principally used, but the spawn was taken also from one dead fish. The plates were thickly covered all over with the ova, which in some parts were several layers deep. They were despatched to Aberdeen in a herring barrel, arriving there the same evening. The frame carrying the plates was put into tank No. 2.

Plates 12, 13, 16, 18, 20 were kept in uncooled water, while plates 14, 15, 17, 19 were put into cooled water.

Uncooled Spawn.

Two days after fertilization those of the plates which were examined looked well. The eggs were in disc stage. Where they were thickly arranged the eggs were polygonal-shaped through mutual pressure. One of the plates showed white powdery patches of excess milt, which could be brushed off. One or two dead eggs were visible. Many herring scales were attached to the eggs of one of the plates.

Plates 18 and 20 were fixed on two of the external surfaces of a cubical wooden frame, which floated freely in the tank. Plates 12 and 16 were put inside an open frame, which was anchored immediately under the inflowing current. Plate 13 was transferred to a metal box supplied with running unfiltered water. This plate at the expiry of a further 22 days was covered with a thick layer of mud. Most of the eggs had died at the stage of the closure of the blastopore. The live eggs which contained embryos ready to hatch were located at the margin of the plate, or scattered here and there on the outside of the thick layers of eggs.

10 days.—Plates 18 and 20 showed a good number of dead eggs. Live eggs were in the stages where (a) the tail first projects as a little process, and (b) where the end of the tail nearly reaches the head. No crystals were observed in the eggs. Plates 12 and 16 had a large number of dead eggs.

20 days.—On plate 20 the majority of the eggs were dead. I was able to detect only a few live eggs; they were near the margin of the plate. Many of the eggs had apparently died early.

25 days.—Plate 20 had a few eggs alive; they seemed ready to hatch. Almost all the eggs were dead.

26 days.—All the eggs of plates 12 and 16 were dead except a few round the margin. Some of the eggs had hatched.

27 days.—Plate 18 had some eggs alive; some had hatched.

34 days.—Some living unhatched eggs were found on plates 16, 18, and 20.

Plates 14, 15, 17, 19—COOLED EGGS.

Two days after fertilization certain of the plates were examined; the stage of development was that of the solid disc. The eggs all looked well. On plate 19 there were some patches of milt among the eggs. They were partly brushed off.

Plates 14, 15, and 17 were put into the frame B, which was rocked till the tenth day. Thereafter it revolved.

10 days.—Plates 14, 15, and 17 showed a lot of dead eggs. The eggs stuck directly to the glass were not so bad. The live eggs, which are at the stage where the blastopore is closing or is just closed, look well. There were lots of crystals inside the eggs. Plate 15 did not show so many dead eggs. Most of the eggs were alive. Dead eggs were scattered here and there, mixed with live, among the eggs which were isolated, or in a continuous single-layered stratum, as well as where the ova were more than one layer thick. The general distribution of the dead eggs throughout the plate would suggest that they had been unfertilized, or had suffered some injury during the spawning operation. This criticism may be applied to all the lots of eggs. Numbers of minute active infusors were running about over the eggs of plates 14, 15, and 17.

The embryo has sufficient room inside the egg to float about. When the egg is rotated the embryo, under the influence of gravity, alters its position and comes to rest again.

20 days.—Live eggs were visible all over plate 14. One showed the tail as a little process. Crystals were seen in both live and dead eggs, but not in all the eggs examined.

38 days.—A dozen eggs taken off one of these plates included three live eggs. The heart was beating slowly. The eyes were beginning to show some black pigment. One egg exhibited the condition where the tail nearly reaches the head. I saw no crystals inside the zona.

44 days.—Of 38 dead eggs, 19 contained embryos; of the embryos, 7 had pigmented eyes.

50 days.—The cooling ceased on this date; no larva had hatched out. The plates were transferred to tank No. 2.

52 and 53 days.—No live egg was found. Some eggs had died in the disc stage, but great numbers have embryos of greater or less size. A good number of the eggs next the glass where the ova have been two or more layers thick had died in the disc stage.

None of the eggs of these plates had hatched.

Plate 19.

4 days.—The eggs looked very well.

8 days.—The eggs were alright; some at the margin were dead.

9 days.—This plate did not show many dead eggs; it was in better condition than those in frame B.

12 days.—Some dead eggs were noticed.

20 days.—There was a large quantity of eggs dead. The live eggs were found all over the plate; the dead eggs were massed in the central region, where there are also a few live eggs. The dead eggs were mainly where the eggs were two layers deep. In one case some eggs on top were dead, while those next the glass were alive. Some eggs showed a fairly long tail, which did not, however, reach to the head. I could see crystals in some eggs, none in others.

28 days.—The majority of the eggs were dead, but numbers were still alive; one was in the stage similar to that found 8 days previously. Numerous infusors were running over the live eggs.

51 days.—I did not notice a single live egg. On one part of the plate where the eggs formed an uniform single-layered stratum completely covering the portion, I found that the dead eggs had been pretty well developed. Inside a high heap the eggs had died early when the embryo was forming. The eggs were well covered in parts with sporozoan colonies and fungus.

IV.—ON THE FOOD OF THE HALIBUT, WITH NOTES ON THE FOOD OF *SCORPÆNA*, *PHYCIS BLENNOIDES*, THE GARPIKE AND *CHIMÆRA MONSTROSA*. By THOMAS SCOTT, LL.D., F.L.S.

The stomachs of over one thousand specimens of halibut, *Hippoglossus vulgaris* (Flem.), have been examined during the period from September 1909 to June 1910. The sizes of the halibut ranged from 18 inches to 5 feet in length. They were captured in various parts of the North Sea and North Atlantic, and landed at the Aberdeen Fishmarket, and I desire to acknowledge my indebtedness to the fish merchants there who so kindly supplied the material for this research, and for the data concerning the sizes of the specimens supplied.

It has been my experience, as it is the experience of others when engaged in a research of this kind, that even under the most favourable conditions a certain percentage of the fishes examined have either no food in their stomachs, or it is so much broken up and decomposed by the action of the gastric fluid—an action that does not cease till some time after the death of the fish—as to be indistinguishable.

Of the halibut stomachs examined, about one-third, or nearly 34 per cent., were found to be empty, or the nature of the food could not be determined, which leaves about seven hundred, the contents of which could in some measure at least be identified.

THE FISHES.

A large proportion of the food observed consisted of Gadoids, chiefly haddocks and whittings; Norway pout (*Gadus esmarkii*) were also met with on several occasions. On the other hand, codfish and brassies were rarely noticed. Flat fishes, such as long rough dabs, were sometimes obtained, but not very often, and once or twice a lemon sole and witch soles occurred.

THE CRUSTACEA.

Crustacea were tolerably frequent, especially in the stomachs of the smaller halibut, but they also occurred in those of the larger examples. In the case of some of the larger halibut it was apparent that little effort had been exerted to crush the crustaceans found in their stomachs; specimens, almost complete, of tolerably large crabs like *Geryon tridens*, *Lithodes maia* and *Munida bamffica*, their carapace only being somewhat softened by partial digestion, being present. Small crabs like *Hyas coarctatus* and *Atelecyclus septemdentatus*, but especially the former, were by no means rare, several of them being scarcely injured except that the shell was slightly softened. Norway lobsters (*Nephrops norvegicus*) were frequent, both in the stomachs of large and small fishes, full-grown as well as young specimens being moderately frequent, and not a few of the smaller as well as the larger examples having apparently been swallowed whole, only the shell being slightly softened and shrivelled. *Nephrops* and hermit crabs—especially *Eupagurus bernhardus*—were the more common among the crustacea observed.

MOLLUSCA.

With the exception of one or two species of Cephalopoda, Mollusca were rarely met with, the only species of shell-fish observed being *Fusus antiquus*, which occurred on one or two occasions; the halibut did not apparently take the whole shell, but simply snapped off the extended head as far as it reached beyond the protecting shell. The operculum of one *Fusus*—a large specimen—taken thus unawares, measures across the longest diameter 60 millimetres by about 33 millimetres at the widest part. But though shell-fish were rare, Cephalopods were tolerably frequent, though sometimes the brown horny jaws were all that was left to represent the cuttlefish—the soft body having rapidly succumbed to the solvent action of the gastric fluid. In several cases, however, fairly complete specimens were obtained, showing that the cuttlefish had been swallowed whole, the body first, with the tentacles streaming behind, as was apparent from the position of the organism in the stomach. The cuttlefishes observed belonged to three, or perhaps four genera, viz., *Loligo*, *Eledone* (and probably *Octopus*), and *Ommatostrephes*. The *Eledone* and *Octopus* are Octopods—that is, they are provided with eight tentacles; they differ in the *Eledone* having tentacles with a single row of suckers and the *Octopus* with a double row—the suckers of the one row alternating with those of the other. This, which is one of the more obvious differences between the two, is in the case of a partly digested specimen somewhat difficult to make out. The specimens, however, which were sufficiently perfect for identification were found to be *Eledones*—probably *Eledone cirrrosa*. Several specimens of *Loligo* were observed, but with the exception of perhaps one or two, they all belonged to *Loligo vulgaris* (Lamarck). None of them appeared to be full grown, and the shell (or bone) of the largest specimen measured only $7\frac{7}{8}$ inches (about 20 centimetres) in length, and $1\frac{3}{8}$ inches (3·5 centimetres) in width at the widest part. The shell of a smaller specimen was rather narrower in proportion to the length; this one measured fully $4\frac{1}{4}$ inches (110 mm.) by $\frac{5}{8}$ of an inch (16 mm.) in width. *Ommatostrephes* was represented by a piece of the anterior end of the shell (or bone) of a specimen of moderate size.

THE ECHINODERMATA.

The Echinodermata were only sparingly represented by fragments of *Spatangus* and a nearly complete but crushed specimen of *Cidaris papillata*. The discs and arms of a few Ophiurids were also observed, but these were probably derived from the stomachs of Gadoids which the halibut had swallowed.

THE ANNELIDS.

Traces of Annelids (*Chaetopods*) were observed in a few stomachs, but these, like the Ophiurids mentioned above, may have come from the stomach of a fish swallowed by the halibut.

TABLE SHEWING NUMBER OF FISHES EXAMINED.

The following is a tabulated summary of the total number of stomachs examined each month, the number containing food that could be identified, and the number empty, or the contents of which could not be determined:—

[TABLE,

Months when the Stomachs were examined.	Total number of Stomachs examined each month.	Number with food that could be identified.	Number empty, or with food that could not be determined.
September 1909	21 stomachs	12 stomachs	9 empty
October "	115 "	74 "	41 "
November "	101 "	53 "	48 "
December "	167 "	117 "	50 "
January 1910	91 "	59 "	32 "
February "	160 "	125 "	35 "
March "	83 "	68 "	15 "
April "	124 "	84 "	40 "
May "	95 "	60 "	35 "
June "	119 "	62 "	57 "
Totals for the ten months.	1076 "	714 "	362 "

It will be observed from the preceding table that the total number of halibut stomachs examined was 1076, and of these 362 (about 33·7 per cent.) were empty, or the nature of the contents could not be determined, while the remaining 714 contained food which consisted of organisms that could at least to some extent be identified.

It will also be observed that during the several months the proportion of empty stomachs differed sometimes considerably; this difference, however, may not be due to natural causes. Sometimes it could be explained by the fact that some of the stomachs available for examination were those of "welled fish"—fish which had been on the ship for a number of days, and kept alive in a tank fitted up for the purpose in the ship's hold; any food, therefore, the stomach may have contained would be more or less completely digested by the time they were brought to the market. Sometimes also the food may have consisted of only soft-bodied organisms, such as cuttlefishes, which are quickly reduced to unrecognisable pulp; in other cases, the only evidence that the fish had recently been feeding was the presence in the intestine of partially eroded otoliths, or other less digestible substances.

In comparing the food contents of the stomachs examined from month to month, slight differences in the constituents of the food have also been observed. For a while crustacea, especially such forms as hermit crabs (*Eupagurus*) and *Nephrops*, were of frequent occurrence, but in the latter months, *i.e.*, from March onwards, crustacea have not been so often met with; while on the other hand, Gadoids, such as haddocks and whittings, but other fishes as well, have constituted the principal part of the food, and sometimes was the only kind observed.

In the following summarised statement a description of the food observed in the stomachs during each of the ten months from September 1909 to June 1910 inclusive, is given.

September 1909.

Twenty-one halibut stomachs were examined in September, and of these 12 contained food that could be identified. The food in one of them consisted of fragments of *Spatangus purpurea* and *Fusus*, that of another consisted of starfish discs and arms. In a third the food consisted of remains of fish and a Decapod crustacean, while the contents of the others consisted entirely of fishes, among which were the remains of haddocks and whittings and a fairly large herring.

October.

The stomachs examined in October numbered 115, and 74 of these contained food. The length of the halibut examined ranged from 20 to 50 inches, but only a few were over 36 inches in length, and the food contents of the larger did not differ in any marked degree from those of the smaller examples. The contents of between fifty and sixty of the stomachs consisted for the most part of crustacea or of fish. Small cuttlefishes constituted the food of about half-a-dozen stomachs, but in the remainder the contents were mixed crustacea and fish, with sometimes a small cuttlefish. The fishes that could be distinguished by their earstones or otherwise were chiefly Gadoids (haddock and whiting) and herrings; the remains of a few flat-fishes were also observed, but the species could not be determined.

The crustacea consisted largely of *Nephrops norvegica*, *Munida bamfica*, and *Eupagurus bernhardus*; several of the *Nephrops* were large, full-grown specimens, measuring over all 8 inches to fully 9 inches in length. In one of the stomachs examined twenty-one specimens of *Munida*, large and small, were counted; in another a nearly complete *Geryon tridens* occurred, but the shell bore evidence of the solvent power of the gastric fluid; while in a third a tolerably large soft-shelled female *Lithodes* was obtained. A few specimens of *Hyas coarctatus* and *Portunus* sp. were met with, while in one stomach, containing a mixed lot of food, the contents consisted of *Nephrops*, small fishes, and a number of tolerably large isopod parasites, *Cirolana borealis*, which are not uncommon on Gadoids in the North Sea, and are described by G. O. Sars as being among the most effective scavengers of the sea, and also as doing injury to the fishes caught on the fishermen's lines when not quickly removed.

November.

The number of stomachs examined in November was 101, and of these 53 contained food. Most of the halibut ranged from two to three feet in length, but four or five of them measured four feet in length and three five feet.

Crustacea (*Portunus*, *Atelecyclus septemdentatus*, *Eupagurus* sp., *Nephrops*, and *Munida*), together with young fishes, formed the principal portion of the food of smaller halibuts, but the food of the larger individuals consisted chiefly of fishes. In the stomach of one of these larger examples the earstone of a tolerably large hake was obtained; the earstone measured 25 mm., and the fish it belonged to could not, therefore, have been less than about 22 or 23 inches in length. For the purpose of comparison, it may be stated that the length of the earstones of a hake 16 inches long measure nearly 17 mm., and those of one 14½ inches 16 mm.* Other fishes observed included a whiting 11 inches long, partly digested; a tolerably large codling, remains of haddocks, a few long rough dabs, and sand-eels. One stomach contained five small flat-fishes, the jaws of a cuttlefish, remains of *Nephrops*, and a few parasitic *Cirolana borealis*. Another was full of hermit crabs (probably *Eupagurus bernhardus*), while a third contained six or seven specimens of *Munida bamfica* and a small stone. Seventeen of the stomachs contained fish only, 13 contained crustacea only, and the contents of other ten consisted of a mixed lot of crustacea and fish, including also the remains of small cuttlefishes; while the food contents of three consisted of cuttlefishes only.

December.

The number of stomachs examined in December was 167, and 117 of these contained food that could to some extent be identified. With the exception of eleven, the food observed in these stomachs consisted entirely either of

*Twenty-fourth Ann. Rept., Part III., p. 66 (1906).

fishes (Gadoids chiefly) or of crustacea (chiefly *Eupagurus bernhardus*, but one or two other species of *Eupagurus*, *Nephrops*, etc., were also occasionally present). The stomachs containing crustacea only, numbered about 65, and those containing fish only, numbered about 43. In eight halibut stomachs the food contents included a whiting and one or two small shell-fish. Another contained the remains of four or five *Munida bamffica* and a small cuttlefish (*Eledone*), while a third contained *Nephrops* and *Gadus* (?) *esmarkii*. The entire contents of one stomach consisted of cuttlefish, one contained Annelids only, and one part of a large *Fusus antiquus*.

The Gadoids met with most frequently consisted for the most part of haddocks and whittings, a few of which were of fairly large size and measured 10, 11, and 12 inches in length. The remains of herrings were also occasionally noticed; one stomach contained a herring 9 inches long and a fairly large cuttlefish—*Loligo vulgaris*. Another contained a herring about 7 inches long, which was sufficiently perfect to show that it had been feeding largely on the Schizopod *Thysanoessa neglecta* before being captured by the halibut.

Among the crustacea observed, the hermit crab (*Eupagurus bernhardus*) was, as stated above, the more common form, but one or two specimens of *Eupagurus pubescens* and *Eupagurus cuanensis* also occurred. The few *Portuni* observed were limited to *P. holasatus* and *P. depurator*. Two of the stomachs examined in December contained each a specimen of *Geryon tridens*, and one or two small *Atelecyclus* were also noticed.

DIFFERENCES IN THE FOOD OF LARGE AND SMALL FISHES.

The only appreciable difference that could be observed in the food of the larger halibut was that fishes appeared to be more frequently consumed, while the smaller preyed more upon crustacea.

The stomachs examined in December were, for the most part, from halibut three feet in length, and only a few from specimens over that size.

January 1910.

In January 1910, 91 halibut stomachs were examined, and 59 of these contained food that could be identified; none of the halibut were over three feet in length. The food contained in 31 of the stomachs consisted entirely of fishes, 19 contained crustacea only, while in the remaining 11 the food consisted partly of fish, partly of crustacea, and also occasionally with the remains of small cuttlefish.

FISHES.

The fishes observed belonged, for the most part, to the Gadoids, chiefly haddocks and whittings, some of which were of tolerable size. In one stomach the remains of two haddocks between 10 and 11 inches long were observed, and a whiting 14 inches in length occurred in another, while in a third there were two specimens of a coal-fish partly digested, the length of which would be about 12 to 15 inches, but these were rather exceptional occurrences. Other fishes observed included one or two Brassies, a few Norway pouts, and the remains of what appeared to be a lemon sole, but the fish was too much digested to be satisfactorily identified; sand-eels were also frequently met with in the stomachs of the smaller halibuts. In the stomach of one of these I found a Pogge (*Agonus cataphractus*), 4½ inches long and nearly perfect, its hard scaly covering being nearly impervious to the solvent action of the gastric fluid,

CRUSTACEA.

The crustacea most frequently observed were *Nephrops norvegicus*, hermit crabs, chiefly *Eupagurus bernhardus*, *Portunus depurator*, and one or two other species such as *Corystes cassivelaunus*, *Hyas coarctatus*, small *Galathea* sp., and *Pandalus montagui*. In one stomach no fewer than a dozen small *Corystes cassivelaunus* were counted, while some of the *Nephrops* and hermit crabs observed were of fairly large size.

CUTTLEFISHES.

Cuttlefishes were rarely met with in the stomachs examined in January, and those observed appeared to be *Eledones*. No Annelids nor starfishes were observed.

February.

The number of halibut stomachs examined in February was 160, and of these 125 contained food; the others were empty, or their contents could not be identified.

A considerable proportion of the halibut were small, being under 3 feet in length, and only a few of them were from 3 to 3½ feet long.

Fishes—Gadoids and sand-eels for the most part—formed the only food observed in nearly sixty per cent. of these, and the stomachs in which crustacea alone constituted the food contents amounted only to a little over nine per cent. On the other hand, the number that contained a mixture of crustacea, fish, and other organisms was larger in proportion than in the previous months. Cuttlefishes were also much more frequently met with.

FISHES.

As indicated above, the fishes observed consisted chiefly of whittings, haddocks, and sand-eels, several of the former being tolerably large. One of the stomachs, for example, contained a fairly large haddock 18 inches long and a small one 8 or 9 inches; another stomach contained two whiting, and, judging by the size of their earstones, both were at least 15 inches long. The occurrence of such large specimens was, however, exceptional; the sizes of haddock and whiting more commonly noticed ranged from about 7 to 10 inches. Most of the sand-eels were only half-grown specimens, but a few were adults, or nearly so, and were full of ripe or nearly ripe spawn. Other fishes which were observed, though somewhat sparingly, included brassies and *Gadus* (?) *esmarkii*, long rough dabs, small plaice, and the remains of herring.

CRUSTACEA.

The crustacea comprised such forms as *Eupagurus bernhardus*, and *Eupagurus prideaux*, *Nephrops norvegicus*, *Hyas coarctatus*, *Portunus holsatus*, *Crangon almanni*, and the leg of a fairly large *Lithodes maia*, as well as the digested remains of *Lernæa branchialis* and other nondescript forms. A number of Schizopods (*Thysanoessa*) and *Euthemisto compressa* were also observed, but these were doubtless from the stomachs of some of the fishes swallowed by the halibut.

CUTTLEFISHES.

Cuttlefishes occurred in no fewer than about 20 of the stomachs examined in February, and in about 13 of these they formed the only organisms present. The only species that could be determined were *Loligo vulgaris* and *Eledone cirrosa*, the remains being usually too imperfect for identification.

March.

In March 1910, 83 stomachs of halibut were examined, and of these 68 contained food which could in some measure be determined, and, as in the previous month, this food consisted largely of fishes; crustacea were only sparingly met with, and very few cuttlefish were observed. The following proportions will show the nature of the food contents in the stomachs examined:—Fish remains only were found in 59 stomachs; crustacea only in 1; mixed fish, crustacea, cuttlefish, etc., in 9; and cuttlefish only in 1.

FISHES.

The fishes observed were, as before, chiefly Gadoids and sand-eels. The only Gadoids satisfactorily determined were, for the most part, haddocks, whittings, *Gadus esmarkii*, and a three-bearded rockling (*Motella tricirrata*). Some of the haddocks and whiting were tolerably large fishes. One of the latter measured about 15 or 16 inches long (its earstones were 24 mm. in length), and one of the halibut about four and a half feet long was found to have swallowed a whiting about 14 inches in length, and two haddocks, one of which would be about 18 inches and the other 14½ inches (their earstones measured respectively 20 mm., 18.5 mm., 16 mm.). Such large fish, were, however, rather exceptional; smaller examples, ranging from 7 to 10 inches long, were more frequent. Specimens of what appeared to be *Gadus esmarkii* were observed on several occasions, but only the one specimen of *Motella tricirrata* was noticed.

Sand-eels, a few tolerably large, measuring from 7 or 8 inches, were not infrequent, and in one stomach the remains of twelve of them were found. There occurred in one of the halibut stomachs a small portion of the vertebra of an apparently large Gadoid; one of the joints measured across the long diameter 22 mm. and 19 mm. vertically (these measurements were made immediately after the specimen was removed from the stomach and before drying). The remains of herring were also observed, but they were of rare occurrence.

CRUSTACEA.

The infrequency of crustacea in the halibut stomachs examined during March, when compared with some of the previous months, was somewhat marked. The species observed included *Portunus* sp., *Eupagurus bernhardus*, *Crangon allmanni*, *Galathea* sp., etc. In the stomach of one of the larger halibut a nearly complete female *Lithodes maia*, loaded with spawn, was obtained, the shell, claws, and legs of which were quite soft.

CUTTLEFISH.

The contents of several stomachs consisted not only of fish and crustacea, but also sometimes of small cuttlefishes; the only specimens that in some measure could be determined were Octopods, apparently belonging to *Eledone* (*E. cirrosa*). In the stomach of a moderately large halibut were found the remains of a fairly large cuttlefish, but the only part that could be utilised for identification was a fragment of the anterior end of the "shell," which apparently was that of an *Ommatostrephes*, the shell of which is entirely different from that of any of the more common British cuttlefishes.

April.

The number of halibut stomachs examined in April was 124; 40 of these were found to be empty, or their contents could not be identified, while the food in the remaining 84 was more or less recognisable.

Small and medium sized fishes, chiefly Gadoids, appeared to be the food mostly sought after by the halibut, and fully 60 of the stomachs examined contained nothing else. Crustacea, on the other hand, were only sparingly met with, and were usually associated with other kinds of food, such as small fishes, but cuttlefish remains were also occasionally present.

FISHES.

Fishes, as stated above, formed the principal part of the food of the halibut examined in April; haddocks and whittings were the species most commonly met with, and, though they were usually comparatively small, moderately large specimens were also occasionally obtained; generally, however, they were so much broken up by the digestive fluid that the accurate measurement of the fish itself was impracticable, but as the earstones were frequently found to be uninjured, a careful measurement of these always afforded a fairly correct indication of the size of the fish they belonged to. Their reliability as a guide to the approximate size of the fish has been frequently tested in the case of such species of haddocks, whiting, codfish, and some other Gadoids, and generally with satisfactory results.*

Three fishes, all haddocks, were found in one of the halibut stomachs examined in April; their earstones measured 18 mm., 17 mm., 16 mm., showing that the first two were from 16 to 17 inches in length, and the third about 14 inches. In another stomach a whiting about 14 inches long and two haddocks about 17 or 18 inches respectively were observed, and the earstones of these three fishes measured—the whiting 20 mm., the larger haddock 18.5 mm., and the smaller 16 mm.; while in a third stomach, viz., that of a halibut over four feet long, were found the remains of a haddock over 18 inches in length (earstones 21 mm.), a moderately large flat-fish, the species of which was doubtful, and the jaws of a cuttlefish, probably an *Eledone*. Among other fishes met with in the stomachs examined in April were a few Norway pouts, *Gadus esmarkii*, a lemon sole, *Pleuronectes microcephalus*, the remains of a moderately large flat-fish that appeared to be a witch sole, *Pleuronectes cynoglossus*, and measured about 12 inches long, a considerable number of sand-eels, a smelt, *Osmerus eperlanus*, about nine inches long, a herring about 10½ inches long, and remains of others, and also a young piked dog-fish, *Acanthias vulgaris*, of moderate size; in this specimen the spine in front of the first dorsal fin measured from the base of the exposed (coloured) part to the tip about 20 mm.

CRUSTACEA.

Crustacea were not very plentiful in the stomachs examined in April, and those met with were usually associated with other forms. The species observed were chiefly *Hyas coarctatus*, *Portunus* sp., hermit crabs (*Eupagurus bernhardus*), and *Nephrops*.

CUTTLEFISHES.

Cuttlefishes, or their remains in the form of dark horn-coloured jaws, were met with on several occasions. They all appeared to belong to the eight-armed group Octopoda, and those of them sufficiently perfect for identification were all apparently *Eledones*. Some of them were tolerably large, but accurate measurements were hardly attainable, as the delicate extremities of the tentacles were usually wanting, besides being otherwise injured. One that was tolerably perfect gave the following measurements:—Body to base of tentacles, 5¾ inches; length of tentacles, or at least what remained of

* Cf. "Observations on the Otoliths of some Teleostean Fishes." *Twenty-fourth Annual Report of the Fishery Board for Scotland*, Part III., p. 48-82, Pls. I.-IV.

them, 6 inches. This *Eledone*, therefore, would have measured over all fully 12 inches in length—a fairly big mouthful to swallow even for a moderate-sized halibut.

CETERA.

Some odd things observed included *Crangon allmanni*, discs of starfishes (Ophiura), small *Echinocardium*, fragments of Zoophytes, a small univalve shell (*Fusus*), and a few small stones. Most of these small things, however, were probably derived from the stomachs of the haddocks, whittings, &c., which the halibuts had swallowed.

May.

The number of halibut stomachs examined in May was 95, and of these 60 contained food which could, to some extent at least, be identified. The size of the halibut from which these stomachs were removed ranged for the most part from 30 inches to 42 inches in length. A few were from halibut under 30 inches, and a few others between 48 and 60 inches. The food found in 54 of the stomachs examined consisted entirely of fishes, chiefly Gadoids. Two contained crustacea only, and two the remains of cuttlefish only, while in two others were found the remains of fishes and shell-fish (*Buccinum*, sp.). From the results stated above, it would appear that in May halibut had been feeding more exclusively on fishes than during any of the previous monthly periods. Whether there is any natural cause for this change—whether, for example, it is due to seasonal influences affecting the supply of food, or merely to some accidental change—there is scarcely sufficient data to show.

THE FISHES OBSERVED.

The fishes met with in the halibut stomachs examined in May included, as usual, haddocks, whittings, sand-eels, and very rarely flat-fishes. Herrings were occasionally observed, a few of which were of fairly large size. In one stomach, for example, a herring of about 10 inches in length, and in another a specimen about 8 inches, were obtained. A witch sole about 12½ inches long was also found in one of the stomachs examined on May 6th. Some of the Gadoids were tolerably large; a whiting 15 inches long and a brassie (*Gadus luscus*) 13 inches were among some of the larger specimens met with.

The fish food in a considerable number of the stomachs examined in May was so much digested that if the earstones were absent the species was practically unrecognisable.

CRUSTACEA, CUTTLEFISHES, &C.

Crustacea and cuttlefishes were both very sparingly met with. *Hyas coarctatus* was almost the only crustacean observed, and the cuttlefish remains consisted chiefly of their dark-coloured horny jaws.

June.

The halibut stomachs examined in June numbered 119. Fifty-seven of them were empty or contained food that could not be identified, while the food in the remaining 62 consisted largely of gadoids. In 47 of the stomachs examined the food consisted entirely of fishes, and in fully 50 per cent. of them the food was so much digested that in many cases only a few bones were left, so that even the species could not be determined. The following Gadoids were recognised, viz.:—The remains of a codfish about 15 inches in

length, and another between 9 and 10 inches; the latter had a small flat-fish of doubtful species in its stomach. Haddocks were observed in seven or eight halibut stomachs, and whittings in about the same number. A *Gadus* (?) *luscus* about 9 inches long occurred in one stomach, and *Gadus esmarkii* in several. A few both of the haddocks and whittings were apparently tolerably large. The remains of fairly large herrings were also observed in three stomachs, and a small flat-fish—species doubtful—in one.

CRUSTACEA.

In ten of the stomachs examined in June, the food consisted entirely of Crustacea. *Hyas coarctatus*, the most common species, occurred in seven of them. The hermit crabs (*Eupagurus bernhardus* and *Eu. prideaux*) were only observed on one or two occasions, while Norway lobsters (*Nephrops*), so frequent during some of the previous months, were apparently entirely absent; so also were several of the other species met with during the winter.

CUTTLEFISHES.

Cuttlefishes were rarely met with in the halibut stomachs examined in June, and those observed were the remains of either small *Eledone* or *Octopus*.

ECHINODERMS.

A specimen of *Cidarus papillata*—a partly crushed test without spines—was obtained in one of the halibut stomachs examined in June.

Having in the preceding notes given a short descriptive account of the food-contents of the halibut stomachs examined from month to month from September 1909 to June 1910 inclusive, it may be useful if the various organisms referred to are brought together in the form of a more or less systematic list, as follows:—

A SYSTEMATIC LIST OF THE FISHES, CRUSTACEA, AND OTHER THINGS MENTIONED IN THE PRECEDING NOTES AS CONSTITUTING THE FOOD OF THE HALIBUT.

FOOD OF THE HALIBUT.

Classified List of Organisms mentioned in the preceding Notes.

Fishes.

Agonus cataphractus, Linné. The pogge.

A nearly perfect specimen, about $4\frac{1}{2}$ inches long, obtained in January.

Gadus callarius, Linné. Codfish.

Remains of a moderately large codling observed in stomach of large halibut in November.

Gadus aeglefinus, Linné. Haddock.

Of frequent occurrence; some of the specimens tolerably large.

Gadus merlangus, Linné. Whiting.

Of frequent occurrence; some of the specimens tolerably large.

Gadus pollachius, Linné. Pollack or lythe.

Gadus virens, Linné. Coal-fish or saith.

Specimens that belonged to one or other of these two species have been occasionally observed, too imperfect to be satisfactorily identified.

Gadus luscus, Linné. The bib.

Gadus minutus, Linné. The poor or power-cod.

Specimens belonging to one or other of these Gadoids were occasionally met with, too imperfect to be satisfactorily determined. Their earstones are somewhat short and massive.

Merluccius vulgaris, Cav. The hake.

The earstone and other remains of a hake was found in the stomach of a tolerably large halibut in November. The hake would be between 15 and 16 inches long.

Molva molva, Linné. The ling.

A small ling, about 13 inches long, was obtained in a halibut's stomach in November.

Motella (Onos) tricirrata, Bloch. Three-bearded rockling.

A specimen of this species was observed in a halibut's stomach in March.

Ammodytes (?) lanceolatus, Le Sauv. Sand-eel or sand-launce.

Sometimes fairly common, especially in the stomachs of the smaller halibut.

Drepanopsetta platessoides, Fabr. Long rough dab.

A few examples, sufficiently perfect for identification, and measuring 5 to 6 inches in length, were obtained in November and January.

Pleuronectes platessa, Linné. Plaice.

Observed on two occasions, one specimen about 8 inches long in February, and another about $6\frac{1}{2}$ inches in April.

Pleuronectes microcephalus, Don. Lemon dab or lemon sole.

Observed on two occasions; one specimen, length doubtful, in January, and one about $10\frac{1}{2}$ inches long in April.

Pleuronectes cynoglossus, Linné. Witch sole.

A specimen about $12\frac{1}{2}$ inches long was obtained in a halibut's stomach in May. The remains of what appeared to be another occurred in April, but too imperfect to be satisfactorily determined.

Pleuronectes limanda, Linné. Dab or common dab.

Only a single specimen observed.

Osmerus eperlanus, Linné. The smelt.

One specimen observed in a halibut's stomach in April.

Clupea harengus. Herring.

Herrings ranging in length from 7 to 10 inches were obtained in about a dozen of the halibuts' stomachs examined. A few of them appeared to have been feeding on *Thysanoessa* before being captured by the halibut.

Acanthias vulgaris. Spur-dog, piked dog-fish.

A young specimen from a halibut's stomach in April; the coloured part of the spine in front of the first dorsal fin measured from base to tip about 20 millimetres.

Crustacea.

Hyas coarctatus, Leach.

Observed on various occasions; specimens usually small.

Portunus depurator, Leach.

Sparingly met with on several occasions.

Portunus holsatus, Fabr.

Obtained only in three or four of the stomachs examined.

Portunus pusillus, Leach.

Obtained once in January along with *Hyas coarctatus*.

Portunus arcuatus, Leach.

Very rare in stomachs examined in January.

Atelecyclus septemdentatus, Mont.

This species occurred sparingly on one or two occasions.

Corystes cassivelaunus, Pennant.

This also occurred sparingly, but on one occasion a dozen small specimens in a stomach in January.

Lithodes maia, Linné.

Three small, fairly perfect specimens were obtained in a stomach examined in October, and a larger female carrying eggs, but with the shell soft and somewhat damaged, in one examined in February.

Geryon tridens, Kroyer.

A fairly large specimen of *Geryon* was found in one of the stomachs examined in October, and two smaller specimens in those examined in December.

Eupagurus bernhardus, Linné.

Tolerably frequent, especially in the winter months.

Eupagurus prideaux, Leach.

Obtained sparingly on two or three occasions.

Eupagurus cuanensis, Thomps.

Rare in one or two stomachs in December.

Eupagurus pubescens, Kroyer.

Fragments apparently belonging to this species occurred sparingly on one or two occasions in December.

Galathea sp.

Rarely met with, and only young or imperfect specimens.

Munida bamffica, Pennant.

Munida was not infrequent during the winter months. In one of the stomachs examined in October, 21 specimens, large and small—mostly small—were obtained, and 6 in another.

Nephrops norvegicus, Linné.

This crustacean was moderately common, especially during the winter months, not a few of the specimens being apparently adult; some of them measured 8 to full 9 inches to the end of the claws.

Cragon allmanni, Kinahan.

Rare, and probably derived from the stomachs of fish swallowed by the halibut.

Pandulus montagui, Leach.

Rare; observed only on one or two occasions.

Thysanoessa neglecta, Kroyer.*Euthemisto compressa*, Goes.

Both of the species named were doubtless derived from the stomachs of sand-eels and herrings swallowed by the halibuts.

Cirolana borealis, Lilljeborg.

Several specimens were met with in one of the stomachs examined in October, probably having been swallowed with the Gadoids to which they were adhering as parasites.

Lernæa branchialis, Linné.

Fragments were observed on one or two occasions, having doubtless been fixed on the gills of Gadoids swallowed by the halibut.

*Mollusca.**Fusus antiquus*, Linné.

Two stomachs contained each an *operculum* only; another contained the head (with *operculum* attached) of a tolerably large specimen.

Ommatostrephes todarus, Delle Chiaje.

A small fragment of a cuttlefish shell, apparently belonging to this species, was obtained in a halibut stomach examined in March.

Loligo vulgaris, Lamarck.

Several specimens of *Loligo* have been met with, and though they may not all belong to the species named, one or two certainly do so.

Eledone cirrosa, Lamarck.

Specimens of *Eledone* were met with on several occasions, but other specimens were obtained which were scarcely perfect enough to determine the species. Cuttlefish jaws were also not uncommon, representing both large and small specimens.

*Echinodermata.**Spatangus purpureus*, O. F. Müller.

Fragments of the test of a *Spatangus* occurred in the intestine of one of the halibuts examined in September.

Cidarus papillata, Leske.

A partly-crushed test was obtained in a halibut's stomach examined in June.

Ophiura sp.

Several discs and fragments of arms were observed from time to time, but not identified.

CETERA.

Annelida were met with on one or two occasions, but appeared to be exceedingly rare in the stomachs of the halibut examined. Fragments of Zoophytes were also occasionally observed, and so also were small bits of stone. One piece of stone measured in millimetres 27 by 21 by 13, and its weight just under half an ounce avoirdupois.

NOTES ON THE FOOD OF *Scorpaena dactyloptera*, *Belone vulgaris*, *Phycis blennoides*, AND *Chimæra monstrosa*.*Scorpaena dactyloptera*, De la Roche.

A considerable number of *Scorpaena dactyloptera* were examined in February and March 1910, but the stomachs of about two-thirds of them contained nothing that could be satisfactorily determined. In one of the stomachs of the remainder was found a nearly perfect specimen of *Sepiola rondeleti*, Leach, and in another a small individual somewhat imperfect, which appeared to belong to the same species. Cuttlefish remains were found in other four, but were too imperfect to be satisfactorily identified, though from their appearance they were probably also *Sepiolas*. In the stomach of another of the same lot of *Scorpaenas* were fragments of *Crangon*, apparently *C. allmanni*.

THE GARFISH OR SEA PIKE (*Belone vulgaris*, Cuvier).

A number of garfish captured in the North Sea, off the Aberdeenshire coast, in April and May, were found to have been feeding more or less extensively on small crustacea; both the stomach and intestine were in some instances filled with them. Eight tolerably large garfish, about 18 to 20

inches in length, had their stomachs filled with almost nothing else than pelagic Amphipods, which appeared to belong to *Parathemisto oblivia*, with a few fragments of some specimens belonging to the *Euphausiadae*, probably *Thysanoessa*. Everything the stomach contained, however, was so fragmentary that the species to which they belonged could not with certainty be determined. No other organisms besides those mentioned were observed.

Phycis blennoides (Brun)—THE GREATER FORK-BEARD.

Stomachs, containing food, of about a dozen examples of the greater fork-beard (*Phycis blennoides*) from the Fish Market at Aberdeen were examined in February and the beginning of March 1910. They nearly all contained the partly-digested remains of small fishes, chiefly Gadoids. Though none of the specimens were perfect enough for satisfactory identification, it is probable that most of them belonged to *Gadus esmarkii*, as the form and structure of their ear-stones appeared to be practically identical with those of that species. In one stomach ten pairs of ear-stones were counted; three of the pairs were those of fishes about six inches long, while the others belonged to fishes of smaller size. One stomach contained a young piked dog-fish about 4 inches (100 mm.) in length, and another, a small lump-sucker (*Cyclopterus lumpus*). The crustacea were represented in these stomachs by *Nephrops norvegicus*, *Crangon* sp., *Pandalus montagui*, *Pandalina brevirostris*, and *Nyctiphanes*; there were also remains of crustacea that could not be identified. The only other organism observed was a small cuttlefish, probably an *Eledone*, but scarcely perfect enough to be satisfactorily determined.

Chimæra monstrosa.

In January 1910 a number of specimens of *Chimæra monstrosa* from the Fish Market were examined, and the food contained in their stomachs was found to consist of various organisms, comprising shell-fish, crustacea, Annelids, and Echinoderms.

SHELL-FISH.

The shell-fish included *Pecten tigrinus*, *Anomia* (?) *ephippium*, small *Fusus* sp., small *Buccinum undatum*, *Cardium fasciatum*, and *Scalaria* sp.

CRUSTACEA.

The crustacea comprised Decapods, such as *Ebatia* sp., small *Hyas coarctatus*, small *Eupagurus*, and Amphipods, such as *Hippomedon denticulatus* and *Ampelisca* sp.

ANNELIDS.

Several fragments of Annelids occurred, but the species could not be made out.

ECHINODERMS.

The only species of Echinoderm identified was *Echinocardium cordatum*; the remains consisted of spines and fragments of tests.

V.—BACTERIOLOGICAL INVESTIGATION AS TO THE CAUSE OF AN OUTBREAK OF DISEASE AMONGST THE FISH AT THE MARINE LABORATORY, BAY OF NIGG, ABERDEEN. By A. G. ANDERSON, M.D., D.Sc., D.PH., M.A.

About the end of August 1908, some haddocks and whittings were required for replenishing the tanks at the Marine Laboratory at the Bay of Nigg, Aberdeen, where for the previous eighteen months I had been carrying out some experimental work on the decomposition of fish and its detection from the public health point of view. This work has been already published by the Fishery Board for Scotland in their *Twenty-sixth Annual Report (Part III.)—Scientific Investigations*.

On the evening of the 21st August some were caught about a quarter mile from the shore in six fathoms of water and about 200 yards from the mouth of the a sewer. The fish were conveyed to the Laboratory in two large galvanized tin boxes and placed in two of the tanks at the Marine Station, amongst other haddocks and whittings which had been in the same tanks for about nine months, and which had been caught three to four miles from the shore. The attendant officer at the Laboratory, who was in charge of the operations in catching and conveying the fish to the tanks, states that he distinctly observed a few spots on some of the fish which attracted his attention. Some of the spots were small and pale in colour, about the size of a threepenny piece; others were larger, reddish-looking, and about the size of a crown piece. These appearances he observed in four or five of the fishes. During the second night after being placed in the tanks, one of the haddocks died; and the disease was observed to be spreading. In the case of those previously showing small affected areas, the areas were now seen to be getting larger and redder; while the rest of the fish not already affected, and including those recently caught and those previously in the tank, now began to show small spots in the initial stage, which were paling and desquamating. The spots were not limited to any particular area, although most common on the neck, back, and tail. By the third day many of the fish showed sluggish movements and a few more died. By the fifth day all the fish in these tanks were dead. The number of haddocks and of whittings in separate tanks previous to introduction of those caught on 21st August is given as probably 25 of each, and those introduced about one dozen each.

APPEARANCE OF THE ULCERS.

On examination of the fish after death the ulcers were seen not to be localised to any one part of the body, but irregularly distributed on the neck, back, tail, and on the fins. They varied in size from one to four or five millimetres in diameter, and were of the spreading and sloughing type. The base of the ulcer was depressed, often reaching down to the muscular tissue in the more advanced ulcers, and usually showing some necrosed and sloughing tissue with some grumous pus. The edges were inflamed, irregular and ragged, and very much undermined. The surrounding tissues in the more advanced ulcers were soft and œdematous. In five of the fish examined the base presented a slightly injected appearance, with apparently some attempt at reaction on the part of the tissues against the attacking micro-organisms; but in no case did the ulcer appear to be passing into the condition of healing with the formation of true granulation tissue. In many

of the fish, when the ulceration was not so advanced, and where there was no loss of continuity of tissue, small greyish-white spots were seen, where the scales were falling off, and rubbed off very readily, while the tissues beneath were very red and congested.

BACTERIOLOGICAL EXAMINATION.

Four of the fish, two haddocks and two whittings, were removed in sea-water tanks to Marischal College. While the fish were still alive scrapings were made from the ulcers by means of sterilised platinum wire and plated out on gelatine, Agar and fish-agar media, and incubated at 20°C. and 37°C. respectively.

Smears were also made on glass slides from the ulcerated areas.

The fish were then opened by abdominal section under sterile conditions. Then cultures and smears were made from both the peritoneal fluid and heart blood by sterilised platinum wire. Streak cultures were also made of the peritoneal fluid on Digralski and Conradi media.

MICROSCOPICAL EXAMINATION OF THE SMEARS.

Smears from the Ulcerated Areas.

These were stained with the ordinary basic aniline dyes—Methylene Blue, Dilute Carbol Fuchsin, Gram's Stain, etc. All these preparations showed the presence of cocci which were strongly Gram positive; also some rod-shaped and many vibrio-like micro-organisms, which in hanging drop preparations were actively motile.

Blood Smears.

These were treated precisely as the last, and in two of the fish examined the blood showed the presence of cocci, which were strongly Gram positive.

Smears from the Peritoneal Fluid.

These, when treated as the above and examined, did not show the presence of any micro-organisms.

EXAMINATION OF CULTURES.

Cultures from Ulcerated Areas.

The gelatine plates were examined 48 hours after inoculation. Many small colonies of a brownish-yellow tint were seen in the media, and around these liquefaction of the media was just seen to be commencing. Also a smaller number of bluish-white colonies around which there was no liquefaction of media. The Agar plates were also examined 48 hours after inoculation. Numerous colonies of a dirty whitish colour with a yellowish to orange tint were seen. There were also present a few large superficial colonies, and a few deep colonies of a brownish-white colour.

From these different colonies, sub-cultures were made on the following media:—

Gelatine tubes—Streak and shake cultures.

Agar tubes—Streak cultures.

Litmus peptone milk.

Bouillon.

Potatoes,

and incubated at 20°C. and 37°C. respectively.

The yellowish to orange-coloured colonies gave the following results:—

In the gelatine stab cultures a thin streak of growth was visible after 24 hours, and by 36 hours liquefaction of the gelatine was seen commencing round the growth on the upper surface of the tube. Liquefaction proceeded rapidly, and the growth gradually fell to the bottom of the tube as a flocculent deposit, and appearing of a bright yellow colour.

The stroke cultures on the Agar tubes showed an abundant shiny opaque growth in 24 hours, generally passing from a faint orange to a yellowish colour.

Litmus Peptone Milk.—This medium was turned acid, shown by the disappearance of the blue colour and appearance of red colour. The milk was also distinctly coagulated.

Bouillon.—In this medium there appeared at first a uniform turbidity which gradually settled to the bottom of the tube, showing a yellowish tint.

Potato Medium.—In 48 hours there was an abundant growth of a distinctly orange colour.

Microscopical Examination of Sub-cultures.

They all showed the presence of cocci varying from 7μ to 9μ in diameter, spherical in shape, and the growths occurred in irregular groups or masses. The cocci were strongly gram positive, and stained with all the ordinary basic aniline dyes. These cocci exhibited all the essential biological, cultural, and microscopic characters of the staphylococcus pyogenes aureus.

EXAMINATION OF THE SUB-CULTURES OF OTHER COLONIES.

These were all examined after 48 hours' growth.

Gelatine Stab Cultures—Thin, whitish streak of growth; no liquefaction of gelatine, and after 8 days a few bubbles of gas in the media.

Agar Stroke Cultures—A thin whitish-opaque line of growth.

Litmus Milk—Medium turned acid and milk clotted.

Bouillon—Slight turbidity.

Potatoes—A thin film of growth, moist-looking, and of brownish tint.

MICROSCOPIC EXAMINATION.

These colonies were seen to be short, rod-shaped bacilli, varying from 0.3μ to 0.7μ in diameter. They stained with basic dyes, but very readily decolorised by Gram's stain.

Hanging drop preparations were then made, and the bacilli were found to be motile, with generally a slow rotatory motion.

The following media were then inoculated and incubated at 37°C .:—

I. MacConkey's Bile Salt Glucose Peptone Litmus Solution.

II. Drigalski and Conradi's Nutrose Litmus Agar.

III. Neutral-Red Bile Salt Agar.

After 48 hours' growth:—

I. Showed the presence of acid and gas.

II. Numerous red colonies.

III. Numerous red colonies colouring the surrounding medium red, and producing a characteristic haze.

From the colonies on media II. and III. sub-cultures were made on the following media and incubated at 37°C .:—

A. Glucose Neutral Red. Broth.

B. Lactose Peptone Litmus Solution.

C. Peptone Water.

D. Litmus Milk.

After 48 hours A. showed greenish-yellow Fluorescence.. FL.

After 48 hours B. ,, Acid and Gas..... AG.

After 6 days C. ,, Indol production:.....:..... IN.

After 4 days D. ,, Acid and Clot..... AC.

By the above method I followed Houston's "Flaginac" basis of classification for *Bacillus Coli*. When these tests are positive, the *Bacillus Coli* is typical or indistinguishable from the typical *Bacillus Coli* of the human intestine. If some of the tests are negative, or not well marked, then the bacillus is considered atypical. Consequently the bacilli found were of the type *Bacillus Coli Communis*.

BLOOD CULTURES.

In three of the fish examined, growths of colonies appeared in the Agar tubes. When these were stained and examined they were found to be pure growths of cocci, and gave the essential tests for the *staphylococcus pyogenes aureus*.

PERITONEAL FLUID CULTURES.

These were all negative.

SECTIONS

Besides pursuing the ordinary methods, I also adopted the method of preparation and staining of sections which was first introduced by Levaditi, and described by him in the "Annales de Institut Pasteur," January 1906.

Levaditi and many others who were working with him found great difficulty in differentiating the *Spirochæta Pallida* in sections by means of the ordinary stains, and devised the following method which was adopted here with the hope that the vibrio-like micro-organisms, which were seen in all the smear preparations made from the ulcers while the fish were still alive, might be exhibited, if present, in sections of the tissues.

METHOD.

(1) Small blocks of tissue were cut out through the ulcers about 1 mm. thick, and fixed in 10 per cent. Formol for 24 hours.

(2) Then washed and hardened in 96 per cent. Alcohol for 24 hours.

(3) Washed in Aq. dest. for some minutes until the fragments fell to the bottom.

(4) The blocks were then impregnated at 38°C. for 5 days in 2 per cent. silver nitrate.

(5) Washed for a few minutes in Aq. dest. and reduced in the following mixture at room temperature from 24 to 48 hours:—

Ac. pyrogallic,	.. ..	4 per cent.
Formol,	.. ..	5 cc.
Aq. dest.	.. ..	100 cc.

(6) Washed in water, dehydrated in alcohol xylol, paraffin sections.

(7) Some sections were mounted in xylol and Canada balsam, and some were further treated by—

(a) Giemsa's Solution.

(b) Toluidin Blue (method of Manourlian).

On examination the ulcers presented the appearance as already described. The floor of the deeper ulcers extended down to the muscular tissue. Small irregular masses of cocci were present in all, and were very numerous in most of the preparations—especially in the subcutaneous tissues and at the spreading margins. The cocci stain very readily with Ag. when precipitated in the metallic state.

Neither by any of these methods of preparation and examination of sections, nor in any of the preparations from the culture media, were the vibrio-like micro-organisms found, although they were undoubtedly present

in the original ulcers, and seen in the smear preparations and in the hanging drop preparations, in which they were actively motile.

After the death of the haddocks and whittings in the tanks, the tanks were emptied and cleaned out, but the water they contained was inadvertently allowed to get into an outside pond in which there were about 150 plaice.

In the beginning of September 1908, 193 plaice arrived from the Moray Firth, and, on being placed in the pond amongst the other plaice, it was then discovered that 58 of the 150 plaice in the pond were dead, and were removed. On the 23rd October, 267 more plaice arrived from the Moray Firth and were placed in the pond; and it was shortly after that date when 129 more dead plaice were discovered and removed from the pond. On the 27th November, 284 more plaice were received from the Moray Firth and placed in the pond, and up to 26th December 1908, 13 more dead plaice had been removed. That is, during four months 200 plaice have died in this pond.

The fish from the Moray Firth, on careful examination, showed no evidence of any disease.

After frequently examining these fish, I could come to no other conclusion than that they were suffering from the same disease as that which appeared in the case of the haddocks and whittings. The superficial ulcers were of the spreading and sloughing type, and presented precisely the same characters as already described in the former fish. They showed the same irregular distribution on neck, back, and tail, but were very seldom seen on the ventral surface. They commenced in paling and desquamating spots, and spreading rapidly to form large ulcerated areas, often one to two inches in diameter. The edges of the ulcers were deeply undermined, the base often extending down to the muscular tissue and covered with broken-down tissue. But here the base of the ulcers often presented a very injected appearance, and there appeared to be a decidedly stronger reaction on the part of the tissues against the invading micro-organisms than what appeared in the case of the haddocks and whittings. This may be due to a better blood supply in the case of the plaice, which on the whole are hardier fish than the round edible fish such as haddocks and whittings; and although difficult to state definitely, yet there has to be kept in view the probability of variation both in the direction of diminution of the virulence of the attacking micro-organisms, and also in the powers of resistance of these different classes of fish.

BACTERIOLOGICAL EXAMINATION.

Two of the plaice were conveyed to Marischal College while still alive, and a bacteriological examination made precisely in every detail as in the case of the haddocks and whittings. Hence I will not repeat the various processes, but state the results.

From all the lesions examined by smear and hanging-drop preparations, rod-shaped and vibrio-like micro-organisms were present. Cocci were also present and strongly Gram positive.

From both fish, by the methods already described, typical *Bacillus Coli* were isolated by means of cultural media and subjected to the same confirmatory tests.

From the blood pure cultures of cocci were obtained. These were subjected to the usual tests for the *staphylococcus pyogenes aureus*.

The cultures from the peritoneal fluid were again negative.

Sections were made as already described. These showed the same appearance as in the case of the haddocks and whittings.

Again, in none of the cultural preparations nor in sections did the vibrio-like organisms appear which were always seen in smear preparations made from the lesions while the fish were alive.

PROVISIONAL CONCLUSION.

In reviewing the above work, the micro-organisms found present were :—

- I. Vibrio-like bodies in all the superficial lesions, but which were not found in any of the cultures, nor in sections.
- II. Micro-cocci ; chiefly staphylococcus pyogenes aureus in all the superficial lesions examined, and in the blood in most cases in pure culture.
- III. The Bacillus Coli Communis in the superficial lesions and also in cultures from these.

Consequently, since these micro-organisms are so closely identified with sewage, it is difficult to avoid the conclusion that the fish had died from some form of septicæmic poisoning, and possibly caused by infection from these sewage-borne micro-organisms.

HOW INFECTION MAY TAKE PLACE.

Johnston, Fisheries Laboratory, Liverpool, informs me that a few years ago he observed at Port Erin a similar epidemic, and that the signs and progress of the disease was very similar to that which I have described in this paper. A large number of the plaice impounded in the spawning pond died rapidly from some apparently infectious disease. He came to the conclusion that the disease was due to a fungus, and that it was probably conveyed to the fish by means of insects, of which large numbers floated about on the surface of the pond.

Johnston also informs me that he has frequently observed how readily superficial ulceration follows in fish which have received the slightest external injury, even from trivial surface lesions produced when caught in the trawls.

Then, as marine fish approach inshore they must become more liable, through various causes, to receive small superficial abrasions, which may be just sufficient to allow micro-organisms to find a lodgment ; and that this will more readily occur in the neighbourhood of sewer outlets into the sea has frequently been observed by M'Intosh and others, who have noted the remarkable influence which such outlets have in attracting fish to such areas.

Thus, while infection by contact in the open sea is possible, there is greater opportunity for such to take place inshore, especially in the vicinity of sewage outlets, and much more so when the fish are confined in tanks.

On the other hand, although it appears that fish may be very susceptible to external microbial attacks through superficial lesions, it appears that they can swallow great numbers of bacteria with apparent impunity.

Many fish feed directly on sewage when available, and especially many of the crustacea, the smaller and often microscopic forms of which, such as the Copepoda, may be said to act as the scavengers of the sea shore. They feed almost entirely on sewage, and are present in vast numbers, and in their turn they become one of the chief sources of the food supply for the larger fish.

Further, we know that fresh-water fish must swallow large numbers of bacteria in so many sewage-polluted streams.

Again, in an article on the "Decomposition of Fish and its Detection," which appeared in the *Twenty-sixth Annual Report of the Fishery Board for Scotland*, I pointed out that marine fish which were caught near the shore or the mouths of inland rivers, or near the discharge of sewage effluents, contained large numbers of bacteria of the sewage type, and which were readily isolated from the intestinal contents, whereas in proportion to the distance out at sea at which the fish are caught the bacteria decreased ; and in fish caught far out at sea, or in a sewage-free locality, very few such micro-organisms could be detected. These results were generally in accordance with those of Houston, and in close agreement with those of Eyre.

Still, I am not aware that either marine, inshore, estuarine, or inland fresh water fish suffer in any appreciable way from the ingestion of sewage bacteria. But it has to be admitted that, although we now have Hofer's "Fischkrankheiten" as the only published treatise dealing with the diseases of fresh-water fish; as regards the diseases of marine fish very little has been done and still less written. Certainly, in my own experimental work on both marine and fresh-water fish, I have never found any lesion which I could attribute to the ingestion of bacteria into the alimentary canal, although this does not exclude the possibilities of the effects of bacterial toxins; nor in any case in which the peritoneal fluid was examined were bacteria of the intestinal type discovered when the fish were living and in a healthy condition.

In this respect, however, the evidence given by Professor Herdman before the Royal Commission on Sewage Disposal is both interesting and important.

While his evidence is in general agreement with the above conclusions, he further stated that, although he had never known of a case of a fish being poisoned by a pathogenic micro-organism, and was of opinion that even if fish were to ingest sewage bacteria in large quantities they would probably show no intestinal lesions, yet at the same time there was the possibility that the bacteria, through their toxins, might cause a lowering of the vitality of the fish. This statement is, of course, an expression of the general mode of action of all bacteria—they may cause local lesions or act through their toxins or by both combined. Herdman, however, makes some differentiations which are not only important from the bacteriological, but also from the point of view of public health. He distinguishes between Pisces or swimming fish and the Mollusca and Crustaceans or shell fish, and considers that in the case of the latter or shell-fish, even although we have as yet no evidence that they suffer in themselves from the ingestion of pathogenic bacteria, yet, since they are so frequently used as articles of food in the raw condition, and consequently often proved to be the medium of transmission of disease, any sewage pollution as regards such fish should be prevented.

As regards the Pisces or swimming fish, this danger is not present to the same extent; and in any case such fish are usually cooked, and when properly cooked any such danger of the transmission of pathogenic bacteria is practically precluded.

Regarding susceptibility, Herdman is of opinion that marine fish are not so susceptible to microbial attacks as fresh-water fish; and that amongst the former there are degrees of susceptibility, inasmuch as flat-fish are probably less susceptible or show greater resistance to bacterial attacks than round fish, such as haddocks and whittings.

Of the first proposition I have no experimental evidence; but regarding the second, certainly my own observations on the reactions of the flat-fish and round-fish respectively to the bacteria, which were the cause of this outbreak of disease, and which forms the subject of this investigation, appear to bear out this statement; and it may be added that in all cases young fish are more susceptible to bacterial poisoning than adult fish.

Recently a great deal of valuable scientific work, on the question of standards for tidal waters in relation to offensive putrefaction and injury to fish, has been accomplished by Dr. Letts of Belfast and Dr. Adeney of Dublin; and as these workers have approached the subject purely from the general and chemical points of view, their conclusions are of great interest and importance, when studied along with the bacteriological aspect of the question.

One of their conclusions, and with which Herdman agrees, has a direct interest, when read in conjunction with the subject of this paper, namely, that, while the discharge of sewage into any river, estuary, or sea-board is in such quantity that its dilution with fresh or sea water is sufficiently large

as not to cause any physical clogging of the gills of the fish, and as to ensure an adequate supply of dissolved oxygen for purposes of respiration, such sewage may have no harmful effect on the fish inhabiting any such areas.

To sum up, it may be said that, although on the one hand the evidence appears to indicate that fish do not suffer readily from the ingestion of bacteria, nor from the presence of sewage in the medium in which they are living, so long as its dilution is sufficient to prevent clogging of the gills, and sufficient to provide an adequate supply of dissolved oxygen for purposes of respiration, yet it further appears from the evidence of this investigation that such occurrences as outbreaks of disease amongst fish due to the presence of sewage-borne micro-organisms is a possibility of some significance to Health Authorities in whose sanitary areas sewage is being deposited in rivers, estuaries, or on to the sea-shore. As a corollary the above conclusions further serve to emphasise the importance of the possibility of the transmission of disease by fish inhabiting sewage-polluted areas, and more especially by shell-fish, whose peculiar constitution, mode of life, feeding, and texture render them specially liable to harbour pathogenic bacteria.

In conclusion, I wish to avail myself of this opportunity of expressing my indebtedness to Dr. T. W. Fulton, Scientific Superintendent, for the facilities and assistance which I have readily received while working in the Marine Laboratory.

VI.—NOTES ON THE EGGS OF THE ANGLER (*LOPHIUS PISCATORIUS*), HALIBUT (*HIPPOGLOSSUS VULGARIS*), CONGER VULGARIS, AND TUSK (*BROSMIUS BROSMIE*); A YOUNG ARNOGLOSSUS, *sp.*; ABNORMALITIES IN *LOPHIUS*, *GADUS*, *RAIA*; DISEASES IN *GADUS*, *PLEURONECTES*, *ONOS*, *ZOARCES*; OCCURRENCE OF *HIMANTOLOPHUS RHEINHARDTI*, AND *CLUPEA PILCHARDUS*; THE EFFECTIVENESS OF A SEINE-TRAWL IN A SMALL POND. By H. CHAS. WILLIAMSON, M.A., D.Sc., F.R.S.E., Marine Laboratory, Aberdeen.

(Plates II.-VI.)

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The Larvæ of the Angler (Lophius piscatorius).

The larvæ of the American *Lophius piscatorius* have been described by Agassiz,* and those of the British example by Prince.†

An opportunity occurred in July, 1907, of studying the larvæ of this fish. A large mass of the spawn was sent in a herring-barrel to the Laboratory by Mr. Caird, Sandhaven. It arrived on the 15th July. Many of the eggs were alive when the mass was transferred to a tank of sea-water.

The embryos, which were black, were already moving about inside the eggs. The oil globule was also pigmented black. The general appearance of the embryo did not seem to indicate that it was in a very advanced stage of development; the tail of the embryo was very short. As was pointed out by Prince, the short tail only partially encircles the yolk when the embryo is ready to emerge.

* *Proc. Amer. Acad. Sci.*, 1882.

† "Notes on the Development of Angler Fish (*Lophius piscatorius*)," 9th Annual Report of the Fishery Board for Scotland, for 1890, Pt. III., p. 343, 1891.

Some of the larvæ had hatched out by 17th July. One is shown in fig. 2, Pl. II. After preservation in formaline it measured 5.5 mm. in total length. The head-end of the larva is very black. The oil globule has a large amount of black pigment associated with it. The pectoral and pelvic fins are short and rounded. The first head filament is seen as a thick papilla rising from the hind region of the head.

In a specimen examined five days later (fig. 10), two of the head filaments are visible. The young form, after preservation in formaline, was 6 mm. long. The anterior filament is already long; the posterior one is very short. The pelvic fin is now much elongated, and is a narrow process.

Another which was taken from the tank on 24th July, *i.e.*, seven days after the larvæ were first noticed, possessed three head filaments (fig. 9). In formaline it measured 8 mm. in length. The pelvic fin had increased in size; a small angle at the base of the fin indicates the rudiment of the second branch. The yolk was much reduced in quantity, but there was still some present. The eyes of the little fish when alive were blue.

On 29th September, *i.e.*, about ten weeks after the arrival of the eggs, the sole remaining larva was examined (fig. 6). It measured, when preserved, 9 mm. in length. The three head filaments were rather longer than in the stage just described. The pelvic fin had further increased in length; it was now about half the length of the fish. It had, moreover, a short second branch.

I obtained a young *Lophius piscatorius* in Loch Fyne, near Otter, in a tow-net worked horizontally about 5 fms. below the surface on 28th July, 1899. It is shown enlarged in fig. 17. It seemed to be still in the larval condition, although I was not able to make out whether there was still yolk present or not. It was examined after preservation in alcohol. It was quite black, except for its colourless marginal fin, and the colourless sub-epidermal spaces on the head. The tail was twisted, and that prevented an exact measurement of its length. It was then about 7 mm. in length. The operculum (*operc.*) was comparatively large. The pelvic fin was a single branch, with a broadened base. Only two head filaments were present. A parasite (*p.*) was adhering to the anal marginal fin.

The sketches here given illustrate stages which differ slightly from those described by Prince. The drawings of Agassiz have been reproduced in "Scandinavian Fishes," and also by Gill.* They also differ in details from the present material. In the latter the second branch of the pelvic fin was only visible in the last described stage, whereas it was a long branch in one of Agassiz's figures, which, judged by the size of the head filaments, would be near that of my fig. 9. Prince's larva of the fifteenth day approximates the condition shown in fig. 6. He describes the histological structure of the embryo and of the larvæ of one, nine, and fifteen days. A post-larval form, 7 mm. in length, was described by McIntosh and Prince.† The changes between the advanced larva described by Prince and this post-larva are inconsiderable.

The head filaments are much further back in the larva than they are in the adult. In the latter the first filament occupies a position close to the upper lip. The head filaments are supplied from the last cranial nerve (*vagus*). The branches to the filaments run forward over the top of the skull.

A sample of the spawn of this fish was obtained on June 25th, 1908, five miles east of Loch Bracadale, Skye, by Mr. Alex. Mitchell, Lossiemouth. Mr Mitchell, who had attended the class for fishermen at the Laboratory, preserved a portion of the spawn and forwarded it to me. It seems probable that the spawn of this form may not always reach the surface.

* "The Life-history of the Angler." *Smithsonian Miscellaneous Collections*, No. 1569. Washington, 1905.

† "Development and Life-histories of Teleostean Food and other Fishes." *Trans. Roy. Socy. Edinburgh*, Vol. xxxv., Pt. iii., 1890.

The Ripe Eggs of the Halibut (Hippoglossus vulgaris), Flem.

The ripe eggs of the Halibut have been obtained on two occasions from the fish-curing yard of Mr. Angus, Aberdeen.

Holt and M'Intosh have described the ripe eggs of this form, and little remains to add to their descriptions. I have, however, made out what I regard as a second investment to the egg. In addition to the zona which is so prominently cross-hatched with short intersecting lines (z., fig. 8), there is a delicate vitelline membrane closely investing the yolk. This was seen crumpled in one of the eggs (*vt.*, fig. 7).

On 25th January a roe was obtained which had some clear eggs in it. The fish had been caught by a trawler 145 miles E.N.E. of Aberdeen in 65 fms. Some of the ripe eggs were measured in sea water. They varied from 2.75 to 3.2 mm. in diameter. Some of the ripe eggs were not yet free from the follicle. Two of these measured 2.7 and 3 mm. respectively. Some white opaque eggs measured 1.8 to 2 mm. in diameter. This is probably the maximum size of the white yolked egg.

A running halibut was observed by Mr. R. Thompson, at Aberdeen, on March 1. It measured 175 cm. in length, and had been captured by a steam liner on the West side of Scotland, viz., Flannan Islands, 12-13 miles W. by N. $\frac{1}{2}$ N.

Another fish which measured 4 feet 3 inches (127 cm.) in length was ripe on March 2.

On May 2 a quantity of ripe ova was sent to the Laboratory in a small box. The halibut from which the eggs had been taken was described afterwards as being about 4 $\frac{1}{2}$ feet (130 cm.) in length. It was believed to have been caught on the Viking Bank, between Shetland and Norway. The eggs formed a fluid mass, but they were quite free from one another. They were quite translucent and showed no oil globule. They measured from 3 to 3.35 mm. in diameter.

M'Intosh had examined the ripe eggs taken from a halibut caught about 150 miles E.N.E. from Peterhead in April. The present records extend the spawning period for the northern part of the North Sea to five months, viz., January to May.

The Eggs of Conger vulgaris.

All the specimens of this species here dealt with were kindly supplied by Mr. Eunson, fish merchant, Aberdeen.

Two Congers measuring 6 feet 1 inch (180 cm.) and 6 feet 3 inches (185 cm.) were examined on 13th November, 1908. The ovaries were very large, filling a large portion of the abdominal cavity in both. Eggs were issuing in a small quantity from the genital aperture. That circumstance was probably due to the rough treatment to which the fishes had been exposed. The eggs were white, opaque, and measured from .47 mm. to .65 mm. in diameter. An albuminous fluid exuded from the aperture with the eggs. It coagulated in sea water, binding the eggs together in a translucent matrix. In an hour or two afterwards the mucous had dissolved, setting free the ova. The eggs showed only a trace of a separation of the zona from the yolk. After preservation in formaline, some of the eggs showed a fairly wide peri-vitelline space.

In view of the fact that Cunningham* found that the ripening congers were undergoing a process of degeneration, attention was paid to the bodily structure. Both fishes were dark-coloured. One especially was black all over except for the belly, which was a little lighter in colour than the rest of the body. The second specimen had a dark-slate dorsum, with a light-slate-coloured ventrum.

* "Marketable Marine Fishes." London, 1896.

Parts of the fishes were left in a tub without any preservative, and two days later they were surrounded by a large quantity of watery fluid which had been derived from them. The fishes, although fat and full of flesh, seemed on arrival to be in a jelly condition. The skull was not soft, but there was a mass of jelly-like substance on top of it. The bones cut fairly easily, but the backbone of a conger 34 inches (85 cm.) long, which had a very small ovary, also cut fairly easily.

On October 30, a conger 4 feet 7 inches (140 cm.) long had large ovaries containing eggs which measured $\cdot 6, \cdot 55 \times \cdot 62$ mm. in diameter. Some eggs and a portion of the ovary were pressed out at the genital aperture. The eggs were white. After being in sea-water for two days a slight separation of the zona from the yolk was seen both in the free eggs and also in some of those attached to the portion of the ovary.

Three congeners were obtained on November 2nd. The largest, which was 5 feet $2\frac{1}{2}$ inches (156 cm.) long, had a large ovary, the eggs of which measured $\cdot 6, \cdot 55 \times \cdot 6$ mm. in diameter. As in the fishes recorded above, the eggs were opaque white. After being in sea water overnight three eggs which had been pressed out by the genital aperture showed a slight separation of the zona from the yolk. No translucent large eggs were visible in the ovary. The fish was in very good condition.

Two smaller congeners, 3 feet $7\frac{1}{2}$ inches (109 cm.) and 3 feet $10\frac{1}{2}$ inches (126 cm.), had small ovaries in which the largest eggs measured $\cdot 12$ and $\cdot 15$ mm. respectively. The eggs were translucent.

The bones of the skull, and of the vertebral column of the largest fish, were more easily cut through with a knife than the corresponding bones in one of the smaller fishes. The largest fish was very black on the dorsum, while the smaller fishes had a slate-coloured back.

Two other specimens were obtained on November 4. They measured 4 feet (120 cm.) and 4 feet 2 inches (125 cm.) respectively. In both the eggs measured $\cdot 15$ mm. in diameter. The smaller fish was of a light-slate colour, with the edge of the marginal fin black. The snout was not so rounded, nor did the eyes appear so large, as in the large specimens just recorded. The flesh was not jelly-like. The skull was difficult to cut through, but the vertebral column was easily cut across.

On December 8, a black jelly conger was examined. It was very fat. It measured 5 feet $6\frac{1}{2}$ inches (165 cm.) in length. A piece of the ovary had been pressed out at the genital aperture. The eggs were opaque white, and measured $\cdot 4\text{--}\cdot 55$ mm. in diameter. Another fish which was received on December 24 was examined after it had been in formaline. The ovaries were developing. The largest yolked eggs were $\cdot 4$ mm. in diameter.

In February, seven congeners measuring from 3 feet 3 inches (97 cm.) to 4 feet 5 inches (132 cm.) in length were examined. They had all small ovaries. The eggs observed in two specimens were $\cdot 17$ and $\cdot 2$ mm. respectively in diameter.

Five fishes were obtained in March. They measured from 3 feet $1\frac{1}{2}$ inches (93 cm.) to 4 feet $3\frac{1}{2}$ inches (128 cm.). The smallest fish had ova $\cdot 1$ mm. in diameter, while two, measuring 4 feet 1 inch and 4 feet $3\frac{1}{2}$ inches, had eggs $\cdot 25$ mm. in diameter. These eggs were visible to the naked eye.

In April, a specimen 5 feet 6 inches (165 cm.) had white yolked eggs measuring from $\cdot 25$ to $\cdot 5$ mm. in diameter. This fish was thick and in good condition.

One conger was dissected in May. It was 4 feet $3\frac{1}{4}$ inches (128 cm.) long. The eggs were whitish, and measured $\cdot 15$ mm. in diameter.

Two examples obtained on July 11 measured 2 feet 7 inches (77 cm.) and 4 feet 1 inch (122 cm.). The eggs measured $\cdot 12$ mm. and $\cdot 2$ mm. in diameter respectively.

In August, six congeners measuring from 3 feet $1\frac{1}{2}$ inch (93 cm.) to 4 feet 3 inches (127 cm.) were examined. The eggs varied from $\cdot 12$ to $\cdot 17$ mm. in diameter.

Two congers examined in September measured 4 feet 4½ inches (131 cm.) and 4 feet 5¾ inches (134 cm.) respectively. The larger specimen was the darker in colour, and its flesh was not so firm as that of the small fish. The ovary of the latter was small; the eggs were white and measured .22 mm. in diameter. The larger fish had large ovaries, the eggs in which varied from .25 to .55 mm. in diameter.

The largest eggs obtained from the conger by Cunningham were opaque white and measured 1.0 mm. in diameter.

Eigenmann* has provisionally described a pelagic egg which was obtained in the waters of the United States as that of *Conger vulgaris*. The egg measured 2.4–2.75 mm. in diameter, and was "very closely related to No. 6 of the Murænoïd eggs of Raffaele."

The Eggs of the Tusk (Brosmius brosme).

Some fertilized eggs of the Tusk were sent by Mr. Duthie, Fishery Officer, Lerwick. They arrived on 12th May, 1905, and were examined next day. A number were alive and floating. They measured 1.2 mm. (1), 1.22 mm. (3), 1.25 mm. (14), 1.27 mm. (7), 1.3 mm. (1). The oil globule measured .25 mm. in diameter. The stage of development was early, viz., blastodisc stage, with the segmentation (or germinal) cavity formed (fig. 51). The oil globule had a bronze colour. The development of this form has been minutely described by McIntosh,† and, so far as my own observations go, they confirm that zoologist's description. As McIntosh pointed out, the zona is creased, and the oil globule may move freely through the yolk. On May 15th, of six eggs taken at random, four showed the segmentation cavity stage; the remaining two had the embryo half round the yolk, or a little further on. The dorsum of the embryo was covered with minute black pigment spots. The temperature of the water on this date was 12.1° C.

An embryo observed on May 16th had a great quantity of black spots dorsally on the head, body, and tail, but massed mainly over the abdominal region. There was a lumen in the gut, and the heart was visible, although not yet beating. There was only black pigment present, and it was all dorsal in distribution.

On May 18th one embryo completely encircled the yolk. Large round black pigment spots were scattered over the dorsum of the whole fish. The heart was beating. The oil globule was still large. The temperature of the water was 12.6° C.

May 22—Some eggs were found to have hatched to-day. In the larva the oil globule is posterior, and is of a bright bronze colour. There are brown-black bars on the little fish—viz., one on the head, a small one on the pectoral region, and a large bar about one-third of the distance between the anus and end of the tail. A jet-black patch on the tail is very marked. The pigment on the trunk is fairly scattered, and stellate in some cases. There are black pigment spots on the ventral half of the body posterior to the anus, showing a slight concentration midway between the anus and the large black bar of pigment. The eye is not black.

On May 26th the larva had the following naked-eye appearance:—It showed five black bars across its body. The big black eyes and black pigment on top of the head form the first bar. The second bar is a big black patch on the dorsum over the hind half of the yolk-sac. The third, fourth, and fifth bars are on the post-anal body. No. 3 is a jet-black patch at about one-third of the length of the post-anal body. The fifth is a big

* "The Age and Development of the Conger Eel." *Contributions from the Biological Laboratory of the U.S. Fish Commission, Woods Hole, Mass.* Bulletin for 1901, pp. 37–44.

† "On the Eggs of the Tusk." *Tenth Annual Report of the Fishery Board for Scotland* for 1891, Pt. III., p. 288. 1892.

jet-black patch on the base of the caudal fin. The fourth is a lighter and smaller bar situated midway between the third and fifth. The yolk-sac is long, and elliptical in shape. The bronze or golden oil globule is posterior. There was still a considerable quantity of yolk present.

On May 29th all the larvæ were dead.

A Post-larval Arnoglossus (Figs. 14 and 16).

The little fish, which was captured by the *Garland* at the mouth of the Clyde, between Sanda and Brennan Head, on 12th September, 1899, is shown enlarged in fig. 14. The tow-nets were being worked at 15 and 20 fathoms. The specimen is a little injured. It is symmetrical; the two eyes occupy practically identical positions on opposite sides.

In greatest length it measured 9 mm.; it was 4 mm. in greatest breadth. The number of rays in the dorsal fin was 79+, and in the anal fin 56+. The fin-rays were not clearly separated off in the posterior part of the dorsal marginal fin, nor at either end of the anal marginal fin. The fin-rays are formed of a number of longitudinal strands. The vertebræ were made out to be about 39; they were counted by aid of the muscle segments. One tooth was made out on each side in the upper and lower jaws.

The most noteworthy feature of the little fish was the presence on the forehead of two very long delicate filaments. These filaments were jointed, and proved to be the two halves of the "single cephalic" tentacle. Gunther* described and figured certain larval Pleuronectids which were obtained by the *Challenger* Expedition off Sierra Leone. They measured 6 and 7 mm. in length, and they had the long frontal filament. They evidently belong to the genus *Arnoglossus*. The possession of this tentacle characterises, as Raffaele and Ehrenbaum showed, the early stages of *Arnoglossus*. An enlarged drawing of the top of the head of this example is given in fig. 16. A little posterior to the first ray (1) there is a second (2), which is larger and stouter than the ray that succeeds it. It is not clear whether this ray is shorn of its natural length. It is injured, but whether shortened or not I did not make out. It is not like the next succeeding rays (*fn.*), split into many fine strands. It appears to have a different character from them.

The top of the head is furnished with short needle-like spines on either side of the beginning of the dorsal fin, and coming down for a little distance on the right side of the skull. Ehrenbaum† has described several young individuals of this genus. Lately the question of the discrimination of the species of these larvæ has been treated by Petersen.‡ I have not been able to satisfy myself as to the specific identity of the specimen just recorded.

A RARE ANGLER—*Himantolophus Reinhardtii*, Lütken. (Figs. 22, 27, 28).

A specimen of this fish was landed at Aberdeen in March 1908, by a trawler which had captured it in Icelandic waters. It was courteously presented by Mr. Eunson. It was preserved in formaline for some time before being examined.

It is jet-black in colour, on the ventrum as well as on the back and sides, except where some pale grooves on the skin give it a greyish tinge. It has a dumpty tapering body, being very high in comparison to its length (fig. 27). It measures 16 inches (40.5 cm.) in length, 8½ inches (21 cm.) in breadth, and 4⅞ inches (12 cm.) in greatest height. When viewed from above it is pear-shaped (fig. 22).

* "Report on the Pelagic Fishes collected by H.M.S. *Challenger*." *Zoology, Challenger Expedition*. Part LXXVIII. 1889.

† *Nordisches Plankton*, Eier u. Larven von Fischen, I., p. 190. Kiel, 1905.

‡ *Meddelelser fra Kommissionen for Havundersøgelser*. Fiskeri, Bind. III. "On the Larval and Post-larval Stages of Zeugopterus, Arnoglossus, Solea." Copenhagen, 1909.

On top of the head there is a single large lure, remarkable both from its size and also from its complexity. The stout stem is hinged at its base, in a depression in the frontal region, between the eyes. It terminates distally in a bladder-like expansion from which wave two pairs of filaments, viz., a very short pair and a long pair. A third pair of filaments is attached to the base of the bladder portion, and below that point come off two more pairs of filaments. All the filaments taper, and the middle pair (or one at least of them) consisted of two branches. The stem and its five pairs of filaments are covered with little membranous scutes which have rounded apices. The following are the lengths of the filaments:—Second pair, 15 and 17.5 cm.; third pair, one side, two branches, common portion, 6.2 cm.; long branch, 16 cm.; short branch, 5.8 cm.; fourth pair, one side, 14.2 cm.; fifth pair, one side, 4 cm.

The second marked feature about the fish is the presence of large membranous scutes on the skin. The scutes vary in size, but they are all of one general form (fig. 28). They resemble very closely the shell of the limpet (*Patella vulgata*), and may be not inaptly termed *Patella*-scutes. As will be seen from the drawings, they are well scattered over the body, some being found on the pectoral fin. They are present in great number on the ventral surface. The scutes have whitish apices, which are stiff, and in many cases fairly sharp. Some scutes were noticed which had twin apices. The scutes are arranged over the body in a rough but not perfect symmetry.

The eyes are small; they are lateral in position and stand protruding on little stalks (fig. 22). In *Lophius* the eyes are sunk flush in an orbit, as in the majority of fishes.

The mouth is superior. The lower jaw is very deep. There is only one distinct row of mixed teeth in the upper and lower jaws, the larger teeth being on the inner, and the smaller on the outer side. The upper pharyngeal teeth are large, and the rosettes of teeth on the four gill-arches are prominent. There are no lower pharyngeals, and no palatine nor vomerine teeth.

There is a single dorsal fin; it has five fin-rays, and it is placed far back. There are no intervening rays between the lure and the dorsal fin. The last ray of this fin is united by web to the beginning of the caudal fin. The number of rays in the caudal fin is nine. A small anal fin, of apparently five rays, is present. It occupies a position opposite the dorsal fin. There are no pelvic fins. The pectoral fins are small, and they are quite different from those fins in *Lophius piscatorius*. In the latter the pectoral fin is thick and fleshy; it is broader distally than at its origin. It has, moreover, the tips of the first seven rays turned over on to the underside of the fin. The number of fin-rays is 26. In the present fish the number of rays was 16 on the left and 16 (? 17) on the right side. The rays were all soft and membranous. In *Lophius* the pectoral fin practically acts as an operculum. In *Himantolophus Reinhardtii* the pectoral fin is superior to the gill-opening.

The fish might be suitably compared to a small black stone on which a number of *Patella* (sp.) are fastened, and from the summit of which waves a stem of *Fucus*.

Lütken,* who first described this Angler, gave it the name *Himantolophus Reinhardtii*. Gill proposed to remove it to a new genus, *Corynolophus*. There does not appear to be any necessity for such a change. The fish might, I think, have been put originally into the genus *Lophius*. It is a typical Angler, and the points in which it differs from *Lophius* would constitute a good specific description.

The specimens described by Lütken† differed in the number of filaments attached to the lure (viz., from 6–9), and also in the extent to which the

* K. D. Vidensk. Selskab. Skriften, Nat. og Math. XI., 5. 1878.

† Lütken, Chr.—“Til Kundskab om to artiske Slægter af Dybhavs-Tudsefiske, *Himantolophus* og *Ceratias* (*Himantolophus reinhardtii*). [Avec un résumé en Français.] 2 plates. Vidensk. Selsk. Skr. 5 Række. Naturvidensk. og Math. Afd. xi. 5. Copenhagen, 1878, and *Ib.* Afd. iv. 5, Copenhagen, 1887.

filaments were branched. He said with reference to one of his examples—“The lure ends in a flattened disc, the skin of which is prolonged into two horns and eight elongated tentacles.” A drawing of the lure is given, and the filaments are branched in the following manner:—Left side, (1) 4 branches, (2) 4 branches, (3) 2 branches, (4) single; right side, (1) 2 branches, (2) 4 branches, (3) 2 branches, (4) single. In another specimen the lure had, in addition to the two terminal horns, nine filaments, branched as follows:—on one side, (1) 2 branches, (2) 3 branches, (3) 2 branches, (4) 2 branches, (5) single,—on the other side, (1) 4 branches, (2) 4 branches, (3) 2 branches, (4) single. Each branch had a swollen clear tip. Still another of these anglers had a lure bearing six filaments, with a single long terminal tentacle on the disc. Lütken did not think that one should search for specific characters in the lure, which is evidently variable. He said that the tips of the filaments were silvery and possibly phosphorescent. Lütken discusses the question as to whether *Himantolophus reinhardtii* is distinct from *Himantolophus greenlandicus*, Reinhardt.* The latter was described from a damaged specimen. Its lure, which is shown by Lütken, is very similar, but it had eleven filaments in addition to the two terminal horns.

There would probably have been no doubt as to the identity of Reinhardt's and Lütken's species if the number of fin-rays given by the former had not diverged comparatively widely from those determined by the latter. I give here a table comparing these data in respect to the Danish and Aberdeen specimens:—

Comparison between *Himantolophus greenlandicus*, Reinh., *Himantolophus reinhardtii*, Lütken, and the Aberdeen specimen in respect to the number of fin-rays.

	<i>Greenlandicus.</i>	<i>Reinhardtii.</i>	(Aberdeen.)
Dorsal fin, ..	9	5	5
Pectoral ,, ..	12	17	16 (17)
Anal ,, ..	—	4	5
Caudal ,, ..	—	9	9

There is no doubt that the Aberdeen specimen belongs to Lütken's species.

THE OCCURRENCE OF THE PILCHARD (*Clupea pilchardus*) OFF ABERDEEN.

A pilchard, 9 inches (22.5 cm.) long, was caught in a herring net 27 miles E.S.E. of Aberdeen on September 1, 1905.

A *Lophius piscatorius* WITH ONE EYE.

This angler was presented by Mr. Eunson. It is shown reduced in fig. 1. The fish was, except for the absence of the left eye, externally normal, but the head was slightly asymmetrical, as is indicated by the shape of the mouth. In the drawing only one sensory-olfactory process (sp) is shown on the upper lip. The other was probably absent although no written note was made of this point. When the skin was dissected off the top of the head in the region of the orbits (fig. 3), two main muscles were exposed, viz., a transverse muscle, *m.*, and a longitudinal muscle, *M.* On the blind side a portion of the longitudinal muscle, *M*¹¹, is inserted in the fascia of the orbit, while the remainder of the muscle, *M*¹, has some strands inserted in the same region. The two tubercles of the frontal which form the upper border of the orbit are exposed on the normal

* Memoires de l'Academie de Copenhague (1837).

side, but are covered with skin on the blind side. The latter are, moreover, smaller than the former.

When the brain was exposed (fig. 4) it was seen that the optic nerve which supplies the left side was absent. In the blind orbit there was a mass of muscles bound together which were apparently the eye muscles, *Em.*, that should have served the left eye. The pituitary body (*pi.*) is remarkable for its projecting a considerable distance in front of the brain. It is attached to the brain by a narrow tube, and is bound *in situ* to the fascia that lines the floor of the cranial cavity. The olfactory nerves arose from a small swelling on the anterior edge of the cerebral hemispheres. I did not make out this swelling in the brain of a normal *Lophius*. The sensory process on the upper lip receives its principal nerve supply from the olfactory nerve.

The under surface of the brain of the abnormal specimen is shown in fig. 5. A small nerve twig (*n'*) was found alongside the origin of the single optic nerve. It may have been a strand of the optic nerve.

For the purpose of comparison, dorsal and ventral views of the brain of a normal *Lophius* are shown in figs. 12 and 11.

Three Cases of Hermaphroditism in the Cod (Gadus callarias).

An hermaphrodite cod was courteously sent to the Laboratory by Mr. Downie, Fishcurer, Whitehills, on February 26, 1910.

The fish was 34½ inches (86 cm.) long. The roe was a large normal pair of ovaries with one small milt attached to the anterior extremity of the right ovary, and a similar small milt attached to the posterior surface at the line of junction of the ovaries. It was of an orange colour, and is shown in dorsal view in fig. 59.

The specimen was for a short time in alcohol before it was examined.

The ovary contained yolked eggs; the largest egg observed measured .8 × .9 mm. In the gathering part of the ovary (*non-ov.*, fig. 68), old empty egg-capsules and some small clear eggs were found. The latter did not exceed 1 mm. in diameter. The empty capsules were probably derived from eggs left in the ovary from the previous spawning.

The testis contained white milt, in which the sperms were free.

The testis at the anterior end is supplied with blood from the same vessel that serves the ovary. The stalk connecting the two organs was cut across close to the milt. The section (fig. 64) shows a large vein, *v.*, and several *vasa deferentia*. An artery (*ar.?*) was probably present, but was not made out. Another section made one-eighth of an inch nearer the ovary showed the two *vasa deferentia*, *VD.* and *VD'*, had united, but the two on the opposite side still remained independent. Where the stalk joins the ovary the wall of the latter exhibits in its thickness a number of slit-like lacunæ. They extend over an area measuring about one inch in diameter; it is indicated in fig. 59 by the dotted line *ch.* A section of the wall here is shown in fig. 60. Solidified white matter was found in one of these spaces. These lacunæ, which apparently serve as vesiculæ seminales, open eventually into the ovary. This is shown semi-diagrammatically in fig. 70. A pad of white solid matter resembling milt was found at the opening marked *o.*

A general view of the arrangement of the parts at the posterior end of the ovary is given in fig. 68.

A section through the stalk connecting the testis to the roe is shown in fig. 67. One *vas deferens* had a thick wall and was filled with white matter; the other had a thin collapsed wall, but it also contained a small quantity of white material.

The two *vasa deferentia*, after they arrive at the line of union of the two ovaries, were still to be traced for a little way down on either side of the blood-vessels there. On the internal surface of the ovary

there was much fibrous stroma-like tissue along the suture. Its presence makes the tracing of any openings of the *vasa deferentia* into the ovary difficult. The two wide *vasa* were soon lost. A section through the skin further down showed the blood-vessels and some slit-like vessels or lacunæ on either side. The actual entrance of the *vasa deferentia* into the ovary was not made out.

Another section (fig. 55) was made across the union of the ovaries. One large *vas deferens* enclosing some white matter was prominent. On the opposite side there was a number of lacunæ.

I am of the opinion that all these long chambers open eventually into the ovarian cavity. One or two that were followed by means of a bristle did so.

A second hermaphrodite reproductive organ was presented by Mr. R. Thompson. The cod was caught in the trawl off the West Coast of Scotland on April 3, 1910.

The roe is shown in fig. 54. One ovary, the left, was full-sized, measuring $11\frac{1}{2}$ inches, while the right one was only $5\frac{1}{2}$ inches long. Attached to the latter was a fairly large milt.

Both ovary and testis were ripe. Quite half of the eggs in the small ovary were clear.

Fig. 71 shows a section through the stalk connecting the testis and ovary. *Vasa deferentia* are seen in the middle region, flanked on either side by a pair of blood-vessels. The honeycombed *vas deferens* evidently opened into the ovary.

Mr. Thompson was able to record another hermaphrodite cod which had been captured at Lossiemouth on March 1, 1910.

There is little doubt that in the two cases described above, both the ovary and testis were functional. While in the first case the testis was apparently in advance of the ovary, in the second the two organs were ripe simultaneously. In the latter case there does not seem to be anything to prevent self-fertilisation.

In the Report of the Fishery Board for 1905, I recorded* several cases of hermaphroditism in the cod, and I referred to some previous records of this condition in Gadoids. I omitted, however, the case in the haddock (*Gadus aeglefinus*) described by Ramsay Smith.† In it the ovary and the testis appeared to be developing *pari passu*.

Johnstone‡ has published an account of the hermaphrodite condition in the Hake (*Merluccius vulgaris*).

A Peculiar Cod (Gadus callarias) from Loch Fyne.

A cod measuring 82 cm. in length was kindly sent by Mr. Dan M'Lachlan, who attended the course of instruction for fishermen in 1909.

The fish attracted attention from its apparently abnormal shape. Its head was said to resemble that of a ling (*Molva molva*). It is shown reduced in fig. 19.

The external colouration was normal. The ovary was large, and it was not pigmented. The number of vertebræ was 52, quite an usual number. I found nothing abnormal in the head or skull. The teeth were said to be larger than might be expected in a cod of this size. I found, however, that they resembled much the teeth in some skeletons of this fish. In the latter the teeth were not quite so stout, although equally long. But that fact might be accounted for by the drying of the skull.

* "On Two Cases of Hermaphroditism in the Cod (*Gadus callarias*). *Twenty-fourth Annual Report of the Fishery Board for Scotland for 1905, Part III., 1906, p. 290.*

† "A Case of Hermaphroditism in the Haddock." *Ninth Annual Report of the Fishery Board for Scotland, Pt. III., p. 352.*

‡ "An Hermaphrodite Hake." No. XV. *Report for 1906 on the Lancashire Sea-Fisheries Laboratory and Sea-Fish Hatchery.* Liverpool, 1907, p. 209.

The post-clavicle is a bone which varies much, and at first sight its representative in the Lochfyne specimen gave room for doubt, but it, I found, agreed also with its counterpart in other cod.

Although the fish was a little misshapen, I do not think it was other than a normal *Gadus callarias*.

Stone in the Bladder of a Cod.

Mr. M'Lachlan also forwarded an urinary bladder of a cod which contained a large stone.

The roe, with the urinary bladder attached, is shown reduced in fig. 13. The roe, which was ripening, measured $4\frac{1}{2}$ inches in greatest length. The urinary bladder consists of two lobes, one which is practically of normal size (*lo.*), and the other very much enlarged (*lo*¹). The latter contained a large stone, which is shown in natural size in fig. 17. The ureter (*ur.*) had been cut away. The drawing of a normal urinary bladder (*ur. bl.*) is provided in fig. 18. It is made to the same scale as fig. 13. Dr. Milne, University College, Dundee, informs me that in its chemical composition the stone resembles the urinary calculus of the human subject.

Several smaller calculi were found in the interior of a cod at Aberdeen. They had evidently been in the urinary bladder. The largest was about $\frac{1}{2}$ -inch in diameter. They were not perfectly spherical.

Cod Bitten by a Cephalopod Mollusc? (Figs. 29 and 34.)

Two prominent scars (*scr.*) were found on the shoulder of a large cod.

In the fresh condition the scars had a greenish colour. They appear to have been due to the bites of cuttlefish (*Loligo* or *Octopus*), as described by M'Intosh.* The part had been preserved in formaline before examination.

The sores have filled up with tissue consisting of fascia and muscle. The ends of two ribs (*r.*, fig. 94, shown in dotted lines) are tightly bound to the posterior scar, while the anterior scar has below it the head of the post-clavicle (*pt. cl.*, *ib.*), which has been exposed apparently by the excision of a portion of the clavicle. The head of the post-clavicle is normally covered by the clavicle.

A section through the larger scar is shown in fig. 29. This scar has a distinct rim or margin (*rm.*, figs. 29 and 34). The epidermis is absent from the uninjured skin, having evidently been rubbed off. The section shows to the right the normal derma (*d.*), containing the scale-pits (*scp.*), and having its outer layer pigmented (*p.*). The pigmented layer ends at the edge of the scar. On the surface of the scar there is a soft layer of dead tissue (*d.t.*), greenish in colour. Beneath it is seen the live tissue, which is also stained a pale green. The scar has been healed by the lateral outgrowth of the tough white derma. It forms the broad rim (*rm.*). The part of the scar within the rim, and next to it, is formed by the great development of the lighter layer of fascia (*f.*) below the derma, which has accompanied the latter in its outgrowth. The central part of the wound (*c.*) is occupied by a pad consisting in its outer rind of fascia and fibres tightly bound together. It forms a protective layer which is not sharply separated off from the muscles beneath. In parts the cortex can be split longitudinally in the same sense as the run of the muscle-bundles; in other parts the rind will not split readily.

An encysted parasite was embedded in the scar. It resembled much the trematode cysts found in the skin of the whiting (*Gadus melanngus*). *Vide*

* (1) "Injuries to Baited Hooks and to Fishes on the Lines." *Fourth Annual Report of the Fishery Board for Scotland* for 1885, p. 203. 1886.

(2) "Further Remarks on Injuries to Food-Fishes on the Lines." *Tenth Annual Report of the Fishery Board for Scotland* for 1891, Pt. III., p. 299. 1892.

below. There was no black pigment associated with the cyst, and the larva within it was not so far advanced as those found in the whiting. I was able to make out no definite characters. The cyst measured $.75 \times .62$ mm.; it had a very thick rind.

Injured Gadus callarias.

The small cod referred to on page 61 had lost the whole of its tail (fig. 41). The wound had, however, healed up, and the fish was well nourished.

On May 5th, 1902, a cod was got in the trawl in the Moray Firth which had some of the opercular and branchiostegal bones exposed. The branchiostegal membrane had been torn, and one ray projected, with the greater part of its length bare of flesh. It had a thick crop of Zoophytes and stalked infusors growing on it (fig. 42; s. indicates the outside of the skin of the fish). The bone was $2\frac{1}{4}$ inches long, and $1\frac{5}{8}$ inch was exposed. The surface of the bone was decaying, and could be scraped off as a white powder. Several small nudibranchs were found among the Zoophytes.

Tumours from the Cod (Gadus callarias). (Figs. 45, 52.)

The larger tumour was sent to the Laboratory on 26th February, 1907. It, along with a number of other abnormal specimens, have been generously supplied by Mr. Angus. It had apparently been attached to the gullet. A mark had been observed on the wall of the abdomen, against which it pressed. It weighed 2 lbs., and measured $6\frac{1}{2}$ inches by $5\frac{3}{4}$ inches by $3\frac{1}{2}$ inches (fig. 45). It was fibrous, composed of laminae, concentric in parts, with radiating fibres. It was supplied with large blood vessels. An opening led into a narrow slit-like cavity, which is shown exposed in fig. 52. The surface of this cavity was in part white and clean; the remaining portions were discoloured, and had a dried substance adhering. One large vessel was discharging a thick whitish fluid into the cavity.

Prince* described a tumour from a cod. It was evidently a connective tissue capsule formed around a foreign body in the peri-visceral cavity; this foreign mass, like a large fragment of undigested food, lying outside the walls of the alimentary canal.

A tumour obtained on 18th February was attached to the wall of the stomach, within an inch of the pylorus. It is egg-shaped (fig. 57); it measured 4.5 cm. in length, 2.8 cm. in breadth, and it rose to a height of 2.5 cm. above the outside surface of the stomach wall. It is solid, and quite smooth externally, with fine blood-vessels showing as little red streaks.

The wall of the stomach is composed of two external layers of muscles and a thick white fibroid layer which forms the internal surface. The muscle-layers run at right angles to each other; they are bound tightly together. The thick white fibroid layer is almost as thick as the muscle-layers, and is separated from them by connective tissue. The muscles are inserted into the fibroid layer. The latter shows its surface marked all over with closely-set dimples.

The tumour seems to be composed almost entirely of muscle and fibrous tissue binding the muscle together. It has apparently been formed by the great local growth of the inner layer of muscles. The outer layer of muscles forms an outer coat to the tumour. External to the muscle there is a thin fibrous skin. The tumour is separated from the cavity of the stomach by the fibroid layer alone. Fig. 63 shows the inner surface of the stomach at the part. The position of the tumour is indicated by a dotted line. That part of the stomach wall is smooth, but there are ridges round it. A

* "On an Internal Tumour from the Abdomen of a Cod." *Tenth Annual Report of the Fishery Board for Scotland for 1891*, Pt. III., p. 324. 1892.

nematode is shown (*ne.*) in a hole in the stomach wall, from which it could not be withdrawn.

Tumour on the Tail of a Cod (24th November, 1909).

The tumour was a red-coloured mass projecting as a round swelling from the side of the fish just above the second anal fin (*tu.*, fig. 61). It was covered up with a soft white layer which has been formed by the coagulation of the secretion poured out of the sore.

The coagulated secretion extends on to the skin on both the anterior and posterior sides of the tumour. Underneath the secretion the derma is bleached. Anterior to the point *p.* (fig. 58) the pigmentation is normal.

When the sore was pressed a thickish and pale white fluid was poured out. The tumour was then like a sponge, from which the matter oozed at various openings. The secretion coagulated in water.

Under the microscope this fluid is seen to be composed of a granular fluid in which are yellowish rod-like or spindle-shaped bodies, apparently crushed and disorganised blood corpuscles, and pale round corpuscles containing bright granules.

A longitudinal section of the tumour is shown in fig. 58. The derma is thickened beneath the sore; the channels crossing this layer obliquely are very wide, they apparently give passage to blood-vessels. The connective tissue layer between the derma and the muscles is also much thickened and supplied with large blood-vessels. The cuticle is absent. The scale-pits (*scp.*) are enormously increased in size. They are filled up with a much-folded and branched ribbon-like frill (*fr.*). This frill is red, and it is well supplied with blood-vessels. The loops formed by the latter are well seen at the top edge. The frill is dotted all over right down to the bottom of the scale-pit with little black pigment spots. Its surface is covered, in parts at least, with little short tubules (fig. 62) which are arranged so closely that the tissue resembles a skin covered with hairs. In end view they appear round, with a circle which might be either a pore or a nucleus visible within them. In side view an oval body is seen within, near the tip. The little tubules break off and are found free in the secretion that is pressed out.

The frill is scalloped and is sub-divided into numerous irregularly-shaped pieces. It secretes the fluid, which lies between the folds, and collects in the middle of the scale-pit. In fig. 65 a surface view of a part of the tumour exhibits the frill (*fr.*) and the secretion (*se.*). Where the secretion is forced out of the tumour, the pits are completely filled up by the frill.

In the centre of the sore the inflammation and extra growth are inside the scale-pits. The latter are very large. In one, at least, a small scale was found. The scale in some pits is partially eaten away.

On the posterior side (*post.* fig. 58), beneath the secretion, the papillæ of the derma (*pa.*) are lengthening and becoming suffused with blood. They would eventually develop into frills I believe. The scale-pits posteriorly show a reddish hue.

In the derma the gland openings occur as very little clear spaces in the pigmented outer layer. Near the tumour these glands are enlarged and the region is slightly reddish.

The skin of the trunk along the base of the anal fin seemed to be drawn to some extent, but was not affected.

The tumour may have arisen in consequence of something having adhered tightly to the skin, to which it remained attached long enough to cause local inflammation. The secretion from the tumour can evidently cause this, as is shown by the condition of the skin at the edge of the tumour. The inflammation has resulted in the development of the frills from the derma both inside and outside the scale-pits.

On the ventral edge of the body, between the second anal and the caudal fins, there was a small sore (so. fig. 61). This may have been caused by some of the secretion having become attached at that point under shelter of the fins.

A whiting had a partially healed sore. The scar was 3 cm. in diameter, and seemed to have resulted from a tumour similar to that just described.

Tumours on the Lemon Sole (Pleuronectes microcephalus).

Tumours resembling that just described were found on a Lemon Sole in the spring of 1909 (fig. 66). Three of the sores represented a secondary condition in which the diseased skin had been removed either partially or wholly, as in the case of the most posterior tumour where the muscles are exposed.

The fish had been in formaline for some time before it was examined.

One tumour had a long process lying on the top of the skin (*tu.*). A longitudinal section was made through the tumour (fig. 69). It showed what appeared to be a group of cysts between which the derma was interdigitated. The cysts are, however, no doubt simply the solidified secretion. The solid is finely granular. The external process was granular in structure and was probably coagulated secretion. A scale from the outside of a part of the tumour was partly eaten away. It is shown semi-diagrammatically in fig. 56.

Disease in the Skin of Onos mustela.

In this connection it may be noted that a disease appeared in the skin of a five-bearded rockling a few days after the fish had been handled.

The fish, which was living in one of the tanks of the Laboratory, had become ripe. It was, however, unable to get rid of its eggs, and the abdomen became very much distended. I caused a considerable quantity of the ova to flow out by passing my fingers from before backwards along the side of the abdomen a number of times. The fish was replaced in the tank, and in a few days the skin over the region that had been rubbed was very much inflamed. When examined it was found that the epidermis was absent from the region.

Tumours in a Zoarces viviparus.

A viviparous Blenny (*Zoarces viviparus*) was obtained from the estuary of the Dee. Its body was much distended, and it was kept alive as it was thought to be carrying young (fig. 43). It died at the end of several months' stay in the tank, and when opened the swelling of the abdomen was found to be due to tumours which were located in the abdominal wall (*T. T.* figs. 36 and 43). They projected into the abdomen and reduced the cavity very much. The two hind tumours (*T.* fig. 36) met in the hind part of the abdomen. The abdominal organs were crushed to one side in the anterior region. A number of tumours were present in the tail portion of the body. The fish was sent to Dr. F. M. Milne, Pathological Department, University College, Dundee. From a preliminary examination he concluded that the tumours do not suggest a true new formation of tissue, but rather something parasitic (*sporidial*).

Spotted Whiting (Gadus merlangus), Cod (Gadus callarias), and Lythe (Gadus pollachius). (Figs. 24, 30, 32, 33.)

Four spotted whittings were obtained at Aberdeen in October and November 1909. They measured from 12½ inches (31 cm.) to 16 inches (40 cm.) in length. One of them is shown reduced in fig. 24.

In general appearance the fishes were well nourished and normal, except that they were thickly covered all over the body and fins with black dots. Under the lens, each black dot was seen to be a little oval translucent cyst surrounded by an irregular ring of black pigment. They are shown enlarged in fig. 30, where they appear shining through the scales.

In a section of the skin it is seen that the cyst occupies the whole thickness (fig. 33). It rests inferiorly on the layer of fascia (*l. l.*) between the skin and the muscles. It reaches above into the lower surface of the scale-pit (*scp.*). The epidermis is not shown in the drawing. Some of the cysts reach the surface in the inner part of the scale-pit, in which case they are, although surrounded by pigment, not visible from the outside.

The cyst measured $.35 \times .3$ mm. and the oval body within was $.22 \times .2$ mm. in size. When the cyst was dissected out of the skin it was found to be very tightly bound to the fibres (fig. 32), and these fibres formed a zone round the body; they did not cover its whole surface.

The trematode character of the larva was evident. The skin was longitudinally and transversely grooved. I was not able to make out any spinules on the skin. The cyst had two investments, the outer a thick rind, the inner a thin membrane closely applied to the larva.

The cysts were found also in the cornea, on the eyeball within the orbit, on the inside surface of the mouth, and some were sunk in the muscles of the dorsum, and head. They were revealed by the black pigment accompanying them. In the eye, some cysts which were lodged in the gelatinous matter between the cornea and the lens had no pigment.

A large number of cysts were found within the brain cavity, in the spinal canal, and in several spinal nerves. The nerves were distended at the points where the cysts were located. There was no black pigment associated with these. None were observed in the tissue of the brain or of the spinal column. Two cysts from the auditory organ measured $1 \times .5$ mm. and $.55 \times .4$ mm. Four empty capsules were observed in the same organ. A cyst was found between the muscles and the top of the skull. It measured $.7 \times .57$ mm.

The cysts found in the nerves, measuring $.6 \times .4$ mm. and $.55 \times .35$ mm. in size, contained larvæ that resembled exactly those of *Gasterostomum gracilescens* as figured by Lebour* (*Plate I., figs. 2 and 3*). They were larger than those in the skin, and contained young forms of a more advanced stage. The cyst had a double-layered investment. The larva exhibited a different appearance in its integument according as it was extended or contracted. In the latter case the rugæ were very prominent. Anteriorly the surface of the skin exhibited a net-work appearance. At the edge, the body appeared serrate and the backward directed teeth described by Johnstone† were made out. Posteriorly, while the faint transverse grooving was evident, no spinules were made out. In surface view the net markings on the anterior end were accompanied by comb-like structures which may have been groups of teeth. When the trematode is extended it is very difficult to make out the above-mentioned structures. The teeth were not definitely seen in that condition of the worm.

The pigment which surrounds the cyst does not apparently belong to it, because in certain regions the pigment was absent. The presence of the parasite would seem to stimulate the development of pigment in the surrounding tissue.

Four spotted whittings, measuring in one case 31 cm., were examined in February. The embryo parasites did not seem to be any further on than those described above. Four others were obtained in March. Of these, one

* Lebour: "Fish Trematodes of the Northumberland Coast." *Northumberland Sea-Fisheries Report for 1907.*

† "Johnstone: Internal Parasites and Diseased Conditions in Fishes." *Trans. Biol. Socy., Liverpool*, Vol. xix., 1905, p. 98.

was a ripe male. The fish were in sufficiently good condition. One cyst taken from a nerve had an embryo that appeared a little further advanced than those previously examined.

Parasites similar to the above were found in the skin of a small cod which had no tail. (*Vide* p. 57.) The fish in its mutilated condition measured $10\frac{7}{8}$ inches (27.5 cm.) in length. The cysts were of approximately similar size to those of the whiting, and had black pigment surrounding them. One cyst measured $.35 \times .27$ mm.; it had a thick rind.

Two small cod and two little lythe were infected with the same Trematode. The cod measured 7.5 and 8 cm. in length, while the lythe were 10 and 10.5 cm. long. One of the lythe was examined. The spots resembled exactly those on the whiting. They were scattered over the sides, fins, and eyeball. None was made out in the spinal nerves. One cyst measured $.35 \times .25$ mm.

The parasite is evidently *Gasterostomum gracilescens*.

Johnstone observed this species in the brain of *Gadus aeglefinus* and *Phycis blennoides*. He also found a *Gasterostomum* (*sp.*) encysted in the muscles of *Pleuronectes platessa*. The cysts were, in the case of the larger, faintly brown, or dull-red in colour. Lebour found the former species common in the nerves of the *Gadus aeglefinus*, *Gadus callarias*, *Gadus merlangus*, on the Northumberland coast. She does not mention its occurrence in the skin.

Nicoll* observed a very similar parasite (*Distomum, sp.*) in *Cottus bubalis*. He found the muscles, skin, bones, and layers of the eye impregnated with small masses of black pigment, accompanied by cysts containing Trematode cercariæ. The only parts of the fish not affected were the brain and abdominal organs. The pigment-spots appeared to follow the course of the blood-vessels, and they are probably spread throughout the body by means of the blood.

Nematodes in the Muscle of the Cod (Gadus callarias).

A codling was observed to have a large number of nematodes scattered through the muscles. The worm lay coiled up in a cavity which it has formed by pressing apart the muscles (fig. 26). The muscles do not appear to be injured at the part. The nematode is reddish-coloured at either extremity. It is enclosed in a light skin of connective tissue, and the cyst itself is lined with fascia which is bound to the muscles. The worm has thus two investments. The cyst is sometimes red-coloured owing to its being well supplied with blood vessels. The coils of the nematode pass through the fascia which often shows well developed blood plexuses, (*bpx.*, *bpx.*', fig. 20). In one case a pillar of tissue joined the floor of the cyst to the roof (fig. 31). The nematode was coiled round the pillar which was red with blood vessels.

A cod fillet containing similar worms had been prepared in the usual method. It had been in pickle for half-an-hour, and then had been in the smoke-kiln for the customary period, viz., from three-quarters of an hour to two hours. It was received on 17th December, and was kept until the 30th of the same month, by which time it was smelling offensively. Live worms were dissected out at intervals from the 17th to the 30th. The fish was, so far as it could be judged by smell, good on the 25th.

A piece of cod infected with these parasites was dried in the open air without any preservative. Three months later the fish was examined. It was quite hard. The worms when removed from the muscle were translucent, amber in colour. They were dry, flattened, and tough. When one was put

* Nicoll: "A Contribution towards a Knowledge of the Entozoa of British Marine Fishes." *Ann. and Mag. Nat. Hist.*, xix. (7), 1907, p. 66. See also *ib.* xvii. (7), 1906, p. 148; xx. (7), 1907, p. 244; iii. (8), p. 237; iv. (8), p. 1.

into water, either sea water or fresh water, it swelled up and became plump. It then gradually turned white. Shortly after the worm was put into the water a little movement was detected in one or two cases, but there was no clear evidence that the nematodes were alive. After they had been some time in the water no further movement was detected. Even when alive these worms are often very sluggish.

Sand-eels (Ammodytes sp.) and an Hermit-Crab (Eupagurus bernhardus) encysted in the abdominal cavity of the Haddock (Gadus aeglefinus), Cod (Gadus callarias), and Saithe (Gadus virens). Figs. 35, 38, 39, 40, 44.

A number of examples of this condition have been obtained among fish landed in Aberdeen. They have been kindly supplied by Mr. B. Erlandsson.

The sand-eels, after being swallowed by the fish, have escaped from the gut and passed into the abdominal cavity. There they have generally damaged the liver before they died. Sometimes they are found with the head or tail jammed tightly into the space between the reproductive organ and the peritoneum. They are covered with a material which resembles a hardened paste, and in some cases they are in part enclosed in a skin of connective tissue derived from the peritoneum. In this way they are reduced to a mummified condition.

The fishes, which had acted as hosts, had all been gutted; an opportunity did not therefore occur of seeing the condition of the gut.

One large sand-eel was most commonly found in the cavity, but in one case three small sand-eels were present.

Fig. 38 (Haddock, 6 Feb. 1909), represents a condition where the sand-eel (*s.*) $6\frac{1}{2}$ inches (16.5 cm.) long had pushed its head through the liver (*l.*) Posteriorly the fish was attached to the peritoneum and to a portion of damaged tissue (*g.*)

Fig. 39 (Haddock, 19 May 1909). In this case the head of the sand-eel was directed posteriorly. The tail had been pushed into the liver which had become attached (*at.*) to the peritoneum. Beneath the middle portion of the fish, that is, between it and the peritoneum, there is only a shred of liver tissue. The sand-eel was covered with a paint-like coat.

Fig. 40 (Haddock, 4 October 1909). Three small sand-eels, measuring $2\frac{1}{2}$ or $2\frac{3}{4}$ inches (6-7 cm.) long, (*s.*', *s.*"', *s.*''') were free in the abdomen. The ovary is much shrunk and wrinkled as if it had been a spent. Two of the sand-eels had their heads tucked in between the ovary and the wall of the abdomen. The ureter (*ur.*) was severed from the urinary bladder (*ur. bl.*), but that may have been done when the fish was gutted. The ovary had become attached to the peritoneum along the edge (*at.*).

Fig. 35 (Cod, 22 May 1909). The cod measured about 24 inches (60 cm.) in length. The sand-eel (*s.*) had poked its head into the loose peritoneum on the outer side of the testis. Small cycloid scales could be made out in the skin of the sand-eel which was completely dried.

Fig. 44 (Cod, 24 Sept. 1909). The sand-eel had in this case destroyed the liver, which is in three detached portions (*l.*, *l.*' *l.*'''). The portions (*l.* and *l.*''') seem healthy. The part (*l.*') is very dark, and unhealthy looking. The portion of liver in the anterior part of the cavity was enclosed in a loose skin (*sk.*) which was attached to the peritoneum and swim-bladder. In the normal condition the liver is here quite free from any attachment to these parts. The liver was as it were in a pouch. The sand-eel lay with its head pointed anteriorly, and having its tail poked into the mesentery between the two ovaries (*ov.*). There are additional growths of tissue attached to the peritoneum at (*x.*). The piece of liver is also attached to the peritoneum. Where new tissue is superimposed on the peritoneum the pigment dots in the latter are concealed or are only faintly visible.

A large sand-eel, $7\frac{3}{4}$ inches in length, was lying along the dorsal region of the abdominal cavity of a codling (March 11). It was thickly plastered with hardened paste. Its tail was twisted round the urinary bladder. The skin of the liver which had evidently been destroyed was attached to the peritoneum as a thickened wall along the ventral part of the abdomen.

Another codling had a very small sand-eel, $2\frac{3}{8}$ inches long, coiled up at the anterior end of the abdominal cavity. The anterior third of the fish was buried in the liver, and the liver had grown attached to the peritoneum.

A sand-eel was discovered in one saithe. It was adhering to the abdominal wall.

Fig. 47 is a drawing of an Hermit-Crab adhering to the internal surface of the abdominal wall of a cod. Dr. T. Scott kindly identified the crab as *Eupagurus bernhardus*. It is in perfect condition. The shell is clean, and quite hard. It covered a stretch of 3 inches (7.5 cm.). One of its limbs was in part covered with the white paste (*ps.*) and two were attached to the peritoneum at (*at.*). The remainder of the body was free. The crab had escaped from its Molluscan shell. Its chelæ and one walking limb had made impressions in the wall of the abdomen, that caused by the dactyl of the second pereopod, being $\frac{1}{4}$ -inch (6 mm.) deep (*x.*). A small strand of white tissue was attached to the dactyl, but not to the peritoneum. Lying between the pagurid and the wall of the abdomen were parts of the limbs of a smaller Crustacean apparently *Galathea* (*sp.*), and also a thin-walled tube quashed and torn.

A nematode was found close to the hermit-crab. It was dead. It was surrounded by small white concretions attached to connective tissue, and all over its surface were similar white bodies (fig. 48). Under the microscope it was seen that the concretions attached to the worm were under the integument. They, in many cases, had the skin raised into a papilla over them (fig. 50), indicating that they had probably been the larvæ which were trying to push their way out of the body of the parent. The larvæ were elongated bodies.

Barrett* described a sand-eel lying on the liver and partly attached to it. It was covered with a white coat which had become attached to the liver. He suggests that the sand-eel may have escaped from the gut to the abdominal cavity of the haddock by passing along a pyloric cæcum. And having once forced a passage to the blind extremity of such a cæcum, either it should force its way through the end, or that the dilated tube should break off at some point, giving to the passenger a tight-fitting cuirass, and at the same time setting it free in the abdominal cavity, there to die, and to become encysted partly by pressure and partly by inflammatory adhesion in some soft organ such as the liver.

While the mode suggested by this author might be the actual method of escape in certain cases, it nevertheless seems probable that if the sand-eel passed while alive from the stomach into the gut, it would be able to rupture the latter at any part. But the perforation of the alimentary canal is not due alone to the effort of the sand-eel, as the last instance described above shows. The hermit-crab, it seems evident, must have passed out by a perforation of the stomach. It does not appear likely that it could have made its way into the gut.

It is therefore not necessarily the case that either the sand-eel or the *Eupagurus* were the sole agents in causing the lesion which afforded them exit. A weakened condition of the wall of the stomach (due to parasites or disease) may have afforded the sand-eel an opportunity of rupturing it.

* "Note on the Liver of an Haddock in which a Sand-eel was Partly Embedded," *Third Annual Report of the Fishery Board for Scotland for 1884*, p. 70. 1885.

Abnormal Ovary of an Haddock (Gadus aeglefinus).

A peculiar roe of an haddock was received from Mr. Erlandsson on February 12, 1910 (fig. 51A). It was hard, tough, and of a red colour. It was the left ovary; it measured $2\frac{1}{2}$ inches in length. The outer surface was finely tuberculated or bossed.

It was evidently an ovary that had been ripe, but which had not been spent. Internally, the ovary was dry towards the rind. About the centre it was suffused with red. The eggs were semi-translucent and hardened. They were apparently still in follicle. The ovarian tissue was suffused with blood. There seemed to have been hæmorrhage inside the ovary.

Abnormal Skate (Raia circularis and Raia clavata). (Figs. 37, 49, 49A.)

An abnormality which, while not common, is not very rare, is the partial separation of the pectoral fin from the snout.

Three instances have come under my notice. A well marked case occurred in a male Cuckoo skate (*Raia circularis*) which was landed at Aberdeen in September 1909 (fig. 37). The separation extended backwards to the level of the edge of the orbit. The tips of the pectoral fins bore large hooked spines, similar in size to those that bordered the orbit. This is a character of the male fish; the female shows only small spines on the anterior corner of the fin.

If the lateral peaks be pressed in to touch the snout, a practically normal condition is attained.

It might be suggested that this abnormality may have been caused by a fisherman who had cut into the fore end of the skate and then set it free. The separation is, however, carried exactly along the dividing line between the snout and the fin, on either side. No part of the fin-rays or muscles was left attached to the snout. It would, therefore, appear probable that this condition has occurred naturally.

Two cases were observed in *Raia clavata*, and both of the fishes were female. One of these (fig. 49A.) measuring $18\frac{3}{4}$ inches across, closely resembles the *circularis*. The other (fig. 49) was somewhat different. This skate measured 18 inches across the body. The anterior ends of the pectoral fins are notched, but in a manner different from the cases just cited. The clefts are smaller and offer a wider angle. Here, moreover, the most anterior fin-rays and their muscles remain attached to the snout on either side. The angle between the fin-rays, that are directed anteriorly and those turned laterally, is filled with muscles in which the bundles run in two directions at least (fig. 50).

In this case also, if the abnormality has been artificially caused, the fish has been very accurately cut to form a symmetrical figure.

There were six pairs of external gill-openings. The sixth pair was not, however, functional. The slit was imperforate, being simply a depression in the skin.

Day exhibits a similar monstrosity in this species, and Johnstone* describes a small *clavata* which had clefts which entered the body nearly as far as the first gill-openings. The last fish was apparently in good health when it was captured. An example recorded by Traquair† was not so deeply cut as the preceding specimens.

* "Ray showing Arrested Development of the Pectoral Fins." No. xiv. Report for 1905 on the Lancashire Sea-Fisheries Laboratory and Sea-Fish Hatchery, Liverpool, 1906, p. 188.

† "Note on an abnormally developed Thornback (*Raia clavata*, L.)" *Annals of Scottish Natural History* for 1892, p. 29, fig. —.

On the Effectiveness of a Seine-trawl in a Small Pond.

On June 16th, some years ago, when the pond at the Laboratory was about to be cleaned, it was necessary to remove the plaice. This was done by means of a seine-trawl about 57 feet long. The pond measures 90 feet by 35 feet, but the whole of this area was not worked over. Eighteen feet of the shallow portion of the pond was not netted (shown shaded in fig. 53). The deep end harboured most of the fish, which were large plaice.

The seine (*ne.*, fig. 53) was run out and dropped down the front of the wall at the deep end. The ground-rope was allowed to sink and then each end of the net was drawn along one of the long sides. One end was taken across the pond near the shallow end and the two ends of the net hauled together in the corner. When the work was started, there was a depth of about $5\frac{1}{2}$ feet at the deep end and $2\frac{1}{2}$ feet at the shallow end, while at the intermediate portion, where the net was taken ashore on one set of drags, there were 3 feet of water. For the next haul the net was taken in the opposite direction, and hauled at the deep end. It was then worked to the deep and shallow ends alternately. During the experiment, the water was flowing gradually out of the pond, and after a time the men were able to take the net ashore on the dried shallow end. The trawling was continued as long as it was effective, that is, until about half of the bottom of the pond was dry. The water remaining then was very dirty with fine mud. There would be about 18 inches of water left at the deep end.

Seventeen drags were made, and the number of fish captured in each was recorded. The direction in which the haul was made is indicated in the following table by the letters "D" and "S." "D" indicates that the haul was made towards the deep end, "S" that the haul was made towards the shallow end.

Number of Drag.	Direction.	Number of Plaice.	Number of Drag.	Direction.	Number of Plaice.
1	S	24	10	D	7
2	D	16	11	S	24
3	S	15	12	D	4
4	D	4	13	S	9
5	S	22	14	D	4
6	D	13	15	S	10
7	S	35	16	S	4
8	D	4	17	S	2
9	S	25			

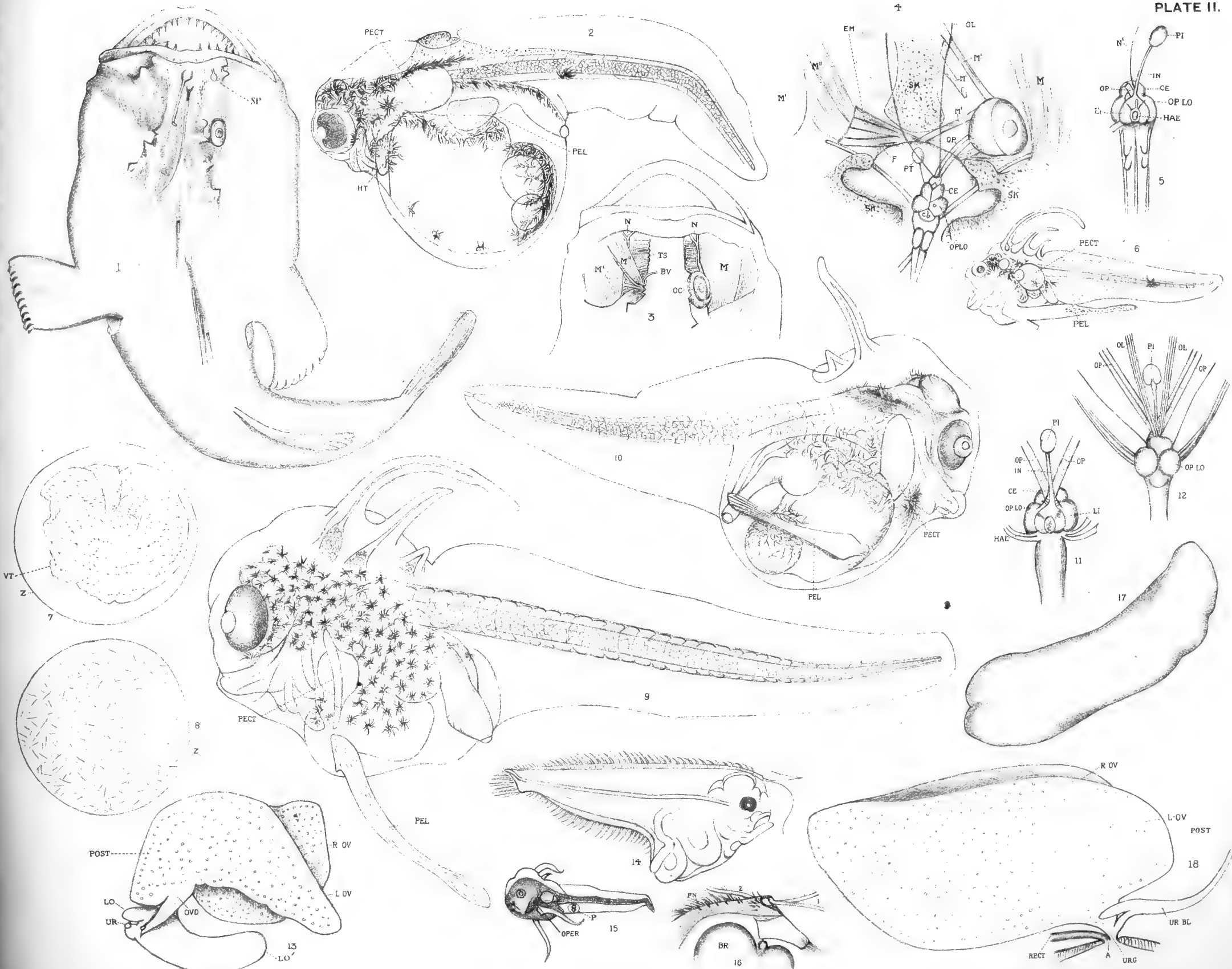
There were actually 282 large plaice in the pond. Of these 222 were taken by the net. 60 plaice were left in the pond.

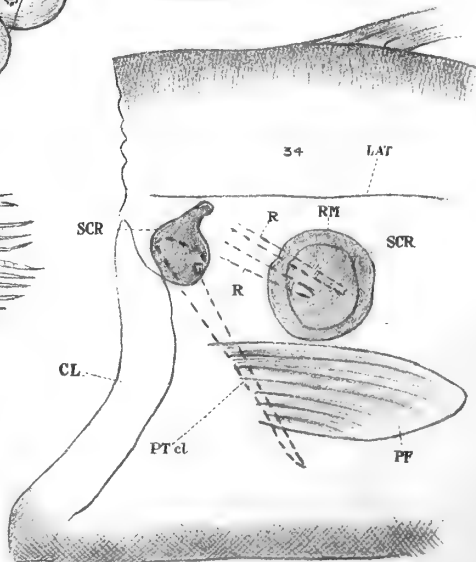
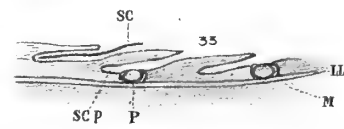
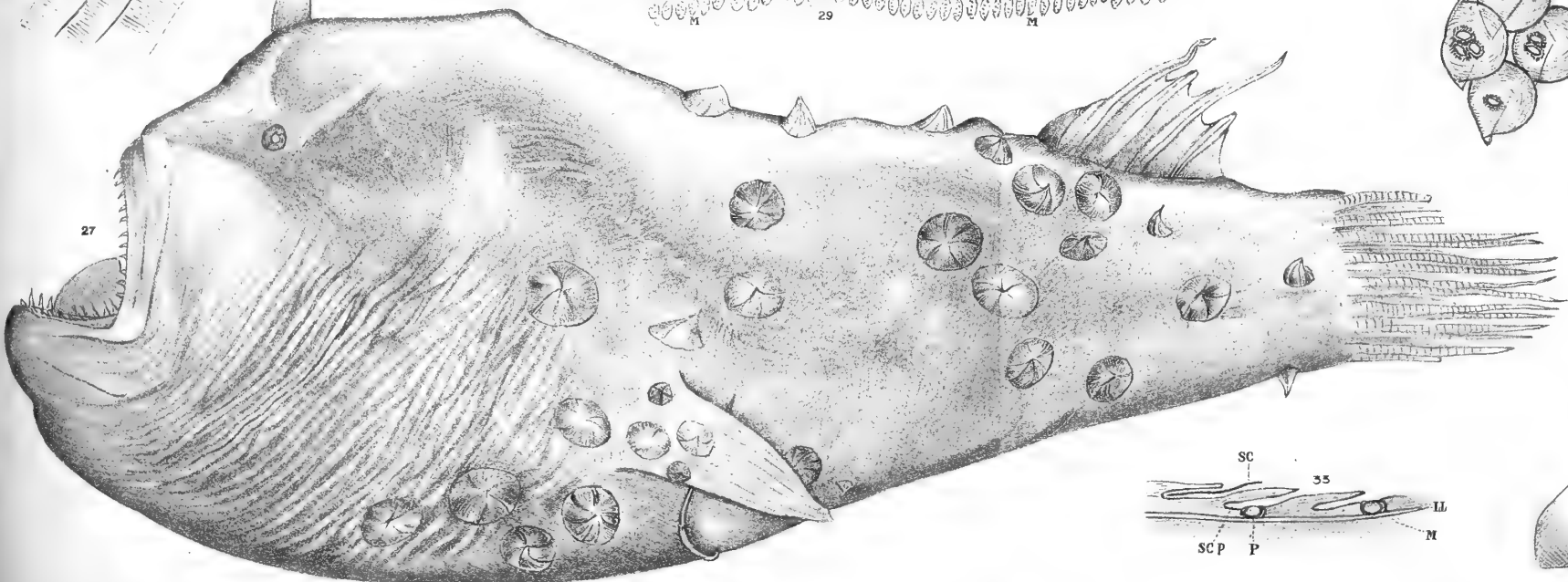
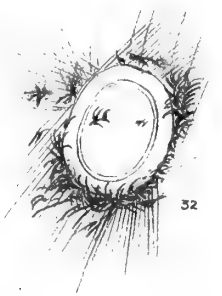
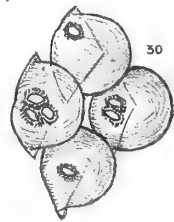
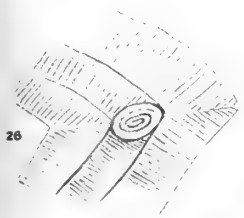
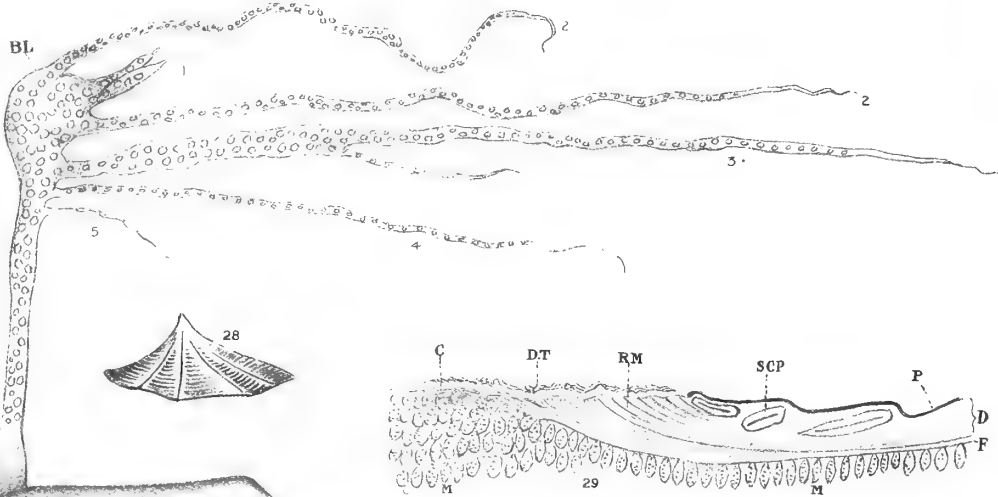
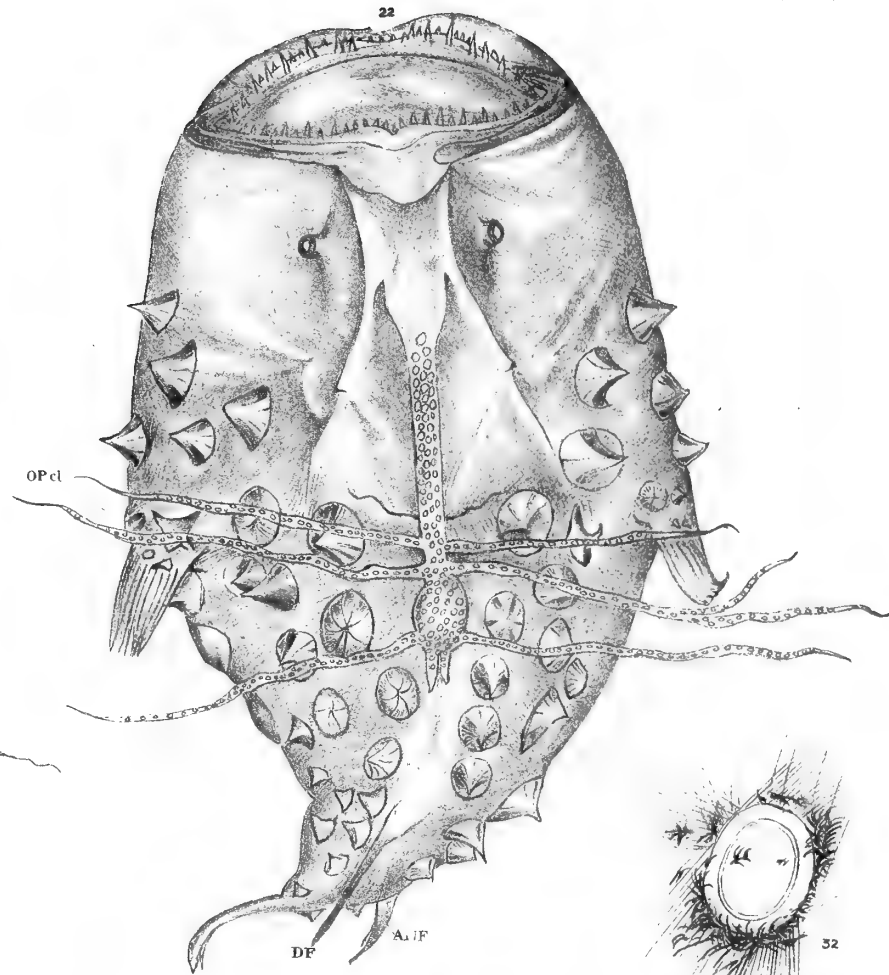
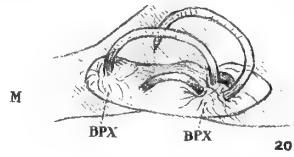
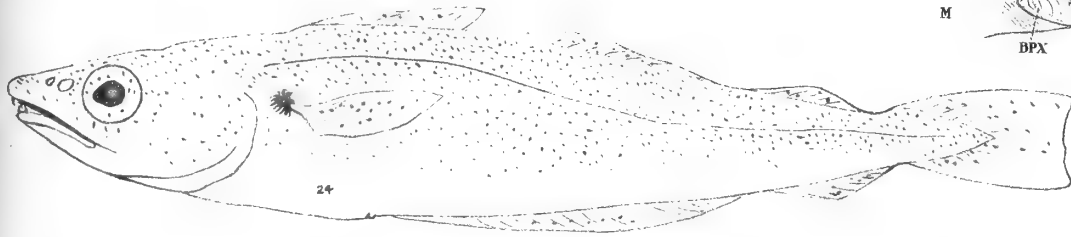
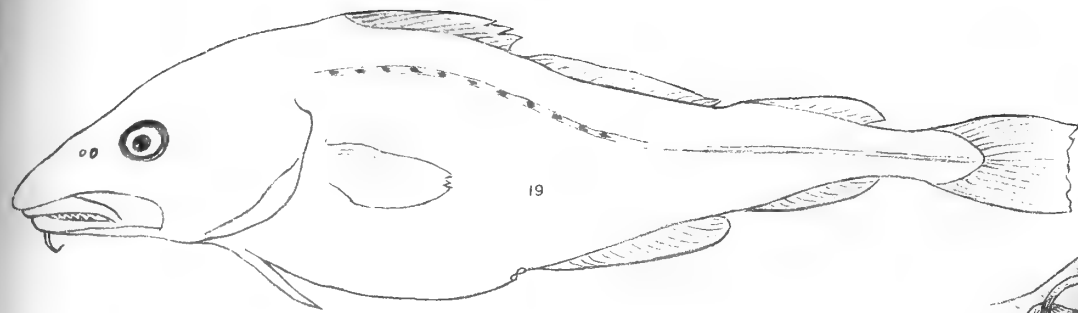
One of the plaice had not yet got rid of its ripe eggs.

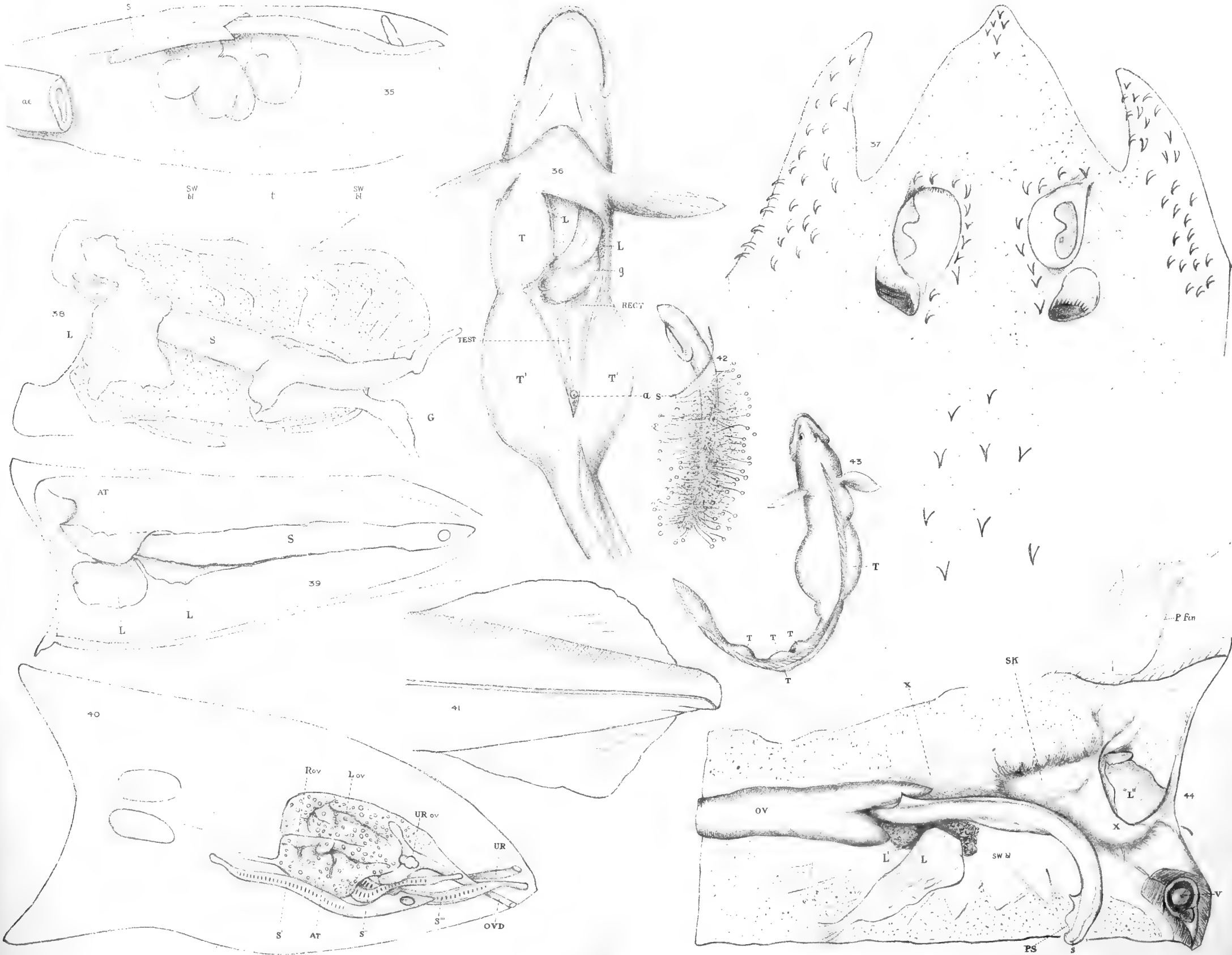
LETTERS USED.

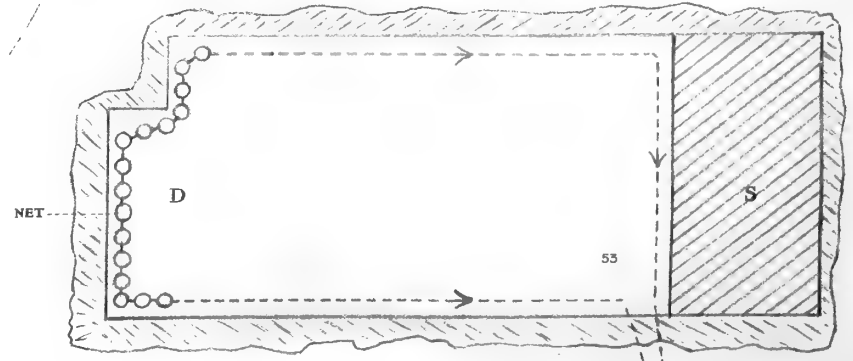
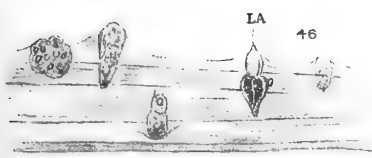
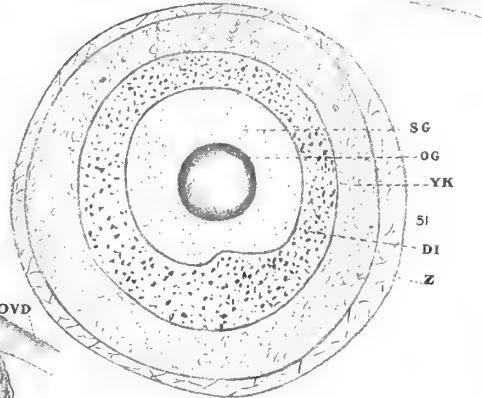
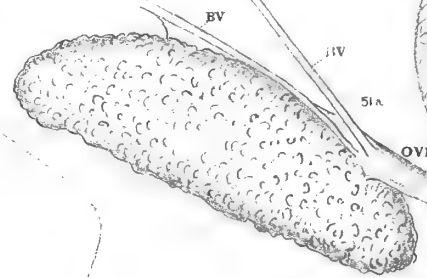
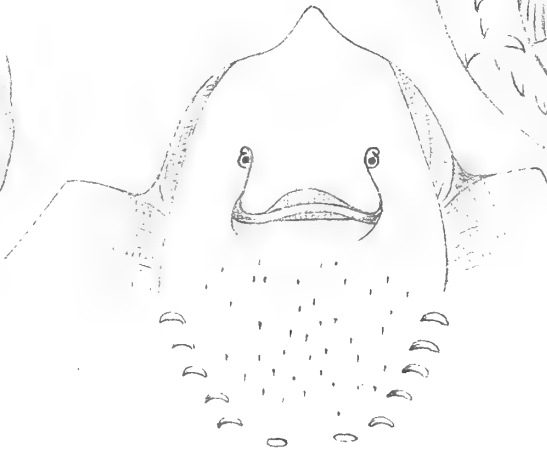
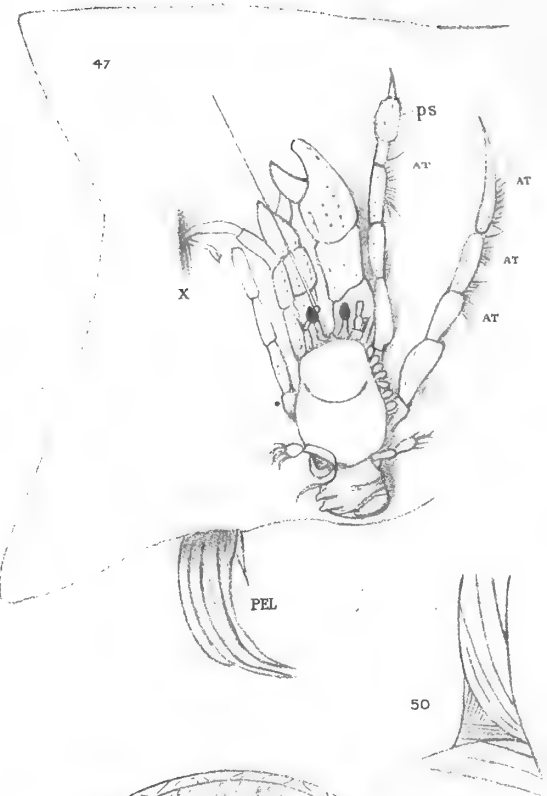
a.—Anus.
2 a.—Second anal fin.
ar.—Artery.
at.—Attached edge.
bl.—Bladder.
br.—Brain.
bv.—Blood-vessel.
c.—Central region.

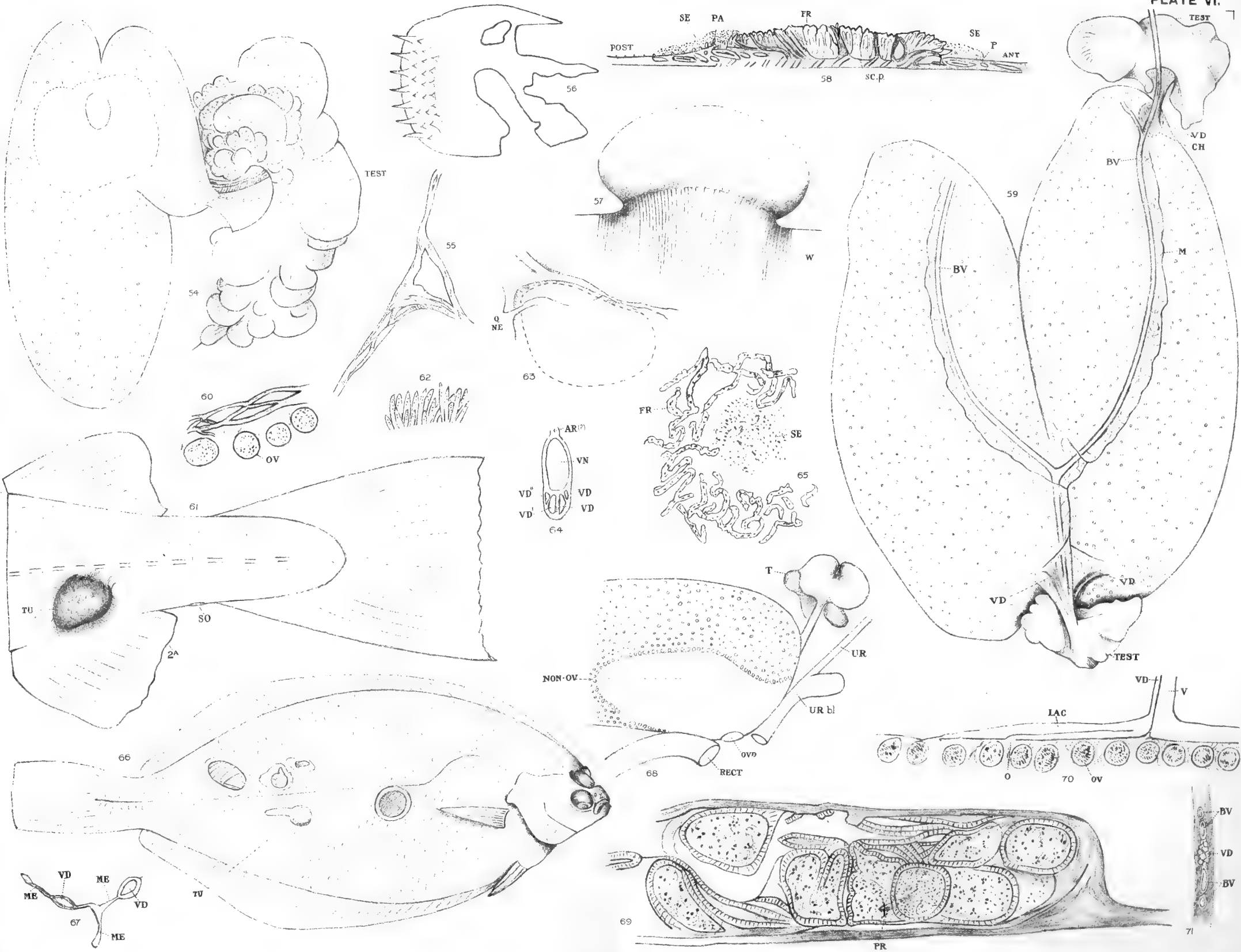
d.—Derma.
di.—Blasto disc.
bpx.—Blood plexus.
cl.—Clavicle.
d. t.—Dead tissue.
ce.—Cerebrum.
e. m.—Eye muscles.
f.—Fascia.











VII.—NOTES ON SOME TREMATODE PARASITES OF FISHES.

By THOMAS SCOTT, LL.D., F.L.S.

(Plates VII., VIII.)

One or two papers on parasitic Trematodes of fishes have already appeared in Part III. of the Annual Reports of the Fishery Board for Scotland, published in previous years. In the present paper four species, in addition to those previously published, are recorded, one of which appears to be undescribed.*

TREMATODA.

Fam. TRISTOMATIDÆ.

Genus *Callicotyle*, Diesing (1850).

CHARACTER.—Body thin, tolerably expanded; posterior sucker discoidal, nearly sessile, and provided with seven rays and two spines; the mouth without suckers.

Callicotyle affinis, new species. Pl. VII., fig. 1.

The Trematode recorded here has a close resemblance to *Callicotyle kröyeri*, Diesing, found on various kinds of skates (*Raia clavata*, *radiata*, and *batis*), but one or two obvious differences prevent its inclusion in the same species, and as I do not know of any other to which it can be ascribed, the name *Callicotyle affinis* may be given to it.

It differs from *Callicotyle kröyeri* in size, being nearly one and a half times longer; in shape it is broadly ovate, and the greatest width, which is near the middle, is equal to rather less than half the length; the width of the posterior half does not vary much, but the anterior half becomes gradually narrower towards the bluntly rounded apex.

The posterior sucker is transversely broadly ovate, the width exceeding the length by about one-fifth; the anterior margin is broadly and evenly rounded, but the margin opposite is flattened and somewhat sinuate. Interiorly this sucker has, like that of *Callicotyle kröyeri*, seven submarginal compartments and a central one; the lowermost of the seven compartments is in the middle line, and has on each side a slightly curved tooth; the centre compartment is not round as it is in *Callicotyle kröyeri*, but transversely narrow. There are apparently no suckers at the anterior end, and in this respect it also agrees with *Callicotyle kröyeri*.

The length of the specimen represented by the drawing (fig. 1) is 9 mm.

Habitat.—Parasitic on the gills of *Chimera monstrosa*, Linné, captured in the North Sea, January 1910. Apparently rare.

Fam. POLYSTOMATIDÆ.

Posterior suckers more or less numerous.

Genus *Octobothrium*, Leuckart (1828).

Trematodes provided with eight posterior suckers and usually with a small one on each side of the mouth at the anterior end.

* I am indebted to my colleague, Dr. Williamson, for the privilege of examining the fishes on which the organisms recorded here were obtained, and to my son, Andrew Scott, A.L.S., for the drawings and photographs.

Octobothrium leptogaster, Leuckart. Pl. VII., figs. 2-5.

1842. *Octobothrium leptogaster*, Leuckart, Zool. Bruchst., vol. iii., p. 25, Pl. I., fig. 5; Pl. II., fig. 2.

In this species the posterior end is considerably expanded, and the eight suckers, which are moderately large, are situated at the ends of short finger-like processes which are spread out in the form of a fan. The body is extremely slender, especially the posterior portion extending from the fan-like expansion with its eight suckers, forward to the anterior thickened genital portion. This slender portion, which seems to have suggested the specific name, is much longer and more flexible than the anterior thickened part; along both sides of the thickened portion extends the vitelline gland in the form of two dusky longitudinal bands; the mouth, in the form of a narrow oval slit, is situated on the ventral surface near the anterior extremity. The pair of anterior suckers—one on each side of the mouth—observed in some species of *Octobothrium*, were apparently absent in *Octobothrium leptogaster*.

The posterior suckers (or *bothria*) are transversely and broadly ovate, the width being nearly equal to one and a half times the length; they are each furnished with about five spines: one springs from the anterior margin and, extending across the middle, divides the sucker into two nearly equal parts; the others are lateral and occur in pairs—two on each side; the smaller spine is nearly straight, but the larger is incurved and hook-like.

The eggs are of an oval shape, widest in the middle; width equal to about half the length, horn-coloured, and semi-transparent; length about 0.2 mm.; one end is produced into a short beak from which springs an exceedingly long and extremely slender colourless filament; the other end is without an appendage of any kind.

The entire length of the specimen represented by the drawing is 39 mm. The neck and body are marked by numerous faint transverse lines.

Habitat.—Parasitic on the gills of *Chimera monstrosa* captured in the North Sea in January, 1910; apparently not very rare.

Genus *Axine*, Abildgaard, 1795(4).

In this genus the posterior suckers are small and numerous.

Axine bellones, Abildgaard. Pl. VII., figs. 6-7.

1794. *Axine bellones*, Abild., Skift. af Naturhist. Selskab., t. iii., p. 59, tab. vi., figs. 3a, b.

1836. *Heteracanthus pedatus et sagittatus*, Diesing, Nov. Act. Nat. Cur., vol. xviii., i., p. 310, tab. xvii.

1850. *Axine bellones*, Diesing, Syst. Helminth, vol. i., p. 425.

1858. *Axine bellones*, P.-J. van Ben., Bull. de l'Acad. Roy. de Belg., vol. xxiii.

1858. *Axine bellones*, P.-J. van Ben., Acad. des Sci., Suppl. aux Comptes rendus, t. ii., p. 53.

1863. *Axine orphii*, P.-J. van Ben. and Hesse, Rech. sur la Bdellodes ou Herudinées et les Trématodes, p. 116, Pl. xii., figs. 19-27.

Body flat, thin, elongated; anterior extremity very attenuated, but becoming gradually wider towards the posterior end; posterior extremity expanded so as to assume the form of a hatchet ("hache"). The anterior end has the apex pointed, but it may also by contraction become emarginate (fig. 7). The mouth opening is denticulated and provided with two lateral, oval, and denticulated suckers. The genital aperture is of medium size and furnished with fascicles of minute teeth or hooks arranged partly vertical

and lateral. The posterior suckers, which are small and of an oval form, are each armed with four hooks, and each sucker appears to be divided into two nearly equal parts. The suckers seem to be supported on minute prominences and crowded together along the edge of the expanded membranous border which terminates the posterior end of the body. The number of suckers on the specimen represented by the drawing (fig. 6) is fifty-two. According to van Beneden, the suckers are mobile and can turn towards or away from each other, and that also by contraction to appear sometimes to be fewer in number and sometimes more numerous. Along the middle of the body and at the posterior extremity the colour is yellowish-white, while along each side is a dusky-coloured border.

The length of the specimen figured is about 10 mm., but others reach only to 8 or 9 mm., or are even smaller.

Habitat.—Parasitic on the gills of the sea pike or Gar-fish, *Ramphistoma belones*, Linn. (*Belones vulgaris*, Cuv.); captured in the North Sea about the end of April and beginning of May, 1910; apparently not very rare.

Genus *Amphiptyches*, Grube and Wagener (1852).

Amphiptyches urna, Grube and Wagener. Pl. VIII.

1852. *Amphiptyches urna*, G. and W., Müller's Archiv (1852). Pl. xiv.

Several examples, which include some apparently adult as well as others scarcely mature, were obtained in the intestine of specimens of *Chimera monstrosa* sent to the Laboratory at the Bay of Nigg from the Aberdeen Fish Market in January, 1910. The fish, it is understood, were captured in the North Sea.

Amphiptyches differs remarkably in its general appearance from the Entozoa usually met with in the intestines of marine fishes, while on the other hand it has a strong superficial resemblance to certain species of the Nudibranch mollusca. There also appears to have been at first some doubt as to the relationship between these parasites and the fish in which they were observed.

The parasite was described by Grube and Wagener in 1852 in Müller's Archiv, under the name of *Amphiptyches urna*. The specimens, along with the shells of *Mactra*—a Lamellibranch shellfish—were found in the intestine of *Chimera monstrosa* captured in the Mediterranean.

Diesing, in his Revision der Helminthen, 1858, ascribes this organism to his genus *Gyrocotyle*, and records it under the name of *Gyrocotyle amphiptyches*, Gr. and W.

In 1859 Dr. Paul Gervais and P.-J. van Beneden, in their work "Zoologie médicale," vol. ii., p. 193, after referring, under the sub-order Polycotylores Blainv., to various genera of the Tristomidae, proceed to remark that the *g. Amphiptyches* found by Grube and Wagener in the intestinal canal of *Chimera* appeared to be a parasite of that mollusc, and that its position in the fish was that of an erratic—a parasite that had lost its way by being accidentally swallowed by the *Chimera*.*

In a further note, however, on these parasites published in his work on "Les Poissons des Cotes de Belgique" in 1870, Professor P.-J. van Beneden remarks that, having studied this singular worm only from specimens preserved in liquor obligingly communicated to him by G. Wagener, he had some doubt about them being internal parasites of fishes, and adds that, having since procured an adult *Chimera* captured on the coast of Norway,

* Le G. *Amphiptyches*, trouvé par Grube et G. Wagener dans le canal intestinal de la Chimère avec des coquilles de *Mactre*, pourrait bien être un parasite de ce dernier Mollusque, se trouvant à l'état erratique dans le poisson qui l'a fourni. Il n'y a en effet aucun autre ver polycotyloire vivant dans le tube digestif.

“we had the good fortune to find two *Amphiptyches urna* in its intestine, and we now conclude that it is an Nostosite,”* that is, a parasite that has now reached its ultimate destination, and therefore a true parasite of the *Chimera*.

In 1890, in *Hist. Nat. des Annelés* (coll. des Suites a Buffon), Vol. III., 2nd Part, the author, M. l'Professeur Léon Vaillant, mentions in a footnote to *Gyrocotyle*, Diesing (p. 539), that this “must not be confounded with the *Amphiptyches*, Gr. and W., the unique species of which *A. urna* has been wrongly described under the name of *Gyrocotyle amphiptyches*, W., this last belonging to a group of Trematodes.” But though *A. urna* is referred to in the statement just quoted as unique, there appears to be at least another species, *A. rugosa*, parasitic in a fish found in the South Seas. In the *Memoir on Flatworms and Mesozoa* by F. W. Gamble, in Vol. II. of the “*Cambridge Natural History*” (1896), the author not only refers to *Amphiptyches urna* and *A. rugosa*, but appears to regard them, not as Trematodes, but as Monozootic Cestodes belonging to a special family, the Cestodaria or Monozoa. The following are that author's remarks on this interesting point (p. 77):—

“Just as some Coelenterata (*Lucernaria*) may be regarded as not having advanced much beyond a scyphistoma stage, so there are unsegmental Cestodes (e.g., *Archigetes*) which have remained as a slightly altered but sexual scolex, directly comparable with a Trematode, and, as all authors are agreed, representing one generation only. Such monozootic forms are now classed as a special family, the Cestodaria or Monozoa of which *Caryophylleus mutabilis* from the intestine of various Cyprinoid fish is the most abundant representative, while *Amphiptyches* (*Gyrocotyle*) *urna* from *Chimera monstrosa* of the Northern hemisphere is paralleled by *A. rugosa* found in *Callorhynchus antarcticus* from the Southern seas.”

The specimens of *Amphiptyches* recorded by Grube and Wagener were found associated with the shells of *Mactra*; the specimens of *Chimera* from the Fish Market in which the parasites dealt with here were obtained had only a moderate quantity of food in their stomachs, which consisted of various organisms, chiefly small Crustacea, Echinoderms and Annelids, along with a few small Molluscan shells such as *Anomia*, *Pecten*, *Cardium*, *Buccinum*, *Fusus*, *Scalaria*, all of them small or immature. The parasites varied greatly in size—in length as well as in width. The longer specimens were narrow in proportion and the wider ones shorter. The longer specimens, such as that represented by fig. 1, measured fully 30 mm. by 10 mm. in width, while that represented by fig. 3 measured 24 mm. by 15 mm. The specimen represented by fig. 4 appears to be a young form. The specimens have the appearance of being incomplete, or as if they were segments of a larger form. They all occurred, however, as separate organisms; there was no sign of any being joined to one another, though considerable care was taken to ascertain if in any case that were so.

* Ce singulier ver a été trouvé d'abord par G. Wagener dans l'intestine de la Chimère de la Méditerranée; nous n'avons pu l'étudier que sur des individus conservés dans la liqueur, que G. Wagener nous a obligeamment communiqués; sont-ils de vrais parasites internes de ces poissons? Nous en avons douté, et nous pensions que ces magnifiques Trématodes étaient des parasites de quelque mollusque bivalve que le poisson avait avalés, c'est-à-dire, un parasite erratique, nous nous étions trompé. Ayant per nous procurer depuis une Chimère adult dans la liqueur, provenant de la côte de Norwége, nous avons eu la bonne chance de trouver deux *Amphiptyches urna*, adultes, dans l'intestin. Nous pouvons en conclure que c'est un Nostosite. Cf. *op. cit.*, p. 21.

EXPLANATION OF THE PLATES.

PLATE VII.

Callicotyle affinis, T. Scott. *

Fig. 1. Underside of specimen to show posterior sucker, - - - × 17

Octobothrium leptogaster, Leuckart.

Fig. 2. Adult specimen, - - - - - × 5

Fig. 3. Anterior end, ventral aspect, - - - - - × 20
(*en.*, mouth: *ph.*, pharynx; *gp.*, genital aperture; *vg.*, vitelline gland.)

Fig. 4. Posterior end, ventral aspect, - - - - - × 30

Fig. 5. Three of the eggs removed, - - - - - × 105

Axine bellones, Abildgaard.

Fig. 6. Adult specimen, ventral aspect, - - - - - × 20

Fig. 6a. One of the posterior suckers, - - - - - × 140

Fig. 7. Anterior end, ventral aspect (*s.*, anterior suckers), - - - × 140

PLATE VIII.

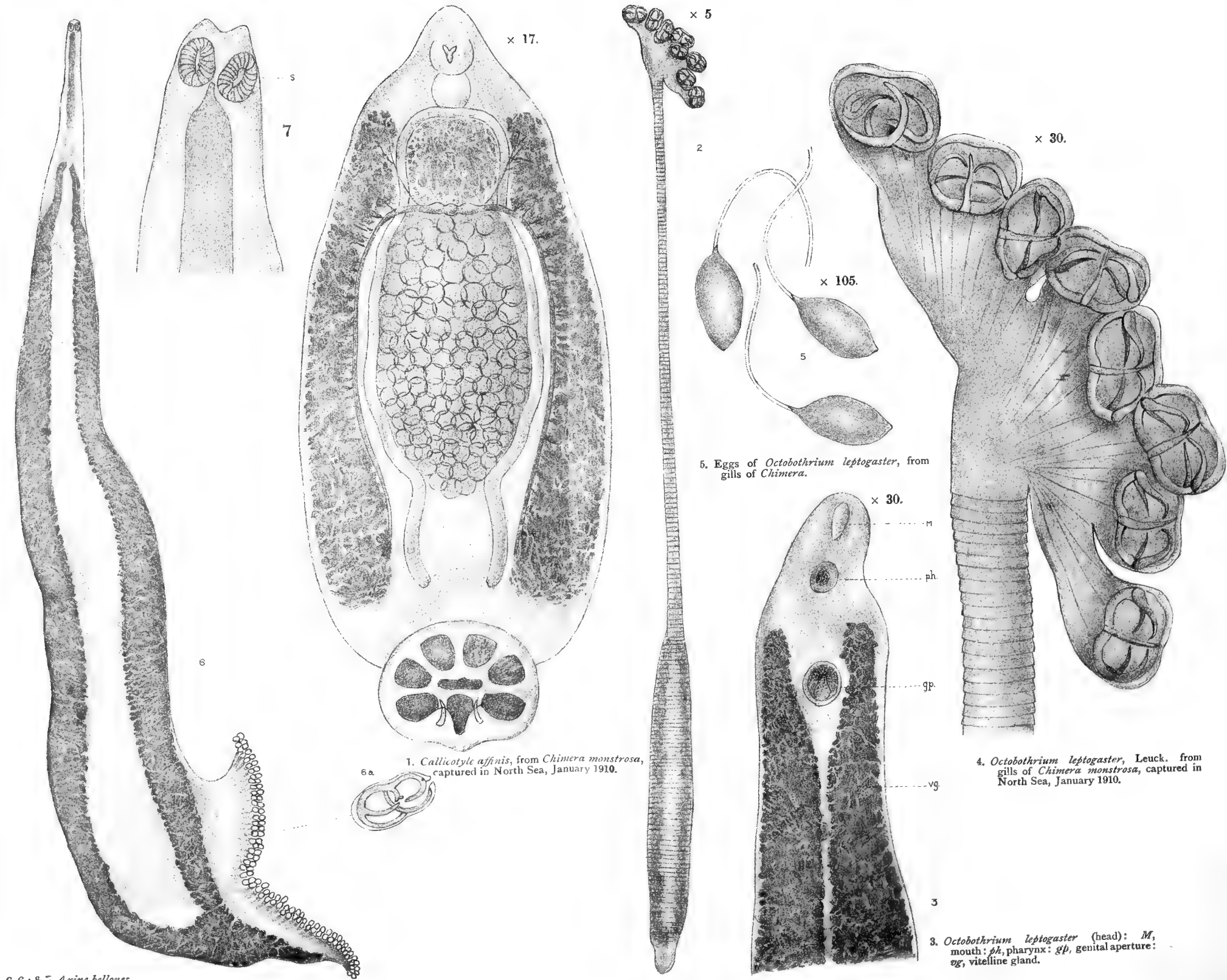
Amphiptyches urna, Gr. and W.

Fig. 1. Specimen seen from above, - - - - - × 4·5

Fig. 2. Specimen seen from the side, - - - - - × 2·3

Fig. 3. Another specimen, seen from above, - - - - - × 2·3

Fig. 4. A small (young?) specimen, - - - - - × 2·3



6, 6A & 7 *Axine bellones*

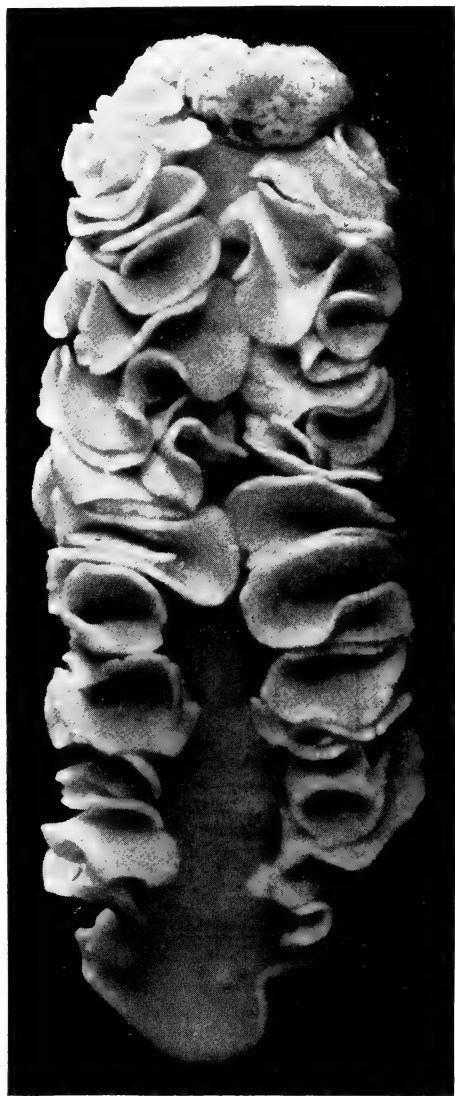
A. SCOTT, del.

1. *Callicotyle affinis*, from *Chimera monstrosa*, captured in North Sea, January 1910.

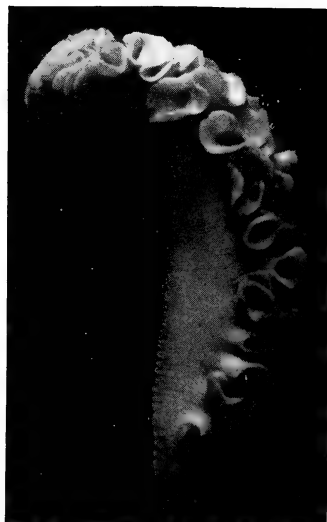
5. Eggs of *Octobothrium leptogaster*, from gills of *Chimera*.

4. *Octobothrium leptogaster*, Leuck. from gills of *Chimera monstrosa*, captured in North Sea, January 1910.

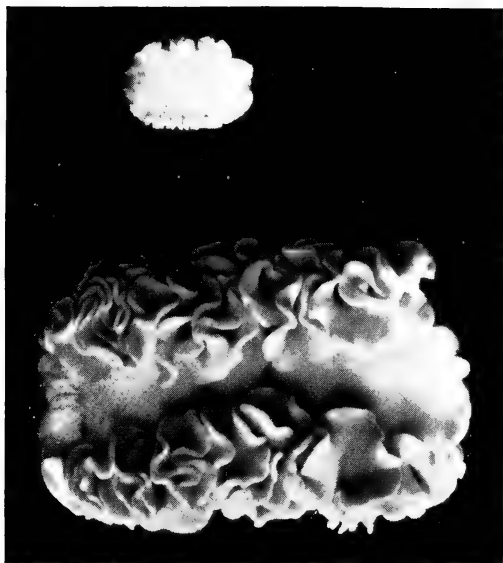
3. *Octobothrium leptogaster* (head): *M*, mouth; *ph*, pharynx; *gp*, genital aperture; *vg*, vitelline gland.



1.



2.



VIII.—A DESCRIPTION OF THE ADVANCED EMBRYONIC STAGE OF *LAMNA CORNUBICA*. By EDWARD W. SHANN, B.Sc., Gatty Marine Laboratory, St. Andrews.

(Plate IX.)

INTRODUCTORY.

Two well-advanced embryos of *Lamna cornubica*—the common porbeagle—together with the entire oviduct of the mother, were presented to the Zoology Department of St. Andrews University by Dr. H. C. Williamson, M.A., F.R.S.E. Professor M'Intosh kindly offered me the interesting task of describing this valuable material. While engaged upon preparing the notes for publication, the writer was fortunate in meeting Mr. H. Bolton, Curator of the Museum at Bristol, who offered for dissection another embryo of *Lamna*, which he had received from Dr. Williamson about three months previously. The Bristol specimen furnished not only a useful check on the observations made at St. Andrews, but, owing to slight structural differences, a clue to the manner of development. The fact that the latter specimen was examined at York will be used in distinguishing it from those which were examined at St. Andrews.

Before proceeding to the account of the work done, the writer wishes to express his gratitude to Professor M'Intosh, Dr. H. C. Williamson, Mr. H. Bolton, and Mr. James Ritchie for the use of material, and for answering patiently his numerous questions.

GENERAL REMARKS.

The only literature on the subject which was forthcoming consisted of a short paper entitled "Notes on an Intra-uterine Specimen of the Porbeagle (*Lamna cornubica*)," by W. L. Calderwood.* This contained an account of the external features of a single embryo, measuring $10\frac{1}{4}$ inches, which was obtained from the uterus (oviduct) of an adult female at Aberdeen; unfortunately, Mr. Calderwood's drawings of this specimen were not published. Pennant† mentions a porbeagle which "had in its belly four young ones, each eight and twenty or thirty inches long." In a letter from Dr. Williamson, several instances of the occurrence of porbeagle embryos are mentioned, viz.:—"I sent one, obtained 29th March 1909, to the Scottish Museum. I am under the impression that other specimens are there. Two specimens are in the Laboratory here, but neither has a date. Mr. Ingram, Fishery Officer, Leith, says that, so far as he can recollect, a female shark having twins was obtained in a herring-net at Stornoway probably about June. One large embryo of the porbeagle was sent by Mr. Ingram from Stornoway to the Fishery Board's Laboratory. It is the largest I have observed. The embryo is 19 inches in total length, and the yolk is very large, the yolk-sac measuring $9\frac{1}{4}$ inches in length. The adult from which Mr. Ingram obtained the twins was about five feet long." The embryos at St. Andrews measured 24 and 18 inches respectively in total length; the adult from which they were obtained measured about five feet. The specimen at

* *Sixth Annual Report of the Fishery Board for Scotland*, p. 263, 1887.

† *Brit. Zool.*, Vol. III., p. 118.

York was $18\frac{1}{2}$ inches long.* R. Collet† has measured various specimens of the porbeagle embryo from the Museums of Christiania and Trondhjem; he speaks of them as half-grown or rather more than half-grown. The adults which contained these embryos were taken on cod and halibut lines during the winter months. The following is a list of the embryos examined by Collet:—

“Selje, Nordfjord, 30th Dec. 1892; 1 embryo, 290 mm.

“Lyngen, W. Finmark, 1st Jan. 1891; 2 embryos, 295 mm.

“Rövaer, Stavangerfjord, 21st Feb. 1888; 4 embryos, 425 mm. (17 ins.).

“The adult containing the latter measured 2565 mm. (nearly $8\frac{1}{2}$ feet).

“The yolk-sac of the embryos had still a diameter of 185 mm. The pectorals were 47 mm., the upper lobe of the caudal fin 121 mm., and the lower 54 mm. in length.‡ These embryos would probably have been born in April or May.

“A specimen (2800 mm., or over 9 feet) caught off the inner islands on 15th February 1905 contained three large embryos.”

It is difficult to believe the report in the Memoirs of the Wernerian Society which states that “no fewer than thirty young ones appeared in the belly of this female, fully formed and apparently ready for exclusion.” This is the only record, among those examined, which gave more than four as the number of young at a birth for the porbeagle. Dr. Williamson says, “I do not know of any adult porbeagle having more than three young at a time.” Two young at a birth is apparently the most frequent number, one being found in each oviduct.

An argument adduced by Mr. W. L. Calderwood§ may be quoted here:—

“The figure of the porbeagle given in Day’s ‘British Fishes’ is taken from a specimen only measuring 33 inches, and thus is not larger than those said to be dissected from the adult by Pennant. It has quite the adult form. From this, and from the statement of the Wernerian Society’s Memoirs, we may therefore surmise that at birth the young porbeagle has not only assumed the matured shape of the parent, but has already absorbed all the nourishment to be derived from the yolk-sac, which forms a conspicuous object in the specimen under consideration.”

It would appear, further, that the young porbeagle at birth measures approximately thirty inches. There is probably considerable variation in this respect, if we consider that porbeagle embryos have been observed measuring $10\frac{1}{4}$, 18, and 24 inches respectively, but all apparently at the same stage of development. It seems possible that the intra-uterine development of this shark may be divided into two fairly distinct periods, which may be styled (1) Formative and (2) Protective—the first, or Formative, period comprising the time during which the organs are developed, and terminated when the eyes, mouth, fins, etc., are fully formed, but the yolk-sac is still conspicuous; the second, or Protective, period during which the organs already formed simply increase in size at the expense of the yolk, and the uterus acts as a protection to the helpless young. This period ends when the yolk is entirely absorbed and the young fish is born in a condition to shift for itself. The duration of these periods is probably variable.

DETAILED MEASUREMENTS.

All the embryos examined were apparently females. There was no sign of claspers on their well-developed pelvic fins. No sexual glands were formed, but in the two examples dissected the oviducts were quite patent.

* Since writing this account I have been informed by Dr. Williamson that this embryo was obtained from the same adult as those which were examined at St. Andrews.—E. W. S.

† Meddelelser om Norges Fiske, 1 Aarene 1884-1901, p. 77.

‡ Compare with measurements in this memoir.

§ *Op. cit.*

One of the specimens at St. Andrews was considerably the shorter, and will be referred to in this memoir as specimen A. From specimen B, the larger, the yolk had been removed; this specimen was accordingly used for dissection, while the other was preserved for the Museum. The embryo examined at York will be referred to as specimen C.

The measurements in the appended table are in millimetres. Specimen C is placed between A and B in the table, since it was intermediate in size.

Region measured.	A	C	B
Tip of snout to base of caudal fin,	367	395	490
Caudal fin (round the curve) { Upper lobe,...	145	135	168
{ Lower lobe,...	75	78	85
Tip of snout to anterior extremity of eye, ...	30	31	41
Width of eye socket,	11	11	14
Eye to nostril,	12	13	14
Eye to mouth, vertically,	18	18	18
Tip of snout to upper lip,	30	27	35
Width of head, eye to eye	44	44	51
Posterior extremity of lips to first gill slit, ...	47	40	52
Tip of snout to anterior end of 1st dorsal fin, ...	166	175	220
Length of 1st dorsal at base,	44	38	57
Vertical height of 1st dorsal,	30	31	52
Tip of snout to anterior end of 2nd dorsal fin, ...	325	335	423
Length of 2nd dorsal at base,	8	6	10
Vertical height of 2nd dorsal,	8	9	12
Base of pectoral fin,	26	26	40
Length of pectoral,	67	69	85
Posterior of pectoral base to anterior of pelvic, ...	94	96	84
Base of pelvic,	11	10	21
Length of pelvic,	29	29	35
Base of anal fin,	9	8	10
Length of anal,	9	9	14
Length of cloaca,	19	18	25
Anterior of cloaca to base of caudal,	100	120	125
Anterior of lower lip to chin pit,	32	...	65
Chin pit to anterior end of yolk sac,	50	...	54
Girth of yolk-sac at contact with body,	325	333	...
Maximum girth of yolk-sac,	545	568	...
Girth of yolk-sac from flank to flank (not allowing for body width),	360	385	...

EXTERNAL APPEARANCE.

The young porbeagles closely resemble the adult in external features, except for the presence of the bulky yolk-sac (Pl. IX., fig. 1). The cylindrical body lies in a somewhat curved posture over the large ovoid yolk-sac, with which it is in contact between the pectoral and pelvic fins for a distance of 100 mm. The dorsal aspect of the head is flattened. The snout is much blunter than that of the adult. The nasal apertures are connected by a furrow. There is a chin pit on the ventral aspect of the head, situated a few centimetres behind the lower lip; in specimen C there was no distinct pit, the under surface in the branchial region forming a shallow concavity, rounded in front, to which the anterior projection of the yolk-sac is closely applied. The inter-nasal furrow and chin pit are embryonic characters, and are not found in the adult. The eyes and mouth are well developed, the latter containing a few small teeth. The latter do not show the two lateral cusps said to be present in the adult.

The presence or absence of spiracles in *Lamna cornubica* is still an open question. Sir William Turner* describes minutely the spiracles in a young female measuring $3\frac{1}{2}$ feet, but these were only wide enough to admit the passage of a pig's bristle. Spiracles are also said to be present by Müller and Henle, in their work on the *Plagiostomata*, by Yarrell in his "British Fishes," and by Duméril in his "Hist. Nat. des Poissons." Fleming, Couch, and Parnell state that they are wanting. Day compromises with the remark, "Spiracles, if present, minute;" Tate Regan, in his "Classification of the Selachian Fishes," agrees with this conclusion. Günther found no spiracles in *L. cornubica*, but states that "a minute pore-like foramen could be seen "on one side of an example of *L. spallanzani*." Mr. W. L. Calderwood,† in describing his embryo porbeagle, says:—"In this young specimen the "skin between the eye and gill slits was very soft and much wrinkled, and "although examined carefully with a lens revealed no aperture." The result of a similar examination of the specimens at St. Andrews corroborated this statement; in the specimen at York, however, a small pit was observed on either side of the head, level with the centre of the eye, and in each case 22.5 mm. from the margin of the latter. The position agrees well with that observed by Sir W. Turner,‡ but some doubt remains whether these were actually the openings of spiracular canals or merely surface pits. They would not admit the passage of a hair; and when a fine surgical wire was used, it was found that the wire did not follow a definite channel, but forged a course for itself through the soft vacuolated tissues. The tissues were unfortunately too soft for sectioning, or some evidence might have been obtained in this manner. Careful examination did not reveal an internal spiracular aperture in the pharynx.

The minute spiracles which have been found in adult porbeagles by various observers can be of very little use to the fish; if they were of vital importance they would be present invariably. It is probable, then, that the spiracles of *Lamna cornubica* are abortive structures. By the law of recapitulation, the spiracle is formed in the embryo, but disappears in most cases before, or soon after, birth. This interpretation of the facts is only an hypothesis, and must await further investigations.

The five gill slits were open and the gills fully developed. All the fins were normal with the exception of the caudal, whose dorsal and ventral lobes had not yet expanded, but had a chelate appearance. The keel on the sides of the posterior end of the body, also the notch in the back at the base of the caudal fin, were characteristic. The skin was slightly roughened with developing scales (Plate IX., fig. 2). The colouring of the trunk and fins was normal; the yolk-sac was yellow. The cloaca was open.

Owing to the courtesy of Mr. James Ritchie, M.A., B.Sc., the writer was enabled to examine the porbeagle embryo which was sent by Dr. Williamson to the Royal Scottish Museum. This form was a female (?)‡ measuring $21\frac{3}{4}$ inches in total length, and the yolk-sac was still of enormous bulk. The young fish was slightly better developed than those examined at St. Andrews. The inter-nasal groove had almost disappeared, the teeth were numerous, and the chin-pit was almost filled out, being only represented by two grooves which ran from the first gill slit towards the point where the pit was formerly placed. In this example, too, a pair of minute pits were observed an inch behind the margin of the eye, one on each side of the head. It was not clear whether the pits communicated with an internal passage. It was not possible to effect an entry with a hair or waxed thread. This is a similar condition to that recorded above for specimen C, and seems to render it yet more probable that these pits have some connection with the problematical spiracles.

* *Journ. Anat. and Phys.*, 1875, p. 301.

† *Op. cit.*

‡ I did not see the interior, but there were no traces of claspers.

INTERNAL EXAMINATION OF SPECIMENS B AND C.

Both surfaces of the wall of the yolk-sac were smooth; the wall was very thin except where it approached the body-wall. The wall was well supplied with blood vessels, whose ramifications could be plainly seen. The yolk formed a dense mass of a pale yellow colour. It was applied closely to the wall of the sac, and found its way into every interstice of the body-cavity, investing completely the abdominal organs. The œsophagus lead into a funnel-shaped organ, whose wide distal end opened freely into the substance of the yolk (Plate IX., fig. 3). The œsophagus was thick-walled, and bore marked longitudinal ridges on its inner surface. The wall of the funnel also showed ridges of thickening at its proximal end, but became thin at the distal end. The margin at the open end was deeply serrated. A lobed mass of tissue was found adhering to the outer wall of the funnel, but its junction was not ascertained; it is shown in Plate IX., fig. 3 (*lt.*). A thick-walled narrow tube lead from the funnel to the spiral intestine. The stomach did not appear to exist as such at this period. The connecting tube mentioned above, and depicted in Plate IX., fig. 3 (*ct.*), was slung from the œsophagus by a tough mesentery. It entered the wall of the funnel where the latter began to dilate, and ran in the wall of the funnel for a short space, finally opening into the funnel. As before stated, this tube enters the spiral intestine; if this portion of the connecting tube is persistent it probably becomes the pylorus of the adult, and accounts for the remarkable constriction at the entrance to the spiral intestine. The intestine lead into the rectum, which opened into the cloaca. The rectal gland was a club-shaped diverticulum opening into the rectum on its dorsal aspect.

The large bi-lobed liver occupied the greater part of the abdominal cavity anteriorly. The oviducts were formed, but, as was previously mentioned, there were no traces of ovaries. The kidneys could be seen on the dorsal wall of the body cavity. A pair of tubes lying anteriorly to the kidneys were thought to be the abortive anterior portions of the Wolffian ducts.

The brain and nervous system were much decomposed, but had apparently reached their full development. The spinal column was composed almost entirely of sectile cartilage, which, however, showed signs of incipient thickening in certain areas, foreshadowing the osseous plates in the vertebræ of the adult which have been described by Owen* and by Tate Regan.† The notochord persisted as a transparent gelatinous substance in the inter-spaces between the vertebræ.

The oral and pharyngeal linings were beset with hollow papillæ throughout the area which Imms‡ has described as covered with denticles in a specimen measuring 790 mm. (about 31 inches). Microscopic examination failed to reveal denticles, even in an incipient condition, in the skin of the mouth and pharynx of the embryos under consideration.

The most noteworthy feature of the internal structure was the condition of the arterial arches. In the majority of the present-day sharks, with the exception of the Notidanoidei, the ventral aorta breaks up into five arches. The posterior pair of afferent branchials leaves the ventral aorta on its dorso-lateral aspect, and supplies the fifth gill pouch. The next two arches, that is to say the fourth and third afferent branchials, leave the ventral aorta on its lateral aspect at varying intervals. Anteriorly the ventral aorta bifurcates, and its right and left branches thus formed bifurcate again to give the second and first aortic arches. This condition was realised in the young porbeagles, but in specimen B in addition there was a sixth aortic arch, whose branches left the ventral aorta on the dorsal aspect slightly posterior to the origin of the fifth aortic arch (Plate IX., fig 4). The origins of these vessels were

* The Anatomy of Vertebrates, Vol. I., p. 33.

† Proc. Zool. Soc., 1906, p. 742.

‡ Proc. Zool. Soc., 1905, Vol. I., p. 44.

perfectly distinct up to the point where they joined the ventral aorta. They differed from the five normal arches in this, viz., that they did not supply a gill pouch, but running almost directly backwards, and then outwards, they ramified among the muscles of the body wall. In specimen C the sixth arch was found, but the vessels were smaller and more delicate than those in specimen B; moreover, they never actually entered the ventral aorta, but ended blindly in connective tissue immediately posterior to the origin of the fifth pair of afferent branchials.

The only literature which threw any light upon this subject was the following extract from Milne' Edwards "Leçons." Speaking of the aortic arches of fishes, he says:—"Les crosses aortiques se constituent successivement d'avant en arrière, et l'on en compte jusqu'à sept paires; mais il est rare que tous ces vaisseaux aient une existence permanente, et, le plus ordinairement, les premiers formés s'atrophient et disparaissent avant que les derniers se soient bien constitués; enfin d'autres fois quelques-uns de ceux-ci paraissent avorter, de sorte que, chez l'animal parfait, le nombre de ces arcs vasculaires ne dépasse que rarement quatre ou cinq paires."

In the case of the porbeagle, it would appear on the contrary that the posterior, or last formed, arterial arch atrophies; for it is this posterior arch which is not found in the adult Selachian.

From the evidence of these aortic arches, it appears highly probable that during the younger stages of the development in *Lamna cornubica* there may be a kind of placental connection between mother and young. It has been shown that the body-wall is continuous with the wall of the yolk-sac; further, that a supply of blood reaches the body-wall direct from the heart. If, at an earlier stage than that under consideration, the wall of the yolk-sac was actually in organic connection with the ridged inner wall of the uterus (which is also well supplied with blood vessels), it is quite possible to conceive that the venous blood brought by the sixth aortic arch to the wall of the yolk-sac might be aerated by arterial blood in the uterine wall. When the gills were formed this method of respiration would no longer be necessary, and the accessory sixth aortic arch would atrophy. In specimen C one might point out that such an occurrence is in the act of taking place. The weak point in this idea is the fact that there is no trace on the wall of the yolk-sac of any such organic connection as was postulated.

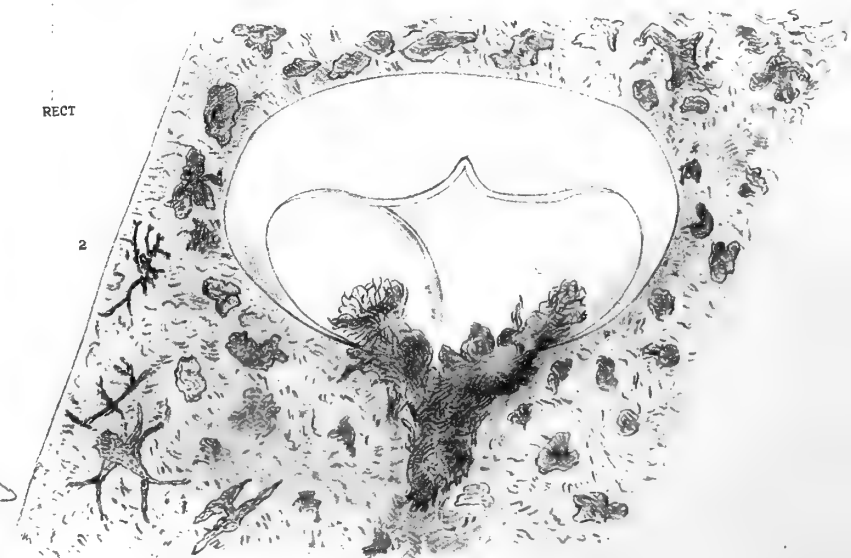
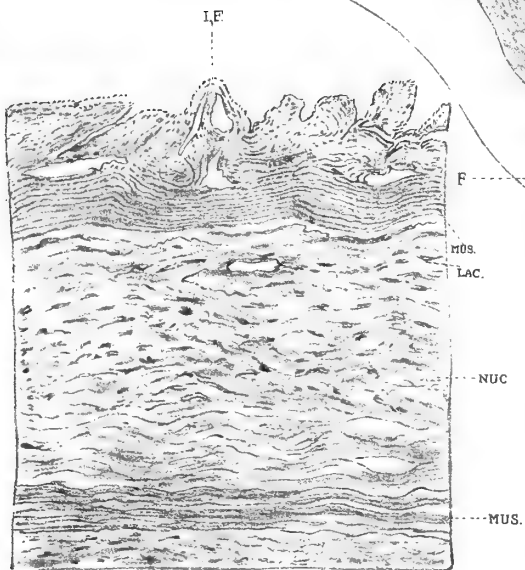
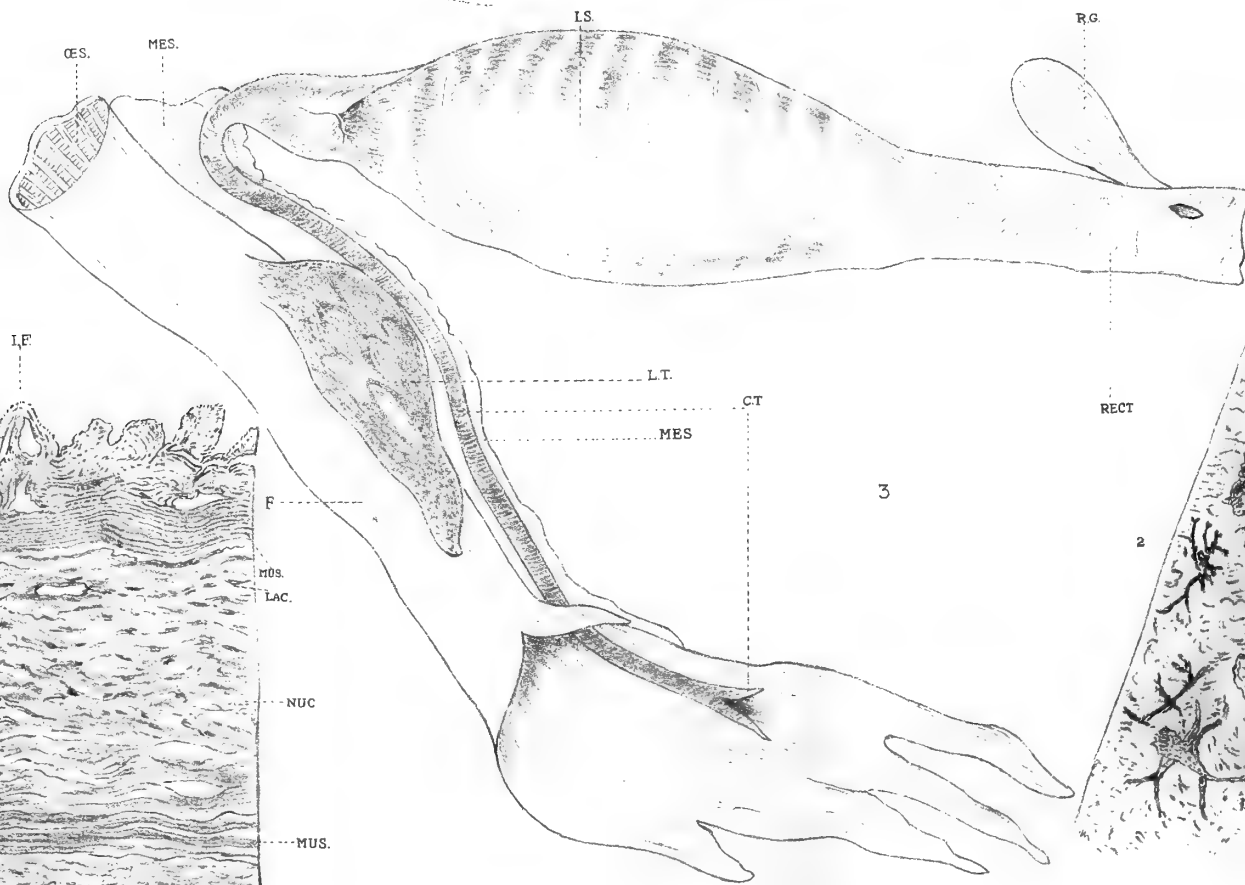
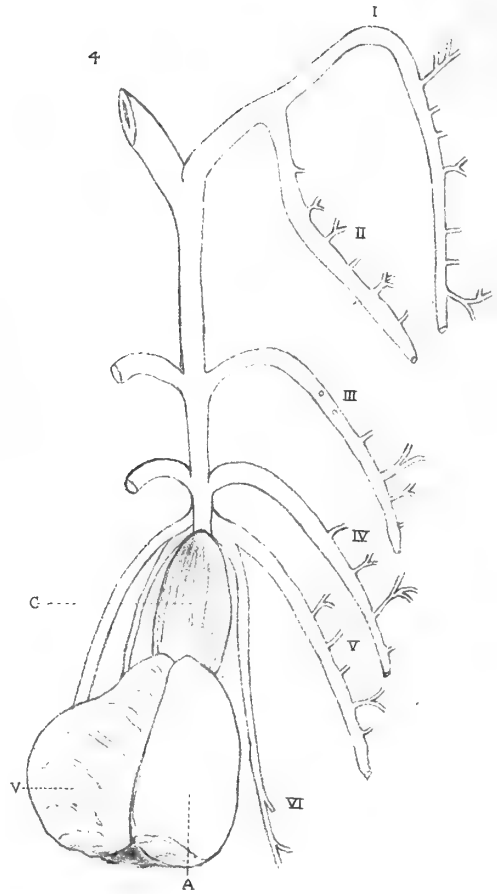
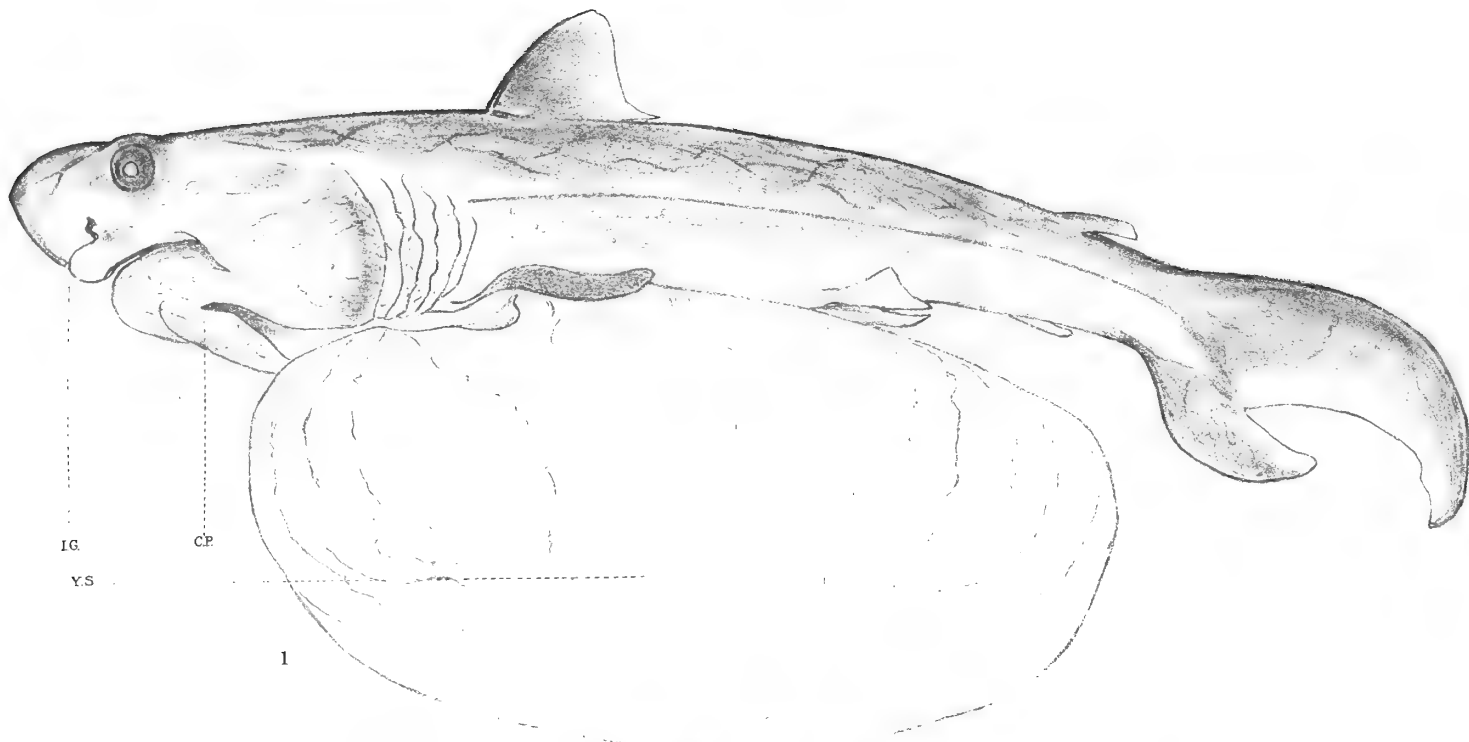
THE UTERUS (OVIDUCT) OF THE ADULT.

The adult female which contained the two embryos A and B which have been described above, measured about five feet in total length. Each oviduct was 23 inches in total length. The oviducts were united by tough mesentery throughout their length. The anterior portion of the oviduct was closed by a dense network of tissue. The uterine portion was very much swollen in order to contain the large embryos; each oviduct contained one of the latter. The uteri united at the posterior end, ran parallel with one another for two inches, then opened by a common muscular tube about three inches in length.

The uterine wall was of a leathery nature. The external surface was smooth, the internal thrown into ridges and furrows. At the anterior end of the uterus the inner wall showed the highest ridges; these were in the form of longitudinal folds, between which lay smaller elevations. The remainder of the internal surface of the uterus was ridged in all directions, the ridges growing less conspicuous towards the posterior end. No villi comparable with those described by McIntosh* for *Zoarces viviparus* were observed.

In transverse section (Plate IX., fig. 5) the uterine wall showed an outer layer of compact cells, next a deep layer consisting of a series of muscle fibres and nucleated cells, and finally a dentate layer composed of small

* *Annals and Mag. of Nat. Hist.*, June, 1885.



cells. In the middle layer there was an upper and a lower stratum composed entirely of closely-packed muscle fibres, between which occurred a more loosely-packed stratum. The latter stratum consisted of nucleated cells among which were found a few muscle fibres; the uterine blood vessels lay in this stratum. This fact is also opposed to the supposition of a placental connection.

EXPLANATION OF THE FIGURES IN PLATE IX.

- FIG. 1. Embryo A Reduced from drawing $\times \frac{1}{2}$. *i.g.* = inter-nasal groove. *c.p.* = chin pit. *y.s.* = yolk-sac.
- „ 2. Skin of embryo B. Reduced from drawing $\times 475$. Showing pigment spots and a dermal denticle in the process of development.
- „ 3. Digestive tract of embryo C. Reduced from drawing $\times 1$. *æs.* = œsophagus. *f.* = funnel. *l.t.* = lobed tissue mass. *c.t.* = tube leading to intestine. *i.s.* = spiral intestine (slit open). *rect.* = rectum. *r.g.* = rectal gland.
- „ 4. Heart and branchial arches of B. Reduced from drawing $\times 1$. Ventral aspect. I.-VI. = first to sixth afferent branchials.* *c.* = conus arteriosus. *v.* = ventricle. *a.* = auricle.
- „ 5. Transverse section of uterine (oviducal) wall of adult. Reduced from drawing $\times 20$. *i.f.* = internal folds. *mus.* = muscle fibre strata. *nuc.* = muscle fibres and nucleated cells. *lac.* = blood lacuna.

* In the light of the probable function of the sixth arterial arch it is perhaps inadvisable to speak of it as an afferent branchial.

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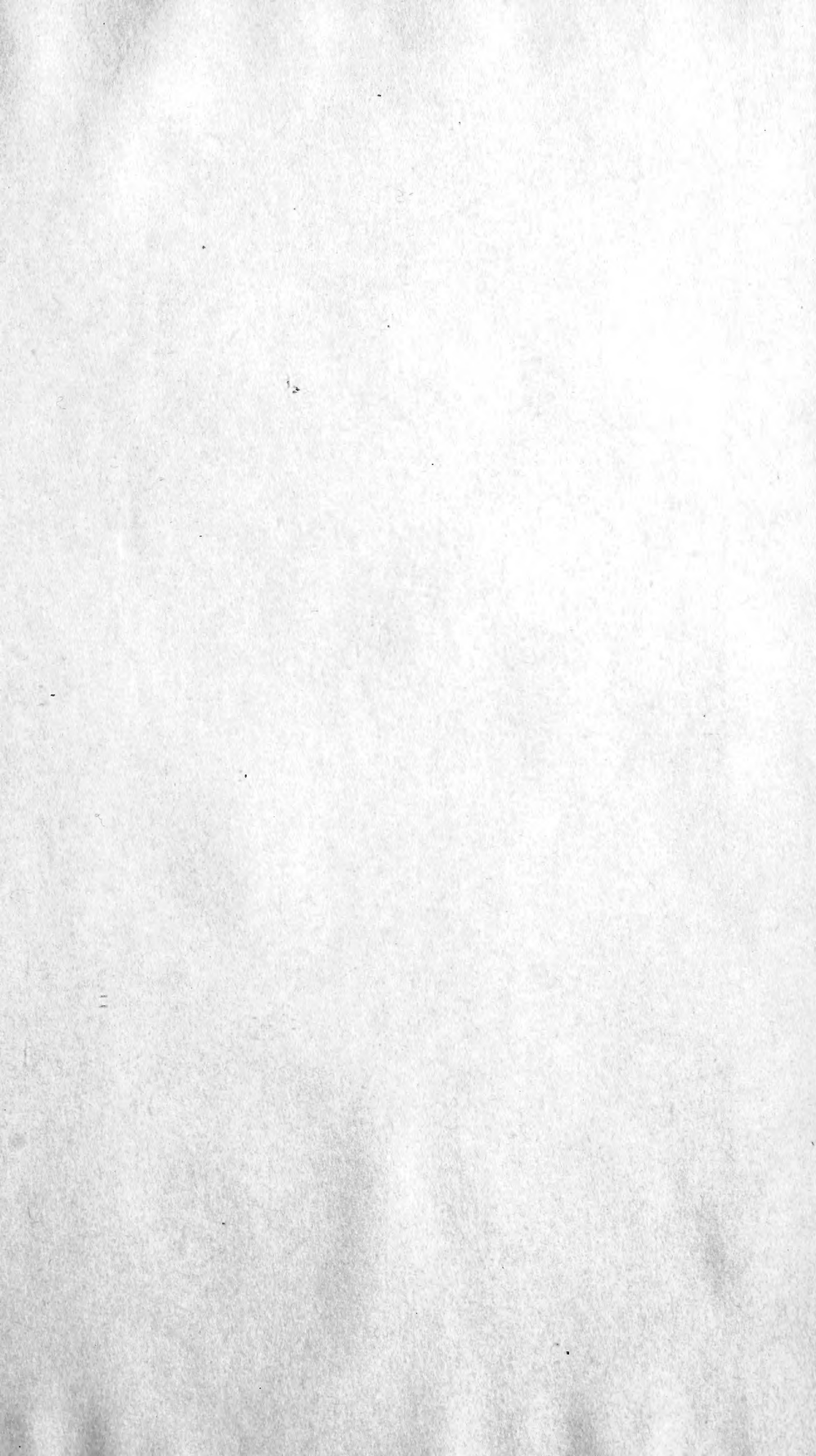
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