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# Journal

OF THE

# MARINE BIOLOGICAL ASSOCIATION

OF

# THE UNITED KINGDOM.

THE PLYMOUTH LABORATORY.

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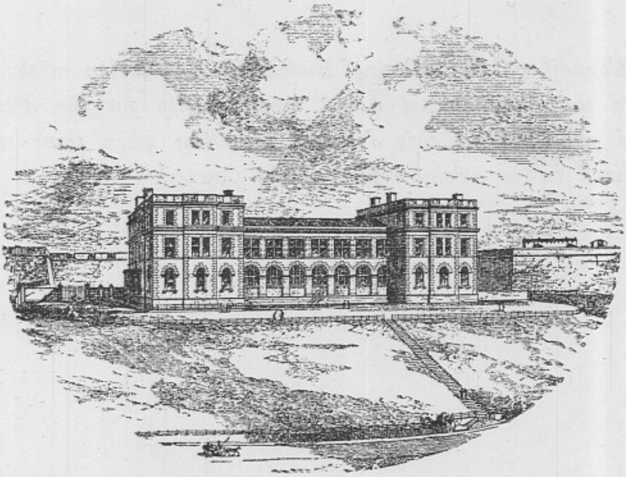

VOLUME IV. (N.S.).

1895-97.

PLYMOUTH:
PUBLISHED BY THE ASSOCIATION.

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*The Council of the Marine Biological Association wish it to be understood that they do not accept responsibility for the accuracy of statements published in this Journal, excepting when those statements are contained in an official report of the Council.*

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| | Income of 1894–5. £ s. d. | Income of 1895–6. £ s. d. | Increase. £ s. d. | Decrease. £ s. d. |
|---|---|---|---|---|
| H.M. Treasury | 1000 0 0 | 1000 0 0 | ...... | ...... |
| Fishmongers' Company | 400 0 0 | 400 0 0 | ...... | ...... |
| Mr. Thomasson's Donation | 250 0 0 | ...... | ...... | 250 0 0 |
| Composition Fees & Donations | 25 15 0 | 32 12 6 | 6 17 6 | ...... |
| Annual Subscriptions | 135 9 0 | 153 5 0 | 17 16 0 | ...... |
| Rent of Tables | 39 11 0 | 89 7 0 | 49 16 0 | ...... |
| Sale of Specimens | 205 12 10 | 256 10 4 | 50 17 6 | ...... |
| ,, Journal | 19 9 8 | 20 19 9 | 1 10 1 | ...... |
| ,, Monograph | 3 10 0 | ...... | ...... | 3 10 0 |
| Admission to Tank Room | 66 17 0 | 76 8 4 | 9 11 4 | ...... |
| Sale of *Firefly* | 6 0 0 | ...... | ...... | 6 0 0 |
| ,, *Pansy* | ...... | 40 0 0 | 40 0 0 | ...... |
| Interest on Investment | 25 18 9 | 25 18 2 | ...... | 0 0 7 |
| | 2178 3 3 | 2095 1 1 | 176 8 5 | 259 10 7 |
| Total Decrease... | ...... | ...... | ...... | 83 2 2 |
| | | | Increase. | Decrease. |
| Ordinary Receipts | 1922 3 3 | 2055 1 1 | 132 17 10 | ...... |
| Extraordinary Receipts | 256 0 0 | 40 0 0 | ...... | 216 0 0 |

| | |
|---|---|
| Total Receipts, General Fund, 1895–96 | £2095 1 1 |
| Total Payments ,, ,, | 2461 18 6 |
| Payments over Receipts | 366 17 5 |

| | Expenditure of 1894–95. £ s. d. | Expenditure of 1895–96. £ s. d. | Increase. £ s. d. | Decrease. £ s. d. |
|---|---|---|---|---|
| Salaries | 630 0 0 | 675 16 8 | 45 16 8 | ...... |
| Wages | 335 10 2 | 439 17 3 | 104 7 1 | ...... |
| Stationery, Printing, Postage, &c. | 159 19 10 | 168 3 9* | 8 3 11 | ...... |
| Printing and Illustrating Journal | 94 10 1 | 143 0 10 | 48 10 9 | ...... |
| Gas, Water, Coal, Oil | 106 19 7 | 107 9 2 | 0 9 7 | ...... |
| Coal and Water for Steamer | ...... | 7 15 1 | 7 15 1 | ...... |
| Stocking Tanks and Feeding | 84 16 6 | 73 6 9 | ...... | 11 9 9 |
| Glass, Chemicals, Apparatus | 125 19 3 | 214 2 10 | 88 3 7 | ...... |
| Maintenance and Repairs of Building | 76 9 3 | 205 15 7 | 129 6 4 | ...... |
| Ditto ditto Boats and Nets | 61 2 1 | 121 6 5 | 60 4 4 | ...... |
| Rates and Taxes | 10 7 2 | 7 12 10 | ...... | 2 14 4 |
| Boat Hire | 72 16 0 | 90 2 7 | 17 6 7 | ...... |
| Travelling | 23 2 0 | 34 7 9 | 11 5 9 | ...... |
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| Library | 40 13 5 | 74 9 3 | 33 15 10 | ...... |
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| Removal Expenses | 25 0 0 | ...... | ...... | 25 0 0 |
| Insurance of Steamer | ...... | 31 13 7 | 31 13 7 | ...... |
| | 1931 12 6 | 2461 18 6 | 586 19 1 | 56 13 1 |
| Total Increase... | ...... | ...... | 530 6 0 | ...... |
| Ordinary Payments | 1906 12 6 | 2461 18 6 | 555 6 0 | ...... |
| Extraordinary Payments | 25 0 0 | ...... | ...... | 25 0 0 |

*Dr.* *Cash.* *Contra.* *Cr.*

| | £ s. d. | | £ s. d. |
|---|---|---|---|
| To Balance June 1st, 1895, *less* £200 from Fishmongers' Co. paid before due | 256 12 2 | By Payments from June 1st, 1895, to May 31st, 1896 | 2461 18 6 |
| To Receipts June 1st, 1895, to May 31st, 1896 | 2095 1 1 | | |
| To *Balance deficit*, May 31st, 1896 | 110 5 3 | | |
| | 2461 18 6 | | 2461 18 6 |

* £10 deducted for cheque not presented.

# STEAMBOAT FUND.

| Receipts. | £ | s. | d. | Expenditure. | £ | s. | d. |
|---|---|---|---|---|---|---|---|
| To Special Donations to May 31st, 1896 . . | 323 | 15 | 0 | By Purchase of *Busy Bee* . . . . | 605 | 0 | 0 |
| „ Balance Deficit * . . . . | 281 | 5 | 0 | | | | |
| | £605 | 0 | 0 | | £605 | 0 | 0 |

* Towards this amount, £185 6*s.* was promised before June 30th, 1896, leaving the Balance deficit on the Steamboat Fund, at that date, £95 19*s.*

| | | £ | s. | d. |
|---|---|---|---|---|
| *June 30th, 1896.* | Balance deficit—General Account . . . . . . . | 110 | 5 | 3 |
| | „ „ Steamboat Fund . . . . . . . | 95 | 19 | 0 |
| | Total | £206 | 4 | 3 |

# INDEX.

C.



D.

PLYMOUTH:
WILLIAM BRENDON AND SON,
PRINTERS.

# The Right Hon. Thomas Henry Huxley.

THE Journal of our Association cannot be allowed to appear without a few words in memory of our first President, the great naturalist and leader of Science, whom we all mourn.

Huxley's studies in marine biology, and his position as a Government official, as well as his keen, practical common-sense, made his selection as a member of two Government Commissions on Fisheries (in 1863 and again in 1883) very appropriate. He did valuable work on those Commissions, and in 1881 was appointed, by Sir William Harcourt, to be Inspector of Salmon Fisheries. In 1883 he took an active part in the work of the International Fisheries Exhibition, and emphasized in an address given there, the fact that, whilst civilized man had brought all the resources of science to bear on the "harvest of the land," little or nothing had been done in the same spirit for the "harvest of the sea."

When, in 1884, the movement was set on foot for the foundation of the Marine Biological Association, Huxley, as President of the Royal Society, took the chair at the important meeting in the rooms of that Society, at which the Association was founded, and subsequently he consented to be the first President of the Association. With that thoroughness and conscientiousness which marked all his work, our President, though no longer in full health and vigour, attended regularly the meetings of the Council, and gave the most careful attention to the very onerous business which had to be discharged in the early days of the organization of the Association, and the building of the Plymouth Laboratory. His advice and direction were always valued in the highest degree by the Council, and his genial presence at our meetings was greatly appreciated, especially in view of the fact that he travelled from Eastbourne to London, in order to assist us. After seven years, when the laboratory was in full working order, he asked us, on the ground of his delicate health, to accept his resignation of the presidency, which, reluctantly, we did.

The successful launching of our Association, the assistance given to it by the Government, by the City Companies, and by other public bodies, are mainly due to the one fact, that we had at our head a man so profoundly trusted as was Professor Huxley.

The brief description of the purpose of the Association, adopted and circulated by its authority, was due to him, and runs as follows: "To establish and maintain Laboratories on the coast of the United Kingdom, where accurate researches may be carried on, leading to the improvement of Zoological and Botanical Science, and to an increase of our knowledge as regards the food, life-conditions, and habits, of British food-fishes and molluscs."

This is not the place to speak of the manifold labours of our late President in other fields. Our Association is but one of a hundred useful works in which his hand can be traced. But it is, above all, as the man who, without sacrificing the respect of his opponents, has gained for scientific thought a freedom and a hearing, such as were absolutely denied to it in his younger days, that Englishmen must ever remember Huxley with gratitude. Whenever we consult his writings, whether in the laboratory, or in the study—we recognise his power, his extraordinary range and accuracy of knowledge, and his charming style: but we must not think of him either as merely a zoologist, or, as merely an essayist, but as a man who most strenuously, and successfully, fought for the supremacy of Science.

E. Ray Lankester.

*July*, 1895.

# Report on the Spawning of the Common Sole (*Solea vulgaris*) in the Aquarium of the Marine Biological Association's Laboratory at Plymouth, during April and May, 1895,

*With preliminary remarks on some of the morphological conclusions that may be drawn from the study of the early embryological history of this form.*

By

Gerard W. Butler, B.A.

---

## I. Introductory.

From April 3rd to May 17th of this year I occupied a table at the Plymouth Laboratory, to study the embryology of Teleosteans. As some of the fish in the flat-fish tank were known to be spawning, a net was fitted to the overflow channel into the adjoining tank. By the kind permission of the Director I examined this net daily, and, as a rule, a number of times a day, so that I obtained a pretty complete record of the spawning of the fish in this tank during the period mentioned.

Four or more species spawned during this period,* but the point most worthy of record is the breeding for the first time in the Plymouth Aquarium, and perhaps for the first time in captivity, of the common sole.

* Fertilized eggs of the Plaice (*Pl. platessa*) 2 mm. in diameter were obtained on April 2nd, 4th, 7th, 12th, and some of these hatched out in 10–12 days. Eggs about 1·5 mm. in diameter, apparently those of the "Merrysole" (*Pl. microcephalus*) were obtained unfertilized on April 19th, and fertilized on the nights of May 5th, 8th, and 10th. Some of these hatched out on the 5th day, the water temperature being 13° C. Smaller eggs, also without oil globule, varying in diameter from ·98 mm. to 1·15 mm., and thus answering to the unfertilized eggs of the flounder obtained from different fish, but possibly including eggs of some other flat-fish besides *Pl. flesus*, were obtained repeatedly during April and first half of May, but only one or two fertilized eggs were seen. Attempts to artificially fertilize flounder eggs resulted in nothing beyond the irregular segmentation of some of the eggs. Probably this was due to the only male available not being in proper condition.

## II. Dates and Times of Spawning of the Sole.

I obtained unfertilized eggs of the sole on April 3rd and 7th, but on April 12th I found fertilized eggs for the first time. Then, again, on April 20th and 21st there were only unfertilized eggs. From this time onward, however, fertilized eggs were found during the rest of my stay at the Laboratory, sometimes on two consecutive days, sometimes with one day's, sometimes with two days' interval; and unfertilized eggs were the exception. Thus fertilized sole eggs were obtained on April 23rd, 25th, 26th, 28th, May 1st, 2nd, 4th, 7th, 8th, 10th. Then on May 11th, 12th, and 13th there were only a few eggs each day, of which the majority were unfertilized, and then again a plentiful batch of fertilized eggs on May 16th.

The time of day at which spawning occurred seemed to get earlier as the weather got warmer. Thus, during the last week of April, the eggs would be in the first segmentation (two blastomere) stage between 6 and 7 p.m., which, according to subsequent observations, would point to their having been spawned about, or rather before, 4 p.m.; but later on the egg-laying would begin about noon. On one occasion, when it began about 11.30 a.m., it was not ended before 2 p.m., which is not so surprising, since, as will be explained later, the eggs seem to be shed one at a time.

## III. On the Appearance of the Ovaries during the Spawning Season.

On May 15th, as it seemed desirable that the state of the ovaries under these known conditions should be studied, it was decided to sacrifice one of the females, of which there were a fair number spawning, and preserve the ovaries for histological study.

I first tried whether any ripe eggs were to be obtained from the living fish, but without success; and on opening the dead fish there seemed to be no quite ripe eggs in the cavity of the ovary tube. This, it may be remembered, was a day on which none of the other fish spawned, though they did on the next day. Judging by the number of fish spawning in the tank and the number of eggs spawned, the number of eggs ripening each day must have been small proportionately to the eggs in the ovary, which is not, of course, surprising, if the spawning is destined to be kept up, on the average every other day, for a period of three months or so. The ova were of all sizes. The largest and most transparent ones, presumably those most nearly ripe, were distributed singly among those less ripe over the whole laminar surface of the ovary, and did not seem to be confined specially to one region of the ovary. However, the third quarter or so of each ovary (reckoning from the head end backwards) was dotted over with small bloodspots, answering to Holt's description of the spent sole.* I presume, therefore, that this region of the ovary was that from which, in the first three weeks or month of the spawning season, the majority of the eggs had been derived.

## IV. The Act of Spawning.

At the time of spawning the soles came to the very front of the tank close to the glass, so that on a number of occasions I had a good view of the process.

The soles lay about on the bottom apparently indiscriminately, here one by itself, there two, three, or more near together. One of them would from time to time move leisurely to another place, and in passing by or over one of its companions, would evidently take notice of it, as by feeling it with the under side of its head, but this never led to anything of the nature of pairing, such as some have imagined might occur in the case of the sole; for the fish would again move on and continue the spawning process elsewhere, apparently regardless of the exact position of its fellows, and preoccupied with its own share in the operation. Doubtless, however, such recognitions in passing are the outward sign of the instinct whereby the fish assemble at the spawning time, so that eggs and spermatozoa may rise together in the water, and fertilization take place.

In spawning the sole lay on the bottom of the tank, and raising its head, brought it down again with force. This act involved a certain agitation of the hinder regions of the body also, which was perhaps as important as the more conspicuous movement of the fore part in assisting the expulsion of the ova or spermatozoa, but the appearance was as if the fish desired to create a splash of sand by the downward movement of its head. The movement was quite different from that by which soles commonly cover their upper side with sand, and had not that effect.

The eggs appear to be shed one at a time, each as the result of one of the movements just described. It seemed to me that this movement wafted the egg tailwards; at least a fresh egg commonly appeared above the tail of a fish after each of the head splashes described.

I never actually saw the exit of either ova or spermatozoa from a fish, but if the eggs are shed singly in the manner described, and the spermatozoa in correspondingly small numbers, one could, perhaps, hardly expect to; and I think anyone who saw the eggs slowly rising

* E. W. L. Holt. "North Sea Investigations" (contd.), *Journal of Mar. Biol. Ass. of U. K.*, vol. ii. (N.S.), p. 371.

towards the surface from within an inch or two of the ground, and fresh eggs taking their place to the accompaniment of the movements described, would draw the conclusions that I have.

In considering how it is that the fish come to the front of the tank, and will spawn undisturbed while you are just on the other side of the glass, instead of, as one might have expected, retreating to the farther side, one must remember that the fish now spawning have been five years or so in the aquarium, and that thus they are not only more or less tame generally, but have probably come to consider the window border of the tank floor as their place of assembly *par excellence;* for it is to that side that they are impelled by the common craving of hunger as feeding time approaches, and on that side that they at all sorts of times tend to linger, from that milder motive of curiosity about us strange creatures in the air-tank on the other side of the glass.

## V. General Remarks on the Development.

On the three occasions on which I tried, I failed to obtain eggs from the living fish, and thus I never witnessed the process of fertilization so as to time the development from the very beginning, as I should have liked. Perhaps I should have succeeded, had I captured the fish as soon as they began to spawn. However, I obtained eggs one hour before the first formation of the protoplasmic disc at the lower side of the egg, and two and a half hours before the first segmentation.

The rapid streaming of the protoplasm between the large yolk spheres of the lower part of the egg (which spheres became temporarily transformed into cones pointing downwards), to form the disc, was a very interesting sight. What I saw fully bears out the late George Brook's explanation* of Kuppfer's account of the phenomenon in the herring's egg.

Segmentation was repeatedly followed and sketched, such sketches agreeing essentially as to direction of the segmentation furrows with Wilson's figures of the segmentation stages of the sea bass; but I saw no nuclei in the living egg, except in the "parablast" at a much later stage.

The intervals between the segmentations decreased markedly at first, but a limit was soon reached. The rate of development, of course, varies considerably with the temperature of the water, whether one considers particular stages, or the whole time before hatching.

* G. Brook, "The Formation of the Germinal Layers in Teleostei," *Trans. Roy. Soc. of Edinburgh*, vol. xxxiii. part i. (for 1885–6), publ. 1887.

As to the latter, a very healthy batch of eggs, spawned on April 28th, hatched out in numbers on the seventh day, while eggs spawned about a week later, and from thence onwards, hatched out on the fifth day, when the temperature of the water was between 13° and 14° *C.* in the daytime. Both these times are considerably quicker than that of eggs studied by Cunningham, when the water was colder.

I found that even the particularly healthy batch of eggs above referred to, in which the mortality all through had been small for teleost eggs, sank to the bottom, as noted by Cunningham, half a day or so before hatching, and less healthy eggs ceased to float a day or two earlier. For this reason it seems to me that the plan of keeping the eggs, which I adopted primarily for my own convenience in studying and preserving different stages at short intervals, would be more suited to these eggs than the usual narrow-mouthed, wide gauze-bottomed hatching jars. The plan I refer to is that of the plain wide-mouthed glass beaker, with a safety siphon; the form of the latter used being not the sand filter bottom, but that with a glass funnel covered with gauze, which I found being used in the laboratory. A small jet of water, if directed so as to strike the glass side of the vessel a little above the surface of the water, and at a small angle to both the glass and the horizon (pointing downwards), seemed sufficient to keep the eggs circulating, since the surface water being made to revolve, any egg on the surface must soon come within reach of the water coming down the side of the glass, and is then driven gently downwards. With this adjustment the eggs, having small buoyancy, tend to collect on the gauze entrance to the exit funnel; but this can, if necessary, be corrected by making a second small jet of water, from a tube carried beneath the surface, gently play across the gauze mouth of the funnel.

The advantages of this type of vessel over the usual hatching jar to the embryologist are obvious, while to the practical fish hatcher it is a consideration that he can easily keep the glass bottom clean and free from dead eggs by the use of a dipping tube, so that when the eggs sink before hatching, they have not to lie on a bed of putrid eggs. Moreover, the apparatus can be at once moved into any light for inspection, and will work with comparatively little water.

## VI. Preliminary Remarks on certain Morphological Conclusions to be drawn from a Study of these Eggs.

I have for some three or four years been one of those who are impressed with the strength of the case for the "Concrescence Theory," and with the lamentable waste of time in futile researches and discussions on such subjects as the morphology of the notochord and the mesoblast, &c., into which some of those have drifted who have failed to avail themselves of this morphological anchor, with all that follows its acceptance; and I have, consequently, been on the *qui vive* for any evidence which might serve to prove the point definitely to its gainsayers, although feeling, personally, that the study of the living Elasmobranch blastoderm for days and weeks, and of the Teleostean egg for hours (supplemented if necessary by sections) gives ocular demonstration of concrescence.

Now the sole egg, I believe, is capable of giving such proof. The curious aggregates of small oil globules, characteristic of the sole egg, are well known, but I am, I believe, the first who has had the good fortune to study the early developmental history under favourable conditions, and thus to recognize that if suitable eggs be selected, and isolated, and carefully sketched with the camera at short intervals, these oil aggregates, which are at first distributed mainly in a zone below the equator, can (*a*) before the formation of the embryonic ring, be used as fixed points, and serve to show, at least within a small angle, the relation of the plane of symmetry of the embryo to the first cleavage planes, and (*b*) after the first formation of the ring, when they become involved in those relative movements of different parts of the egg, which are usually spoken of as epibolic gastrulation and concrescence, (by those who accept the "Concrescence Theory") may be used, so to speak, as floats whereby to follow these movements.

Having noticed this fact, I thought I could not make better use of the splendid material by the kindness of the Director so freely placed at my disposal, than by concentrating my attention chiefly on that early period of developmental history (the first two days or first day and a half, according to whether the eggs are hatched in seven days or five) during which these and other problems of fundamental morphological interest are to be studied.

I hope shortly, when I have supplemented my serial camera-sketches of different stages of the same living eggs, by sections of corresponding stages from my preserved material, to publish something fuller on the above two points, and on other matters, such as the structure of the egg, the morphological relations of the disc, the parablast and the yolk, and gastrulation. For the present, I may state that:—

*I.—The plane of symmetry of the embryo does not bear one and the same fixed relation in all eggs to the first segmentation plane.* Thus out of eleven eggs I found that in three the plane of symmetry of the embryo coincided with the first segmentation plane, in four with the second segmentation plane, and in four with a plane bisecting the angle between these.

I bring this forward essentially as a *negative* conclusion; as evidence, I mean, that in this form, at least, the axis of symmetry does not always coincide with the first cleavage plane, or always with the second, as some have suggested. When I speak of "coincidence," I, of course, merely mean that the directions of the planes appear to coincide. To be on the safe side, I will only assert that the planes said to coincide were not more than 15° apart, though I believe that in the case of some eggs it is possible to reduce this angle.

*II.—The axial part of the embryo is formed by concrescence of the embryonic ring, or lip of gastrula mouth, from in front backwards.*

# North Sea Investigations.

By

J. T. Cunningham, M.A.



---

In accordance with instructions from the Council of the Association, I arrived in Cleethorpes on February 4th last, and proceeded to make investigations into the biological questions presented by the fisheries in the North Sea. A large portion of my time was, however, absorbed by the work of preparing a summary of our knowledge of the natural history of marketable marine fishes, for publication in book form, and consequently the observations to be here recorded are not so extensive nor so complete as I should have otherwise been able to make them. It must also be noted that they are confined to a period of only three months—from the beginning of February to the end of April. The work has consisted only of observations in the fish market at Grimsby Docks, and of the examination of fish there procured in the Cleethorpes Hatchery; I have not been able to make any voyages on fishing boats. I have received from Mr. Holt, my predecessor at this post, all the assistance that information concerning persons and circumstances could afford me, and I have had the valuable services of Mr. Clark, the caretaker of the Hatchery.

## I. Statistics of Small Fish Landed at Grimsby.

The statistics to be here recorded are in continuation of those published in preceding numbers of the journal by Mr. Holt. My responsibility for them consists only in the addition of the figures, and the comparisons made. The counting of the boxes in the market has been entirely the work of Mr. Clark, who has continued to follow the method arranged between himself and Mr. Holt. As far as I am able to judge, the results are very reliable.

*Plaice.*—During the seven months covered by the figures, no Iceland fish have been landed, and I understand that it is uncertain whether any vessels will visit the Iceland grounds this summer.

| | Month. | Total boxes. | Large. | Small. |
|---|---|---|---|---|
| 1894. | October | 13,300 | 13,087 | 213 |
| | November | 20,835 | 20,607 | 228 |
| | December | 13,640 | 13,637 | 3 |
| 1895. | January | 5,764 | 5,764 | 0 |
| | February | 6,937 | 6,937 | 0 |
| | March | 9,180 | 8,083 | 1,097 |
| | April | 11,614 | 10,931 | 683 |

In March, 13 boxes of the small were from the Humber; in April, 25; the rest being from the east side of the North Sea. In April, 200 of the boxes from the eastern grounds were landed by German steam trawlers, and 16 boxes by cargo steamer, leaving only 442 boxes landed by English trawlers. If these figures are compared with those of the corresponding months in 1893-94, as given on p. 170, vol. iii. of this Journal, it will be seen that there is a considerable falling off in the quantity of small plaice landed, and an increase in the quantity of large. Except October, the total of large plaice for every month is larger, and that of small plaice is smaller for every month, without exception. The totals of the seven months taken together are:

In 1893-94, 51,654 boxes of large, 10,042 small.
In 1894-95, 79,046 „ „ „ 2,224 „

I am unable to give a reason for this. In the earlier period there was only one month of the seven, namely, April, in which any of the vessels were fishing at Iceland, but there may have been diversion of fishing power to other regions. Whether the increased supply of large plaice is due to greater abundance of fish, better weather, or more vsseels, is entirely beyond my knowledge. In the statistics of the earlier period, however, there were eighteen days omitted, and this alone may be sufficient to account for the difference in the figures of large plaice, while it makes all the more striking the difference in the quantity of small. An apparent scarcity of small plaice on the eastern grounds will be mentioned below.

*Haddock.*—The numbers of boxes of small haddock landed monthly are as follows:

| | | |
|---|---|---|
| 1894. | October | 9,138 |
| | November | 17,134 |
| | December | 12,627 |
| 1895. | January | 3,806 |
| | February | 7,077 |
| | March | 12,908 |
| | April | 15,908 |

Comparison of these figures with those given by Mr. Holt on p. 174 of vol. iii. shows a very great increase, except in January, for which the total is smaller. There is no indication, so far as I know, that the supply of large haddock has fallen off.

*Cod.*—The following are the monthly totals of boxes of trawled codling:

| | | |
|---|---|---|
| 1894. | October | 2638 |
| | November | 3114 |
| | December | 1994 |
| 1895. | January | 867 |
| | February | 2222 |
| | March | 4329 |
| | April | 5411 |
| | | 20,575 |

The total for the corresponding months of the previous year was 17,319; but the figures for nineteen days were not obtained, so that the difference does not appear to be really very great.

## II. Notes on the General Course of the Fishing.

In the latter half of February, a large number of steam trawlers were fishing in the neighbourhood of Flamborough Head, where the coast is steep, the 20 fathom line being only four or five miles from the coast, and the soundings descending to 35 fathoms. The principal item of the catch on this ground was large cod, which were taken in large numbers in spawning condition. This region is, in fact, a spawning ground for cod, and I am informed by the fishermen that it is worked for cod regularly every year at this season. The proportion of codling was not great; for instance, in one voyage of a steam trawler, lasting nine days, there were 90 score of cod, and only 4 boxes of codling. There were also caught 10 to 12 boxes of large plaice, a few boxes of haddock (about 20), a few turbot, mostly large, about 1 box of soles, 1 or 2 of lemon soles, and a few boxes of whiting.

Other steam trawlers, but not many, were fishing on the Great Fisher Bank, at depths of 35 to 50 fathoms. The chief item in their takes was haddock, some vessels bringing in 200 to 300 boxes of large haddock, and 6 to 27 boxes of small. They also got usually about 8 to 10 boxes of large plaice, 5 or 6 boxes of witches (*Pleuronectes cynoglossus*), a few large turbot, a few halibut, rarely a brill, skate, roker, cat-fishes, and "monks" (*Lophius piscatorius*).

Some of the smaller steam trawlers, and some sailing smacks, were fishing the Great Silver Pit, on the south edge of the Dogger Bank, and here, as usual in cold winters, considerable numbers of soles were taken, 10 boxes down to 2 or 3 being the usual quantity. Usually I only saw 2½ or 3 boxes of soles landed by a sailing smack, and 5 to 7 by a steamer; but once I saw 10 boxes from a single smack. On this ground haddocks were taken in moderate numbers, also a few boxes of plaice, whiting, dabs, some cod and codling, and ling; turbot were rather plentiful, brill less so.

Others of the smaller steamers fished within a radius of 50 miles from Spurn Head to the east and south-east. These brought in mixed catches—sometimes a number of turbot and brill, a few soles, haddock, plaice, cod, roker, and skate. These grounds appear to be fished more or less regularly all the year round.

The first voyage of small plaice from the Eastern Grounds was landed on March 20th. There were 246 boxes of the small, 29 somewhat larger, and also 4 brill and 1 turbot; but no other fish. They were taken on the Sylt Ground, at 13 to 17 fathoms, south of the Outer Horn Reef Lightship. These fish fetched 11s. to 12s. per box, the larger 18s., while on March 15th the ordinary large plaice sold for 34s. 6d. per box. Another voyage of 230 boxes was landed on March 21st, also from the Sylt rough ground, and another on March 25th, consisting of 150 boxes, from the same neighbourhood. In this last voyage there was a box of small turbot, containing 90 to 100 fish, mostly about 1 foot in length.

In the latter part of March, many steam trawlers were fishing the grounds south of the Dogger Bank, namely, Well Bank, and a place called Markham's Hole, which is 80 miles east of Spurn Head. These grounds are on the south side of the valley called the Silver Pit, and are from 15 to 20 fathoms deep; but the Hole, so far as I can judge, is one of the depressions which descend to 40 fathoms. The catches were mixed, consisting of about 50 to 70 boxes of haddock, about 70 cod, a few boxes of plaice, some soles, lemon soles, and whiting, and a few brill and turbot.

In April, although occasional catches were brought in from the Flamborough Head ground, and from the Great Fisher Bank, a number of vessels were fishing on the Dogger, where, so far as I could learn, fish were very scarce in the winter months. Here, as well as on neighbouring grounds, small plaice were in excess of the large, and formed a few separate boxes; the condition of these small plaice is discussed below. Haddock and plaice formed the main part of the catch. It has been explained in Mr. Holt's papers that haddock are packed for sale on the pontoon in three sizes—the largest, called gibbers, from the mode in which they are gutted; the medium, called kit, because conveyed in kits to the curing houses; and the small. From the Dogger Bank, a week's voyage produced about 30 to 40 boxes of the gibbers, about 60 upwards of kit, and 30 to 50 small. The largest catch I saw from a steam trawler was landed on April 25th, from one week's fishing, and consisted of 6 boxes plaice, 150 boxes kit, 80 boxes gibbers, 3½ boxes small haddock, 1 score of turbot, and ½ score cod. This catch realised £130, which is considerably more than the average value of a week's catch.

I have already mentioned three voyages of small plaice, landed March 20th, 21st, and 25th. The small number landed altogether in March and April offers a remarkable contrast to the condition of things in the same months in 1894. On March 26th there was landed a voyage of 260 boxes, the result of three weeks' fishing south of the Horn Reef. On the 27th another voyage, this time of a fortnight's fishing, of 200 boxes was landed. It should be mentioned here that more than one vessel had tried the Sylt grounds for small plaice before March 20th, and had failed to catch any. The explanation offered to me by Mr. Alward, and also by several of the skippers of steam trawlers, was that the weather had been too cold; that the small plaice bury themselves in the sand in cold weather, and remain motionless, taking no food—hibernate, in fact—so that the trawl passes over them without disturbing them. It is certain that the small plaice in the tanks at the Cleethorpes Aquarium did behave in this manner, and emerged in a lively and hungry condition in the fine warm weather, at the very time that the small plaice were landed at the docks. On the 29th a sailing trawler landed 78 boxes. Voyages of small were landed on April 3rd, 4th, 8th, and 9th, but from this date until the 26th no catches were landed from the Eastern Grounds. It is true that cold easterly winds set in during the greater part of this time, and the weather was dull, and this change in the weather may have been the principal cause of the disappearance of the fish from the market. On the 26th, 30 boxes were landed by a German steam trawler; and on the 29th, 170 boxes from another German boat.

It seems to be the fact that on April 24th, large numbers of small plaice, from the Eastern Grounds, were landed by steam cutters at

Billingsgate. A statement to that effect was made at the conference of the Protection Association, and I saw a considerable proportion of plaice, from $5\frac{1}{4}$ inches upwards, among those landed at Billingsgate Market on May 3rd and 4th. But I am unable to say whether any were landed in London or other ports between the 9th and 24th, when they were absent at Grimsby.

### III. Observations on the Natural History of Plaice.

In order to obtain a more exact and detailed knowledge of the habits and history of the fish on the North Sea fishing grounds, I have, as far as time and opportunity allowed, endeavoured to ascertain the condition with respect to feeding and breeding of the fish that were brought in from different grounds at successive times. The observations I have here to record are merely tentative and preliminary, but I think they are enough to show that the method is a necessary continuation and extension of those of a more general character which have already been applied with good results.

The first sample of plaice which I examined consisted of six specimens caught in the north-west part of the Great Fisher Bank at a depth of 35 to 39 fathoms. They were obtained in the market on February 13th. There were four females 17 in. to $21\frac{3}{4}$ in. long. Three of these, $21\frac{1}{4}$ in. to $21\frac{3}{4}$ in., were approaching the spawning condition: the ovaries were much enlarged, the eggs full of yolk, but no ripe eggs present: they had not commenced to spawn. In the smallest female, 17 in., the roe of the right side was $3\frac{1}{16}$ in. long, measuring from the anterior end of the ventral fin; the end of it $6\frac{1}{4}$ in. from the posterior end of that fin. There were no yolked eggs in the ovary. Under the microscope all were transparent, but there were opaque granular masses, which I believe to be evidence that spawning has taken place. I have given in my paper on the "Ovaries of Fishes," in this Journal, vol. ii. p. 154 to 160, some evidence that these masses are the disappearing remnants of partially developed yolked ova, which are always found in the spent ovary. This specimen of 17 in. would undoubtedly have been considered, according to the views hitherto accepted, as immature, but it seems to me it was probably a spent fish. It cannot be asserted as a certainty that these granular masses never occur in an immature ovary; to settle the doubt it will be necessary to make a careful examination of plaice in November and December, when all fish which are about to spawn will have a large amount of yolk in the eggs, and all fish in which the eggs are transparent and yolkless must be immature. In other words, at that season recently-spent fish will not exist, and then it will be possible to ascertain with certainty whether an immature ovary can contain these granular masses. In the meantime it is not certain that this fish, and others like it, are immature, and have not already spawned. The remaining two specimens, $16\frac{1}{4}$ in. and $17\frac{3}{4}$ in. long, were ripe males. This length, $16\frac{1}{4}$ in., was about the smallest of these Fisher Bank plaice, and it follows that these were chiefly mature plaice in the breeding condition. The stomachs of all were empty, or very nearly so; in the intestines of some were a few crushed shells, the remains of previous meals.

On February 16th, I found that most of the fish landed was from the home grounds. There are at Grimsby a number of rather small steam trawlers, which never remain out more than a week, and confine their operations within a limit of about 100 miles from Spurn Light. I noticed that the greater number of the plaice landed were rather small, not forming separate boxes of "small," but each box containing a large number of small at the bottom, with a few large fish on the top. I examined a sample of the smaller. There were seven females, from $11\frac{5}{8}$ in. to $14\frac{5}{8}$ in. long. One $12\frac{1}{2}$ in. was nearly ripe, a large number of the eggs already transparent, that is to say, almost ready to be shed. All the others had small ovaries, in appearance immature, but in all of them under the microscope the opaque granular masses were very conspicuous. Even the smallest fish, $11\frac{5}{8}$ in. long, had the ovary in this condition. It seems probable that all these were spent fish. There were six males, the smallest $10\frac{7}{8}$ in. long, the largest 16 in. This last was the only one ripe, in all the others the testis was very thin, and would, I suppose, have been put down by previous observers as immature, but in my opinion were more probably spent. I did not ascertain more particularly where these fish were caught.

On February 27th I saw the fish landed from a steamer which had been fishing off the Leman Shoal, at a depth of 12 to 17 fathoms. She had so many small plaice that they formed $7\frac{1}{2}$ separate boxes, in addition to $35\frac{1}{2}$ boxes of fish of the usual sizes. I bought a whole box of these small plaice, the price of which was 16s. 6d. The box contained 212 fish, the smallest a little over 7 in., the largest between 13 and 14 in. The small plaice from the Eastern Grounds, according to Mr. Holt, were about 300 to a box, the majority from 7 to 13 in. long. It is evident, therefore, that the plaice here considered are within the same limits of size as the eastern small, but apparently a little larger on the average. Examination showed that there were 186 males, and only 26 females. The condition of the males may be thus shown :—

| | Ripe or nearly spent. | | Apparently immature. |
|---|---|---|---|
| 7 in. . . . | 1 | ... | |
| 8 „ . . . | 12 | ... | |
| 9 „ . . . | 33 | ... | 1 |
| 10 „ . . . | 35 | ... | 2 |
| 11 „ . . . | 60 | ... | |
| 12 „ . . . | 36 | ... | |
| 13 „ . . . | 6 | ... | |
| | 183 | | 3 |

It is obvious that the three in the second column were not likely to be really different from the rest, and I have no doubt that they were really spent.

The condition of the females was:—

| | Ripe or certainly spent. | | Apparently immature. |
|---|---|---|---|
| 9 in. . . . | 1 | ... | |
| 10 „ . . . | 1 | ... | 1 and 1 ? |
| 11 „ . . . | | ... | 4 and 3 ? |
| 12 „ . . . | 5 | ... | 3 and 6 ? |
| 13 „ . . . | | ... | 1 ? |

The smallest female was $9\frac{1}{8}$ in. long, the right ovary $3\frac{3}{8}$ in. long and flaccid, and this fish had certainly spawned, as there were some ripe eggs still in the cavity of the ovary. Eight of the specimens, 10 to 12 in. long, showed no signs of previous spawning, and were very possibly immature, but the others marked ? showed in abundance, and very distinctly, the opaque granular masses, which I believe to be evidence of previous spawning. One specimen, $11\frac{1}{4}$ in. long, showed very numerous masses of granules: the end of its right ovary was $2\frac{1}{8}$ in. from the anterior end of the ventral fin, and $3\frac{3}{4}$ in. from the posterior end. I consider this fish to have been almost certainly spent. But putting aside all questions of probability, the examination of this sample proves that male plaice are sometimes ripe in the North Sea at 7 in., and females at 9 in. Mr. Holt found a ripe male at 6 in. (see his paper in this Journal vol. ii. p. 376), but regarded it as altogether exceptional, and found only a few nearly ripe at 9 and 10 in., none at 11 and 12. He records one female as mature at 13 in., none at 14, and many from 15 in. upwards. On the other hand, the condition of the sample considered agrees closely with the results I obtained at Plymouth, where I found a male and two females mature at 9 in. Mr. Holt states that he examined the larger fish chiefly during the spawning season, and I can only infer that he did not begin to examine smaller fish until it was too late. The fact that he put down all the females under 13 in. which he examined as immature, tends to support my contention that hitherto plaice which have spawned and recovered, have been frequently confounded with immature. At the same time, it is an established fact that plaice and other fish do not all begin to spawn at the same size, and that some immature specimens are larger than others which are spawning. The question is, what is the maximum size of the immature, and that, in my judgment, cannot be determined until a large number of specimens are examined in November and December.

On March 13th I bought some of the smallest fish out of a box of large plaice from the Great Fisher Bank, in order to further examine the condition of deep-water plaice. Of these, 6 were males from 14$\frac{3}{8}$ to 17$\frac{1}{4}$ in. long, all ripe. Only 3 were females; one was 12$\frac{1}{2}$ in. long, the ovary small and apparently immature, the end of it 2$\frac{3}{4}$ in. from the anterior end, 4 in. from the posterior end of the ventral fin. Only transparent eggs were visible under the microscope, and as far as could be judged at that time of year, the specimen was immature. The second was 16$\frac{5}{8}$ in. long, and certainly spent, the third 20$\frac{5}{8}$ in. long, ripe.

On March 20th, I saw landed the first "voyage" of small plaice from the Eastern Grounds. They were caught on the Sylt ground south of the Horn Reef Light, at a depth of 13 to 17 fathoms. There were 246 boxes of small, 29 of somewhat large fish, and the price was 11s. to 12s. a box for the small, 18s. for the larger. I examined a sample of the small: they were taken at random, without any selection, and were given to me by Mr. George Alward. The total number was 55, the sizes and sexes being as follows:—

| | Males. | Females. |
|---|---|---|
| 7 in. | 1 | ... |
| 8 „ | 4 | 1 |
| 9 „ | 4 | 2 |
| 10 „ | 9 | 6 one spent? |
| 11 „ | 14 | 12 one spent? |
| 12 „ | 2 | ... |
| | 34 | 21 |

In all the males the testes were a mere thin band, and apparently immature. In none of the females was the spent condition found with certainty, the ovaries were all small, as in the immature, and under the microscope all the ova yolkless. But in nearly all granular masses were present in the germinal tissue, although these in most cases were very rare and small. In one specimen 10$\frac{7}{8}$ in. long, they were large and numerous, and had obviously the character of dead yolked eggs. In one 11⅝ in. long, no granular masses were seen.

Nearly all these fish were crammed with food only partially digested. In most cases this consisted of Lamellibranch remains, broken shells and flesh. In many of the stomachs there were a number of long white muscular masses 1 to 2 in. long. I identified these as the "feet" of *Solen*, having found them sometimes connected with shells and remains of the entire animal, but many stomachs were full of the muscular masses, with no shells in either stomach or intestine. It appears, therefore, that the plaice bites off the foot of the larger *Solens* without swallowing the whole animal; the entire *Solens* present were small. Less frequently there were present Polychaeta (usually *Nereis* sp.), crabs (*Portunus* sp. of small size), brittle-stars (*Amphiura* sp.), and in one case a Nemertean, apparently *Carinella*. Five of the fish contained nothing recognisable, of the other 50

| | | | |
|---|---|---|---|
| Lamellibranch | occurred in | 42; | 84 per cent. |
| Solen | „ | 33; | 66 „ |
| Polychaeta | „ | 17; | 34 „ |
| Amphiura | „ | 5; | 10 „ |
| Nemertean | „ | 1; | 2 „ |

On the following day, March 21st, another voyage of small plaice was landed from the same ground, and I bought a sample. I had the smallest selected from four boxes, and the sizes and sexes were found to be as follows:

| | Males. | Females. |
|---|---|---|
| 6 in. | 8 | 12 |
| 7 „ | 46 | 38 |
| 8 „ | 53 | 27 |
| 9 „ | 3 | ... |
| | 110 | 77 |

I examined the ovaries of two specimens—one 6½ in., one 7¾ in.—and saw no trace of the granular masses. The food was the same as before.

On April 1st a steam trawler landed 10 boxes of large plaice, and 9 of smaller, caught on the western shoal of the Dogger Bank, at a depth of 9 fathoms. I bought a sample of the smaller: there were 19 of them in all. The results of examination were:

| | Males. | Females. | |
|---|---|---|---|
| 10 in. | . . . . | . | 1 immature? |
| 11 „ | 2 spent, 1 immat.? | ... | 2 „ ? |
| 12 „ | 2 „ 1 „ | ... | 2 „ ? |
| 13 „ | 4 „ | 1 spent | 1 „ ? |
| 14 „ | 2 „ | | |
| | 12 | | 7 |

The spent female was 13½ in. long, the ovary 3 $\frac{3}{16}$ and 4 $\frac{1}{16}$ in. from the ends of the ventral fin. Under the microscope it showed no yolked eggs or opaque masses—apparently they had already been absorbed—although the ovary had not lost its collapsed flaccid condition. Nearly all the other females, although otherwise not indicating the spent condition, showed more or less of the opaque granular masses in the substance of the ovary, and I have little doubt that all had spawned. The males also, I have no doubt, had spawned, the testes being somewhat larger and softer than in the immature.

These fish had been feeding, but were not so crammed as those from the Sylt grounds. In 10 the stomach was nearly empty, and the contents of the intestine much digested, though usually containing a few shells. Of the other 9 Lamellibranch remains were present in all, and consisted chiefly of *Solen*. One 13½ in. long had the stomach crammed with bits of white molluscs' flesh about ½ in. long. These were the ends of the siphon tubes of some Lamellibranch, apparently not *Solen*. Polychaete worms occurred in 4.

On April 2nd I examined a few small plaice caught by the shrimp shove-net at Cleethorpes. Among them was a female 7⅛ in. long, the end of the right ovary 1½, 2⅛ in., from the anterior and posterior ends of the ventral fin respectively, the eggs under the microscope without yolk and without any trace of granular masses. Another female was 7 in. long, likewise without any trace of granular masses. These fish were undoubtedly immature. I have found it quite impossible to rely with confidence on the relative length of the ovary, as a criterion to distinguish between the immature and the spent condition. Mr. Holt, in his discussion of the question (vol. ii. p. 368), states that the length of the posterior process of the ovary in the immature condition does not exceed one-third of the distance between the first hæmal spine and the caudal peduncle. This distance appears to be the same as that which I have used as the standard, namely, from the anterior to the posterior end of the ventral fin, but I am in doubt about the point from which the length of the posterior process was measured by Mr. Holt. To obtain a constant point of measurement, I have measured the length of the ovary *in situ*, from the front of the first ray of the ventral fin to the posterior extremity of the ovary. In the immature fish the length of the ovary thus measured is less than the distance from the end of the ovary to the posterior end of the ventral fin, but more than a half of that distance. It is usually very little less than ⅔rds. Now in specimens in which the granular masses are conspicuous, the ovary is often less than ⅔rds of the described distance. I have never seen these granular masses in a plaice less than 9 in. long, so that there is no reason at present to suppose that they ever occur in a specimen which has not spawned. In specimens in which the ovary, measured as I have described, is equal to, or greater than a half of the length of the ventral fin, there is no doubt that the fish is spent. So far, my conclusions agree entirely with Mr. Holt. But that observer has rejected the possibility that the spent ovary might go on diminishing until it was as small as in an immature fish, and he does not mention the granular masses at all. My contention is that not only are the granular masses evidence of previous spawning, but that they are rapidly absorbed, so that in a fish over 9 in. long, there may be, some time after it has spawned, no indication left to distinguish it from an immature fish, which has never spawned at all. I have reason to believe that this complete reversion of the ovary to the apparently immature condition occurs chiefly or only in the smaller, *i.e.*, the younger fish, and does not take place to the same degree in fish which have spawned several times.

On April 15th, I saw thirty boxes of plaice landed from a vessel which had been fishing at Markham's Hole and the Swatchway, grounds to the S.E. of the Dogger Bank, and from twenty to twenty-five fathoms in depth. I bought a sample for examination. There were 23 fish in all—11 females, 12 males.

| | Males. | Females. |
|---|---|---|
| 9 in. | 1 ripe | |
| 10 „ | 2 spent ? | |
| 11 „ | 4 two spent, two ? | 1 |
| 12 „ | 4 one ripe | 3 probably spent |
| 13 „ | 1 spent | 4 „ „ |
| 14 „ | | 2 „ „ |
| 15 „ | | 1 spent. |

I could not be quite certain that any of these were really immature. Of the males four were doubtful, two at 10 in., two at 11 in., but I do not believe they were immature. Of the females, the one at 11 in. had no yolk and no granular masses, and may have been immature. Of the three females at 12 in., one showed no masses, the other two showed them very distinctly. Of the four at 13 in., one showed no masses. Of the two at 14 in., both showed the masses. The one at 15 in. showed the masses very distinctly, and was certainly spent. As usual the food was *Solen* and other molluscs, worms, and occasionally a small crustacean.

On May 3rd and 4th, I visited the Billingsgate Market, in London, where I was introduced to Mr. Johnson, the officer of the Fishmongers' Company, and from him received great courtesy and assistance in my enquiries. He informed me that about a third of the supply of fish received there is landed by steam cutters, who bring it from fleets of trawlers fishing in the North Sea, the rest coming by railway. It had been stated a few days before, at a conference of the National Sea Fisheries Protection Association, that great numbers of small plaice were being landed at Billingsgate. On the two mornings when I was there, the proportion of small fish was not so large as it had been, and I failed to obtain a box for complete examination. I saw, however, some of the fish landed from a "cutter," or carrier, and the smallest plaice I could see and measure was 6 in. long. This was one of a few lying about the deck, which had fallen from the boxes. I also examined 8 specimens brought to me by Mr. Johnson, of these only two were over 6 in., the rest were below that size, the smallest being 5¼ in. I could not find out where these fish were caught, except that it was somewhere on the eastern side of the North Sea.

I think it will conduce to clearness and precision in considering the data I have given, to keep separate the questions of size and reproductive maturity. To dispose of the latter first, it seems of interest to me, whether it has a practical bearing or not, to try to discover whether immature plaice are found on all grounds, or to what depths and regions they are chiefly confined. I have described samples, 15 fish altogether, from the Great Fisher Bank, and among them were no immature males, and one female apparently immature. The Fisher Bank is from 20 to 40 fathoms in depth. In the large sample of 212 fish from the Leman ground, there were eight females possibly immature, and three possibly immature males. In 13 fish from the home grounds, I am not sure that any were immature, and the same is true of the 19 from the Dogger Bank. Of the sample from Markham's Hole on April 15th, some may have been immature, but it was difficult to be sure. On the other hand, in the plaice from the Sylt ground, there can be no doubt that a large proportion were immature, all females under 9 in. certainly, and a proportion of those above that size, although I am inclined to think, for the reasons given, that some had spawned. I have not examined many plaice from the Humber, but there can be no doubt that in the earlier months of the year nearly all of these are immature. As far as we can judge at present, it would appear that the year-old fish, all of which are immature, are not taken at the season of the year covered by the present observation, in any considerable numbers on any of the off-shore grounds. I consider that the small plaice from the Sylt grounds and from the Humber, consist largely, but not exclusively, in the case of the former, of year-old fish.

To consider now length only. The lower limit of plaice from the Fisher Bank was 12½ in. Of the small fish from the Leman ground, which is opposite the Lincolnshire and Norfolk coasts, the lower limit was 7 in. for males, 9 in. for females, and only one fish in a box of

212 was under 8 in. Of the sample from the home grounds, there were no males under 10 in., no females under 11 in. Of fish from the Dogger Bank and grounds to the south of it, the lower limit was 9 in. for males and 10 in. for females. In the first sample from the Sylt ground, the minimum was 7 in., and there was only one fish out of 55 under 8 in. In the second sample, selected from 4 boxes, the minimum was 6 in., and there were 104 fish out of 187 under 8 in. At Billingsgate, a considerable number of the plaice landed were under 6 in. The upper limit is also of some importance, although it is not fully determined by these observations. Of the fish from the Sylt ground none were above 13 in. in length; in the sample from the Leman ground the upper limit was 14 in., but there were plenty larger than this in the same catch, and in all the other samples there were fish over 14 in.

It appears, therefore, that in the period covered by these observations, the usual minimum on the off-shore grounds is 9 in. for males, 10 in. for females, but occasionally it may be as low as 7 in. and 9 in. Fish below these limits have been obtained only from the Sylt ground and the Humber. Parts of the Dogger Bank are quite as shallow as the Sylt ground, where the small plaice are taken, yet such fish are not found there. Proximity to the land, therefore, appears to be an essential condition in the rearing of young plaice. But the question is, why are the small plaice so much more abundant on the Continental than on the English side? There can be no doubt that the history of the plaice is the same on the two sides. We have sufficient evidence that the plaice hatched from January to March, are to be found abundantly, in summer, along the edge of the shore on the English side, wherever there is sand or sandy mud. Those of a year old, and some of those which are two years old, are the small plaice which are taken to market by the inshore boats in the Humber, and all along the coast of Lincolnshire, Norfolk, Suffolk, and Essex, and by the large trawlers from the Eastern Grounds. But the difference in numbers obtained on the two sides is enormous. On the eastern side a steam trawler brings in between 200 and 300 boxes after about a fortnight's fishing, but I have not heard of a large trawler ever having been able to get a voyage of small plaice on the English side. The cause of the difference seems to me to lie in the configuration of the sea bottom. There is a rather broad tract, less than 20 fathoms deep, extending from England to Holland, from the latitude of the Humber to that of the north coast of Norfolk. But north of this region the 20 fathom line is about 40 miles from the coast of the islands on the Continental side, from 15 to 3 miles on the English side. South of this region also there is a depression deeper than 20 fathoms, which is nearer to the English side than to the Continental. It may be true that more of the floating eggs and larvæ of plaice are carried to the Continental side than to the English, but this would make no difference, if food for the young plaice, and other suitable conditions, especially shallow water, were not more abundant and more extensive. We have seen that the food of the small plaice largely consists of *Solen,* and it is probable that the abundance of this mollusc depends upon wide tracts of shallow sandy ground in the neighbourhood of the mouths of large rivers. A somewhat similar case is that of Lyme Bay, on the south coast of England, where the 20 fathom line is a long way from the shore, and the smaller Brixham trawlers have been in the habit of taking large numbers of small plaice. In Dr. Fulton's investigations, he took a limit of 12 in., and found that plaice under this size were chiefly confined to depths below 10 fathoms, and a distance from shore less than 3 miles. This was on the east coast of Scotland: the 10 fathom line, according to the chart, is in some places 20 miles from the coast of Sylt Island.

All this, however, being admitted, it does not afford a reason why the young or small plaice should be less plentiful on the English side, off the coasts of Lincolnshire and Norfolk, where the general slope is nearly as gradual as on the Dutch and German coasts. There is another difference to be taken into account in this locality, namely, as a study of the chart will show, the existence of numerous banks and holes and rough rocky ground. The grounds are worked by trawlers, but are intricate, and necessitate short hauls, while the Eastern Grounds are noted for the slight wear and tear which they cause to the trawl, and the long hauls which can be made on them. It appears probable that the number of young plaice reared is proportional, not merely to the area of ground near the coast below 15 or 20 fathoms, but to the area of ground of a certain quality, and producing certain kinds of fish food; and a scientific, accurate comparison of the English grounds with the Continental, from this point of view, would doubtless throw much light on the "eastern question" of the North Sea trawl fishery. I hold strongly to the opinion that the business of naturalists in relation to fishery questions is to establish a sound and extensive basis for conclusions on fishery problems, by a thorough study of the physical and biological conditions of the various fishing grounds. With regard to the North Sea, it cannot be maintained that the investigations already made, valuable as they are, supply anything like an exhaustive knowledge of those conditions. On the contrary, they form merely a foundation and preparation for further progress.

In March, 1894, Prof. Dr. Heincke published in the *Mittheilungen* of the Deutscher Fischereiverein an article on the question of protection of undersized plaice, &c., reviewing at considerable length the report of our Parliamentary Committee on Sea Fisheries, which sat in 1893.

In criticising and objecting to Holt's biological limit of 17 inches for plaice, he maintained that the average size of plaice spawning for the first time is much smaller in the German part of the North Sea than in the English. He stated that as the plaice of the Baltic was, at corresponding stages, a smaller race than the plaice of the North Sea, so the plaice of the eastern side of the North Sea was smaller than that of the northern and western parts. According to Heincke, the existence of local differences made not only the same closed areas and the same close seasons for the whole North Sea, but also the same limit of size, impossible. Heincke mentions no observations which support his assertion, but it appears to rest on his own personal experience, and it will be seen, from the observations above recorded by me, that Mr. Holt's figures were probably somewhat too high. My present conclusion is that although there is considerable variation in the size of plaice spawning for the first time, there is no difference between a German plaice and an English. To those engaged in the fish trade, it may be very beneficial to have a limit of size, to exclude the small plaice, because the uncertainty and risk of the business may be thereby diminished, whether any benefit to the fishery is produced or not. This seems to be especially the case at Billingsgate, although it is, to a certain extent, true in other markets. At the former place, I am informed that a considerable proportion of the smallest plaice are worthless, or very nearly so, and the buyer is unable to judge accurately of the value to himself of the box, as it is sold by auction. The fish at the top of the box are of considerable size, and many a poor dealer, I understand, finds great difficulty in retailing his plaice without a loss. It is certain that numbers of the smallest plaice are thrown away, both at Billingsgate and at the various shops, as worthless, and are carted away for manure. There is practically no demand for plaice 5 or 6 inches long, and dealers naturally object to have to buy the goods they require mixed with a quantity of rubbish which is of no use to them, and often to pay good money for the worthless fish. But all this has little to do with us; we are only concerned with the possibility of maintaining and increasing the natural supply of the larger plaice.

The limit proposed in the bill now before Parliament is 8 inches for plaice. It is clear, from the facts given, that the effect of this, if the law is enforced, will be to exclude the plaice mentioned above —5 to 8 inches in length. But the question is, how far this exclusion will cause the fisherman to avoid certain grounds. It is very doubtful if throwing the fish overboard will lead to their survival, except, perhaps, in the case of small boats fishing in places like the Humber. On the other hand, there is reason to believe that on the Eastern

Grounds the smaller fish are nearer the land, and, to some extent, the existence of a legal limit may have the effect of causing the trawlers to fish further out, where the larger fish are. I hope to study this question by visiting the grounds on the fishing boats. At present, very little of the remuneration is obtained from plaice under 8 inches, so that the effect of the proposed law is not likely to be any very great protection of the small fish. I have always thought that the question of reproductive maturity is not the question of chief practical importance in this matter. To my mind, the question is, can a limit be discovered which will make the small plaice grounds unprofitable, without causing waste on all other grounds. So far as I can see at present, a limit of 10 inches would have conferred considerable protection to the Eastern Grounds, without causing a corresponding or considerable waste on the grounds in the open and central parts of the North Sea.

The probable, or we may say the certain, effects of a limit of 8 inches and of 10 inches can be seen, to some extent, by inspection of the data given in vol. ii., p. 347, of this Journal. The box there recorded from Arlberg, Denmark, containing 198 plaice, would not be affected by the limit of 8 inches, while the box from Schiermonnikoog, containing 286 fish, would lose only 9. With a limit of 10 inches, on the other hand, the latter box would lose 200, and the former would lose 97 out of a total of 193. Of the Humber plaice recorded in the same list, a limit of 8 inches would exclude in one sample 224 out of 425 fish, and a limit of 10 inches would shut out all the 425 except 8.

In the report on the Dutch Fisheries for 1893, Dr. P. P. C. Hoek has published the results of some experimental trawlings made with a hired trawler off the Dutch coast. The trawl used had a beam of 35 feet in length. The mesh of the net was $2\frac{1}{5}$ inches at the cod end, taking the length of the whole mesh, which presumably means $1\frac{1}{10}$ inches from knot to knot. The hauls were made between Terschelling on the north, and the latitude of Amsterdam on the south, and may be considered in three groups—(1) within 6 miles of the coast; (2) 15 to 30 miles off; (3) about 55 miles off. The following are the sizes and number of plaice taken:

*First Group of Trawlings.*

Sept. 15. Less than 3 miles from shore; depth, 7 to 4 fms. About 175 lbs. of plaice, number not given, size $4\frac{4}{5}$ in. to 16 in.; but of the latter only 1 in 50 fish.

Sept. 14–15. 5 or 6 miles off; depth, 8 fms. About 43 lbs. plaice, $6\frac{4}{5}$ in. to 10 in.

Sept. 15. About same distance; 9 fms. A slightly larger number, $7\frac{1}{5}$ in. to $10\frac{4}{5}$ in.

August 30. Depth, 11 fms. About 26 lbs., $6\frac{2}{5}$ in. to $12\frac{1}{5}$ in.

August 31. Depth, $8\frac{1}{2}$ fms. About 175 lbs., 4 in. to $10\frac{3}{5}$ in.; one in 114 fish was $20\frac{4}{5}$ in.

Sept. 1. Depth, 12 fms. About 96 lbs., $6\frac{1}{5}$ in. to $9\frac{1}{5}$ in.

For the records given a sample only was measured; but in all cases a large proportion were under 8 in., and few over 10 in.

*Second Group of Trawlings.*

August 24. Depth, 15 to 17 fms. 460 plaice; of 25 measured, 15 8 in. to $8\frac{2}{5}$ in., 10 $8\frac{4}{5}$ in. to $9\frac{1}{5}$ in.

August 28. Depth, 14 fms. 52 lbs., 8 in. to $11\frac{1}{5}$ in.

August 29–30. Depth, 15 fms. 70 lbs., 8 in. to $11\frac{1}{5}$ in., and a few up to $14\frac{2}{5}$ in.

Sept. 5. Depth, 15 fms. $17\frac{1}{2}$ lbs., $6\frac{4}{5}$ in. to $11\frac{2}{5}$ in.

Sept. 5. Depth, 15 fms. 32 lbs., $8\frac{2}{5}$ in. to 14 in.

Sept. 5–6. Depth, 16 fms. 119 lbs., $8\frac{2}{5}$ in. to $11\frac{3}{5}$ in.

Sept. 20–21. Depth, 16 fms. 119 lbs., $5\frac{3}{5}$ in. to $10\frac{3}{5}$ in.

This last haul was about 15 miles from the coast of the island of Terschelling.

*Third Group of Trawlings.*

Sept. 11–12. Depth, 17 fms. 35 lbs. smaller, $17\frac{1}{2}$ lbs. larger; 8 in. to 14 in., some up to $18\frac{2}{5}$ in.

Sept. 12. Depth, 17 fms. 24 plaice, $7\frac{2}{5}$ in. to $18\frac{1}{5}$ in.

Sept. 12–13. Depth, 17 fms. $52\frac{1}{2}$ lbs., $8\frac{3}{5}$ in. to $14\frac{2}{5}$ in.

The exact proportions below different limits cannot be ascertained, but the above data indicate that a limit of 8 in. would go far to make the ground where the first group were carried out unprofitable. The different sizes on the different grounds are well brought out by the average lengths given.

Thus in the first group the averages were:—

$6\frac{2}{5}$ in., $8\frac{3}{5}$ in., $8\frac{7}{10}$ in., $7\frac{3}{5}$ in., $6\frac{1}{10}$ ins., $7\frac{3}{5}$ ins.

In the second group:—

$8\frac{4}{5}$ in., $9\frac{3}{10}$ in., a little less than 10 in., $9\frac{3}{5}$ in., 10 in., $9\frac{4}{5}$ in.

In the third group:—

$11\frac{3}{5}$ in., 12 in., 12 in.

In Denmark the limit for plaice by law is now 8 in. to the root of the tail, or very nearly 10 in., including the tail. In Belgium the limit enforced is $7\frac{1}{5}$ in. (18 cm.). In France it is $5\frac{3}{5}$ in., while in Holland the only limit is $3\frac{1}{5}$ in. for flounders, and there is no law for plaice.

## IV. On the Relations of the Generative Organs and of the Sexes in Some Fishes.

Although a considerable number of observations have been made and published concerning the sizes of ripe, nearly ripe, and spent fish, and on the condition of the reproductive organs in these various stages, we are far from possessing at present a complete and satisfactory knowledge of the changes through which these organs pass in the development of the fish to maturity, and from one spawning period to the next. This is in fact a subject where investigation requires minute microscopic study, and the application of advanced microscopical science; and the investigation is necessarily an extended one, because it involves a complete examination of all stages in a given fish, and a comparison of all the different fishes with one another. I have a few observations and suggestions to offer here in addition to those contained in my papers on the subject in previous numbers of this Journal.

The first point I wish to consider is the remarkable difference in proportional size between the ovaries and testes in different species, and in relation to this, the differences between the sexes in number and size. To Dr. Fulton belongs the credit of having first drawn attention to these phenomena, and he has published some important data concerning them, and suggested some explanations. (See his papers in the 8th, 9th, and 10th Reports of the Scottish Fishery Board). It is well known that in some fishes, as in the herring, the testes or soft roes are as large as the hard, and the same is true of Clupeoids generally. In the cod family it is difficult to judge without accurate weighing, but the testes, which are of a curious frilled shape, quite different from that of the ovaries, do not appear obviously smaller than the latter. In the flat-fishes, on the other hand, the testes are always smaller than the ovaries, and the minimum is reached in the sole, where they are so small as to have been formerly entirely overlooked. Dr. Fulton has given the actual weights of the organs in a number of specimens, but has not worked out the proportion they bear to the weight of the fish. From averages of 10 male herrings and 16 females it was found that in fish of 11·2 in. in length the testes weighed 35·6 grammes, the ovaries 35·0, so that the testes were actually a little heavier. In a male cod 39 in. long the ripe testes weighed 846 grammes, while in a female of 38 in. the ovaries weighed 2,124 gms., or more than twice as much. A difficulty in exact comparison arises from the varying conditions of the organs, whether in the development towards maturity, or whether the discharge of products after spawning has commenced; all that can be done is to compare them just before the commencement of spawning.

In a male plaice 21 in. long the testes weighed 29·5 grms.; in a female 23¾ ins. the ovaries weighed 503 grms. In the lumpsucker, in a male 12 in. long the testes weighed 70·8 grms., in a female 17 in. long the ovaries weighed 878 grms.

If the small size of the testes were compensated by the greater abundance of the males, an approach to equality in the quantity of the generative products might be the result. But the opposite of this, according to Dr. Fulton's researches, is usually the case. Thus in the cod there were found to be 133 females to 100 males, in the plaice 142 females to 100 males, but in the lumpsucker there were only 25 females to 100 males, and in the herring the numbers of the two sexes were very nearly equal. Dr. Fulton considers the probable significance of these relations, and concludes that the testes are usually smaller in fish with pelagic ova, and more nearly equal in those with adhesive ova, and he thinks the explanation is that fertilisation is more certain in the case of pelagic ova, because the sperms move upwards like the eggs, while in the case of attached ova a great deal of the milt is wasted. There is probably much truth in this suggestion, but I would put it in a somewhat different way. In the sea the water is generally moving in one direction or another, and the milt shed into the water disperses by diffusion, even without the movement of a current. Therefore, if the eggs are fixed, much of the milt must travel away from them, and more of it is required. Where the eggs are free in the water like the milt, they scatter together, and are moved together by the currents. It is remarkable, however, that in the angler, of which the eggs, though free in the water, remain connected in a continuous sheet, the males are much more numerous (100 males to 26 females), and the males are also larger, though whether the testes are larger than the ovaries has not been ascertained.

But the proportion in bulk between testes and ovaries differs very greatly among fishes which agree in having pelagic ova. For instance, in the cod the inferiority of the testes is very much less than in the plaice, and in the plaice than in the sole, while in the flounder, although the testes are smaller, the males are more numerous than the females. It seems to me that these differences are to be explained by the differences in the rate of spawning. Some fishes, like the herring, shed the whole crop of eggs for the season at once. The eggs are all in the same stage of development, and therefore are all ripe at one time, and when spawning begins it continues at a rapid rate until the roe is empty, and the fish is spent. Plaice and cod do not spawn so rapidly as this, but it is certain that in both these fishes a large number of eggs can be squeezed from a ripe female at one time, so that the roe is soon emptied. The rate of spawning, and its duration, can be studied by examining the ripe and ripening ovaries, as Dr. Fulton has done to a great extent in his investigation of the fecundity of fishes. In some cases, although the number of ripe eggs present is considerable, there are others in various degrees of development, so that spawning is prolonged. This is the case in the gurnard, and in some fishes with attached ova, such as *Syngnathus acus, Anarrhichas lupus* (the cat fish) and others. In the plaice, according to my own experience, and Dr. Fulton's observations, a large number of ripe ova are shed at once, and the season's crop is soon exhausted. There is no prolonged production of young ova to succeed those first shed. The fish being of a high degree of fecundity, and having all its eggs nearly ripe at once, the distension of the body by the ripe ovaries is very great. In accordance with this state of things the testes are rather large, very much larger than in the sole, and spent fish appear early in the spawning season. The spawning process being thus completely and abruptly terminated, the ovary reverts to a resting condition. At Plymouth I found a spent specimen as early as January 28th, at Grimsby the first I recognised was obtained on February 27th. The conclusion that the ovary does revert to its original condition, based on the evidence given in my paper on the ovaries of fishes, vol. iii., p. 154, has been confirmed by my observations this season at Grimsby. It has been shown in former papers by Mr. Holt and myself, that in the spent ovary the chief peculiarity is not the appearance of empty follicles from which ripe eggs have escaped, but the presence of partially yolked eggs, which are found to be afterwards absorbed. But the opaque granular masses to which I have so often referred above, had not attracted my notice very much before the present season. They are easily overlooked, not because there is any difficulty in seeing them, but because they are so indefinite in shape, and do not appear at first to have any important significance. The history of the ovary could be worked out with more certainty if we were able to examine specimens in captivity, the date of whose spawning was known from actual observation. I have in a former paper described a few such specimens, but they were not killed until several months after spawning.

I have not yet made a thorough examination of shotten herring, but the few notes I have made tend to show that in the spent ovary the ova are all quite yolkless and transparent, as in the immature ovary. A newly-spent herring can be recognised from the flaccid and congested condition of the ovary, but it is extremely probable that this condition soon passes away.

The haddock presents a condition similar to that of the plaice, that is to say the spawning of an individual fish is soon over, the development of the eggs being nearly simultaneous. On April 20th I examined

6 specimens in which the condition of the reproductive organs was as follows:—

Length of fish $14\frac{3}{4}$ in. Testis a thin translucent cord: fish apparently immature.

Length 15 in. Female, ovary small, $1\frac{1}{4}$ in. long, no yolk, no granular masses: apparently immature.

Length $17\frac{3}{4}$ in. Female, ovary spent, $1\frac{9}{16}$ in. long, much mucus in cavity. In the germinal tissue yolkless eggs and dead partially yolked eggs as in spent plaice, but the latter were few and scattered.

Length $19\frac{3}{4}$ in. Female, ovary $2\frac{1}{8}$ in., spent. Same condition as in preceding.

Length $20\frac{1}{2}$ in. Female, spent; same condition.

Length $20\frac{1}{2}$ in. Male, spent, testis almost invisible.

There can be little doubt here about the rapid recovery of the ovary, and the danger of confusing immature with recovered fish.

On the other hand, in the lemon dab and common sole, the spawning process in a single female is gradual and prolonged, and spent females do not appear early in the spawning season. When a ripe ovary of these two species is examined, the eggs are not found to be nearly uniform in development, but to form a graduated series down to the minute. In spite of this similarity I have observed that a large number of ripe eggs can be obtained at one time from a lemon dab, and the testes are of considerable size, but still, according to Dr. Fulton's figures, smaller in proportion to the ovaries than in the plaice. The witch appears to resemble the plaice, the eggs developing uniformly, and the testes being rather large.

I have examined a few witches at Cleethorpes. The size of mature and immature specimens has not been so carefully studied in this species as in others. On February 18th I examined 6 specimens. Two were males, both mature, $15\frac{1}{2}$ and $16\frac{7}{8}$ in. long; four were females, $16\frac{1}{2}$ to $18\frac{5}{8}$ in., and all mature, but not ripe; that is to say, the ovaries were enlarged, and the development of the yolk in the eggs advanced. On February 23rd I examined 4 more, all females, 15 in. to $19\frac{1}{2}$ in. long, and all mature.

Mr. Holt found some lemon dabs immature at 12 in., and 50 per cent. of the females at 11 in. At Plymouth I examined numbers of females down to 7 in. long, and none were immature. My observations were made from January to March, Mr. Holt's between February and September. On February 18th last I examined 6 specimens: 2 were mature males, $12\frac{1}{8}$ and $12\frac{1}{2}$ in. long, 3 were mature females, $12\frac{1}{2}$ to $13\frac{3}{4}$ in.; and one $9\frac{1}{4}$ in. was an immature female. There could be no doubt about the last specimen, as no spent females were to be found at that date.

In all the fish hitherto mentioned there are no oil globules in the ripe egg, and the development of the yolk follows the course which I have described in my two papers, vol iii. pp. 154 and 258. In all these cases I have satisfied myself that the development of the yolk in the eggs takes less than a year. In other words the formation of the crop of eggs for the next spawning season does not begin until some time, about three or four months, after the preceding spawning. But in my paper, vol. iii. no. 2, I described in the egg of the sole the presence of minute globules in the ova of immature females during the spawning season, and in spent females. Recent observations have shown me that these minute globules occur only in those eggs in which oil globules are present in the ripe condition, and I conclude that the deposit of oily matter commences in the ova long before that of yolk proper.

On April 8th I examined 3 small brill, procured from a lot of 34, brought with 4 small turbots and 120 boxes of small plaice from the Sylt Grounds. One was $9\frac{1}{4}$ in. long, a male not ripe, but with testes rather large and soft, evidently approaching ripeness. One was $11\frac{1}{8}$ in., a ripe male. One was $11\frac{1}{2}$ in., a female, the end of the ovary $4\frac{1}{4}$ in. from the anterior end, $4\frac{7}{8}$ from the posterior end of the ventral fin. All the ova under the microscope were transparent, but except in the very smallest there were small, clear globules, principally collected round the germinal vesicle. I think this specimen could not have matured its eggs during the present spawning season, and would not have been ripe for at least 12 months. On April 22nd I examined another specimen, 15 in. long, in which the left ovary was $3\frac{7}{8}$ in. long and 5 in. from the end of the ventral fin. There was nothing to indicate that this specimen was spent, all the ova were transparent, but here and there one showed the scattered globules I have mentioned. This specimen was presumably immature.

On April 24th I examined the ovaries of two turbot. One was $19\frac{3}{4}$ in. long. The roe was opaque white from the development of yolk, and obviously approaching maturity. Under the microscope the yolk in the eggs was in all stages of development. In some there were only the peculiar globules I have mentioned, in others a little larger, these were more numerous, and began to form a *dark* zone round the germinal vesicle, while in the outer part of the egg were globules of ordinary yolk of a much lighter appearance. In all the eggs in which the development of yolk was considerable, there was an inner darker and an outer lighter zone. The other specimen was $15\frac{1}{2}$ in. long, and the formation of the dark inner zone had commenced in an egg here and there. Apparently this specimen would have spawned this season.

On April 26th I examined a number of *Trigla gurnardus.* I did not note the sizes of these, but all were mature, and in most of them there were some ripe eggs. In each ovary there was every stage of development, from the transparent egg with a few globules to the large also transparent ripe egg, with its large single copper-coloured oil globules. As in the turbot, what may be called the second stage consisted in the formation of a dark inner zone round the germinal vesicle, with scattered globules in the outer region. In the next stage the egg is full of yolk, no clear protoplasm is visible, but there is a marked contrast between the dark inner zone and the light outer. In the fourth stage the contrast is less marked: the dark inner zone appears to consist of very minute globules of oil, and at this stage they run together and form large globules, in consequence of which the inner zone becomes more translucent. In the fifth stage the coalescence of the inner globules and of the outer into larger and larger drops can easily be seen, and it is perfectly obvious that the inner drops form the oil globule of the ripe egg. Thus the oil globule originates in the central part of the egg, and only rises to the surface when the whole yolk becomes a continuous liquid.

These facts considerably modify the criticism I have given in vol. iii. p. 263, of Scharff's account of the development of the egg. I have not his paper here to refer to, but he worked with the eggs of *Trigla gurnardus,* and described the division of the protoplasm of the egg into two layers. In the eggs of plaice and flounder I could only find an outer yolk layer and an inner without yolk. I have now shown that there are at any rate two types in the development of yolk in the eggs, one characterising the eggs without oil globules, the other those that possess the latter. In the ovaries of fish whose eggs possess oil globules, the presence of minute scattered globules, in otherwise protoplasmic eggs, does not imply the "active" condition of the ovary—does not, that is to say, prove that the maturation of the ovary for the next spawning season has commenced. It seems to me quite possible that in these fish also a spent ovary may revert to the condition of the immature, but on this point we have at present little or no evidence. The dark inner zone in the developing eggs above described appears to be due to the presence of exceedingly minute and numerous globules of oily matter, which by their great sub-division and refracting power cause the opacity of that part of the egg.

## V. Two Trips to the Eastern Grounds.

In order to acquaint myself, by personal examination, with the condition of the Eastern Grounds, and the products of the trawling there carried on, I have made two trips on board steam trawlers bound to those grounds. On my first voyage, I left Grimsby Docks on May 14th, on board the s.s. *Lucania*, belonging to the Alliance Company. The run was about 260 miles E. ¼ N. When we reached the neighbourhood of the Horn Reef on the 15th, it came on to blow, and we lay-to for twenty-four hours without shooting the trawl. This was the commencement of the disastrous gale, which continued, with little interruption, on the English side of the North Sea, until Monday, May 20th, but on the German, or eastern side, it moderated on Thursday evening, and for the rest of the trip we had very fine weather.

The trawl was first shot on the evening of May 16th, and hauled at 11 p.m., but I did not make any observations until the second haul, at 6 a.m. on the 17th. The position, then, according to the captain, was thirty miles south of the Horn Reef, twenty miles west of the Sylt. The marketable fish taken were haddock, cod, and plaice. Of the last, the smallest was 12¼ in. long. The refuse consisted of whelk spawn and crabs (*Hyas araneus* and *Cancer pagurus)*. The bottom was sand and broken shells; there were pieces of shell on the net.

During the third haul the depth was 11 to 13 fathoms, and the bottom consisted of coarse sand, called rice-ground by the captain. A tow net was put on the trawl head, and the tin at the end of it came up half full of this sand, in which were three living specimens of *Amphioxus*. The fish caught were 2 baskets of plaice, none under 12 in., 14 baskets of haddock (9 of kit and 5 of gibbers), 23 cod, 2 turbot 1 brill; none of the turbot or brill under 12 in. The stomachs of the plaice contained *Solen*.

The fourth haul, lasting like the preceding six hours, was concluded at 8 p.m. on the 17th. A net of mosquito-netting on the trawl head, brought up a number of larval flat-fishes in process of transformation, probably plaice and dabs, and also one sand-eel. The fish in the trawl were 14 baskets of haddocks (10 of kit and 4 of gibbers), several cod, 3½ baskets of plaice, the smallest of these being 11½ in. by measurement. There were 2 lemon soles, one of them 8¾ in. long. A large number of dabs were obtained in this and all other hauls, but were not saved for the market, their value, after being iced for some days, not being considered sufficiently great. A few of the largest were cleaned for the cabin table, the rest thrown overboard. The haddocks' stomachs contained brittle stars; these, and all other marketable fish, were gutted before being packed away in the fish hold. Edible crabs occurred in every haul, but were not saved for market, only a few being eaten on board.

At the fifth haul, at 3 a.m. on May 18th, were taken 22 baskets of haddock (7 of gibbers and 15 of kit), and 2 of plaice. A larger number of haddock are usually taken at night than in the day-time.

At the sixth haul, at 10.30 a.m., the catch comprised 8 baskets of haddock, 3 of plaice, 1 turbot, 1 hake, 5 codling, a few whiting, numbers of dabs, and 1 gurnard. The smallest plaice was $10\frac{5}{8}$ in. long.

Seventh haul, 5 p.m., May 18th. 9 baskets of haddock, viz., 3 of gibbers, 6 of kit, 2 baskets of plaice. 1 turbot, $28\frac{1}{2}$ in. long, a female, nearly ripe; 1 brill, $13\frac{1}{2}$ in. long, approaching ripeness. The food of the plaice was, as usual, *Solen*.

During the eighth haul the vessel was steered first N.N.E., and then S.S.W., the depth was 13 fathoms and the Inner Horn Reef light was seen, bearing E. by N., distant about ten miles. I could not obtain the exact position for every haul, but it must be understood that trawling was carried on without interruption, so that one or two fixed points are enough to indicate the fishing ground. A steamer carries two trawls, one on each quarter, and as soon as one was hauled, the other was shot. As we were keeping in the same neighbourhood, the vessel was steered on one course for about three hours, and then on the opposite course for the remaining three. It may be pointed out, that the principal part of the catch in these hauls was the haddock. At the eighth—a night haul—there were 8 baskets of gibbed haddock and 20 of kit, and only 2 baskets of plaice.

Ninth haul, 8 a.m., May 19th. The foot-rope was broken and the net torn, an indication of rough ground. The marketable fish were, 8 baskets of gibbers, 16 of kit, 2 of plaice, 4 brill, 2 turbot, about 20 cod, 1 halibut. The kit haddocks measured about 15 in. long, the gibbers 20 to 26 in. The smallest plaice was $12\frac{1}{2}$ in. long, the largest 26 in. Of the brill—2, 13 in. and $14\frac{1}{2}$ in. respectively, were immature females; 2, 14 in. and $16\frac{1}{2}$ in. in length, were ripening. Of the turbot—1, $13\frac{1}{2}$ in., was an immature female; the other, 14 in., a mature male. The smallest cod was 13 in. long, the rest were about 3 ft.—some more, some less. The stomach of one large cod contained 4 sand-eels and 2 crabs *(Inachus)*; another contained 12 sand-eels; another a large crab *(Hyas)*. The halibut was 4 ft. 8 in. long, a spent female, and had 10 haddocks in its stomach.

Tenth haul, 6 p.m.; depth, 13 fathoms. The trawl was down nine hours this time, the day being Sunday. There was in the net 1 mackerel —a ripe male; 3 hake—2 males, 1 female, mature, but not ripe; 7 large turbot, female, mature, but not ripe; 1 brill, over 12 in.; 1 sprat, a ripe female; 4 baskets of kit haddock, $\frac{1}{2}$ basket gibbers; 2 baskets of plaice. In the stomach of one of the turbot were 3 sprats and 2 sand-eels. A few large mackerel were also got at the eleventh haul.

Twelfth haul, 8 a.m., May 20th. During this haul, at 2 a.m., the Outer Horn Reef Light was seen, bearing N.E. by N., and distant about 10 miles. The net brought up 9 baskets of kit haddock, 2 of gibbers, 3 of plaice, 1 of gurnard *(Trigla gurnardus)*, 2 turbot, one 14 in. long, a mature male, one 24 in., a mature female; 25 large cod, and some small. As usual, there were no small plaice, but many large, 20 in. long and upwards.

Thirteenth haul, 5 p.m. The depth of 15 fathoms was obtained by the lead. There were 7 turbot—2 mature females, $29\frac{1}{2}$ in. long, 5 mature males, $14\frac{1}{2}$ to $21\frac{1}{2}$ in.; 2 brill, $17\frac{1}{2}$ in. and 20 in., both mature females. Also 10 baskets of kit haddock, 3 of gibbers, 3 of plaice, and 1 of gurnards. About half a basketful of small haddocks, about 10 in. long, were shovelled overboard with the dabs. The smallest of these were $6\frac{1}{2}$ in. long, but there were few as small as this. The smallest dab was 5 in., an immature female, but nearly all of them were mature and spawning, many being nearly spent.

Sixteenth haul, 4.30 p.m., May 21st. There were $3\frac{1}{2}$ baskets of kit haddock, 1 of gibbers, $3\frac{1}{2}$ of plaice, $1\frac{1}{2}$ of gurnards, a few codling and roker. The plaice were nearly all large, none under 12 in. There was 1 brill, $12\frac{1}{4}$ in., an immature female; no turbot. 1 *Acanthias vulgaris* and 1 *Echinus* were taken.

At 6.30 p.m. we were steering E. by N., the depth 13 fathoms, bottom fine sand. We saw the Outer Horn Reef Light after dark.

Eighteenth haul, 5 a.m., May 22nd. There were 2 turbot, $25\frac{3}{4}$ in. and $27\frac{1}{2}$ in., both mature females; 3 brill, $15\frac{1}{2}$ to $18\frac{1}{2}$ in., all mature females; 1 basket of large plaice, none under 12 in., about a basketful of haddock and one of gurnard.

In the last, or nineteenth haul, there were 2 soles, one $7\frac{1}{2}$ in. long, a male, immature, one $11\frac{1}{4}$ in., a male, mature. A few other soles were taken during the voyage, but never more than 2 or 3 in one haul. Roker, *i.e.*, *Raia clavata*, and other species, were also taken, but I paid no particular attention to them. The most important points noticed in this voyage are the following:—

No small plaice were thrown overboard, because none were taken of so small a size as to be unmarketable. None of those taken were less than $10\frac{5}{8}$ in. long, and a large proportion were 20 in. and upwards. The captain said that when we were in sight of the Inner Horn Reef Light, we were on the same ground on which he obtained chiefly small plaice in the previous March. Whatever the significance of that fact may be, supposing it to be correct—and I have no reason to doubt it—it is certain that the small plaice were not there in May.

Only two or three lemon soles and an insignificant number of soles were taken. A few immature turbot and brill were observed, but none were under 12 in. in length.

The only fish thrown overboard were the dabs, a comparatively small number of small haddock, and some small gurnard and whiting.

After my return from this voyage, I noticed in the market that the catches from the Eastern Grounds often included large numbers of small brill and turbot, and a considerable quantity of soles. Thus, on May 30th, a vessel which had been fishing 10 miles off the Sylt Light, at about 13 fathoms, landed about 200 boxes of small plaice, 3 boxes of soles, 130 small brill, and 28 small turbot. By small here, I mean brill and turbot about 12 in. in length, very few of these fish exceeding 14 in. I bought a sample of the brill for examination, not selecting them in any way There were 20 in the sample—3 males, 17 females. The smallest female was $10\frac{3}{4}$ in., the largest $12\frac{3}{4}$ in., and all were immature. On examination of the ovarian tissue with the microscope, a few of the eggs, in nearly all the specimens, were found to contain the scattered central globules, which I have mentioned elsewhere, as occurring in immature brill and turbot. The three males were from $10\frac{1}{4}$ to $11\frac{1}{2}$ in. in length; the smallest was sexually ripe, the other two nearly, but not quite so.

On June 1st I bought a box of small plaice, brought from the ground off the Sylt. The price of this was 3s. 9d. It contained 360 fish—211 males, 149 females. It is of importance to note that the males were the more numerous, although it is known that the females are more numerous in plaice on the whole. The smallest male was $7\frac{5}{8}$ in. long, the largest $11\frac{1}{2}$ in. There were 3 males under 8 in., 131 under 10 in. The smallest female was $7\frac{3}{8}$ in., the largest 13 in. There were 4 females under 8 in., 86 under 10 in. The total number in the box under 8 in. was 7; the total number under 10 in. 217, or 60 per cent.

I examined the roes of a few of the females microscopically, with the following results:—

| | | | |
|---|---|---|---|
| Plaice | $7\frac{3}{4}$ | in. long. | Ova all yolkless; no opaque masses. |
| „ | $8\frac{1}{4}$ | „ | „ „ „ |
| „ | $8\frac{1}{2}$ | „ | „ „ „ |
| „ | $8\frac{7}{8}$ | „ | „ „ „ |
| „ | $8\frac{3}{4}$ | „ | A few opaque masses, or dead yolked eggs. |
| „ | 9 | „ | No yolk, no opaque masses. |
| „ | $9\frac{5}{8}$ | „ | No yolk, a few distinct granular masses. |
| „ | $9\frac{5}{8}$ | „ | „ „ „ |
| „ | $9\frac{7}{8}$ | „ | „ „ „ |
| „ | 10 | „ | Granular masses distinct. |
| „ | 11 | „ | Granular masses distinct, but small. |
| „ | $12\frac{1}{4}$ | „ | No yolk, no masses. |
| „ | 13 | „ | „ „ |

On Monday, June 3rd, I examined in the market the fish landed from a steam trawler, which had been fishing about 21 miles off the

Amrum Light, *i.e.*, to the north of Heligoland, and was struck with the very large number of small brill and turbot in her "voyage." I found, by actual count, that she had 646 small brill and 150 small turbot. Many of these brill were under 12 in. and many of the turbot. There were also 26 larger brill, and 10 larger turbot, the largest of the former being 20 in. long, of the latter, 28 in. The rest of the catch included 61 boxes of medium plaice, 100 boxes of small and 7 boxes of soles. The last were by no means undersized. On this same vessel I went to sea the next day, to make observations during her fishing.

We steered E. ½ S. from the Newsand Lightship. The trawl was first shot a little before twelve (midnight), on June 5th. The position was about 18 or 20 miles west of the Sylt; the depth 13 to 14 fathoms.

First haul, 6 a.m., June 6th. The marketable fish were: 5 baskets of kit haddock, 2 baskets of plaice, none small, 4 cod, rather small, 2 coal fish, 6 turbot. Three of the turbot were females, 2 of them 29⅛, 31½ in. ripe, 1, 21½ in., 2 others were mature males 13½ in. to 20 in. The largest turbot yielded ripe eggs freely, and was nearly spent after I had squeezed it: this shows that the turbot, like the plaice, sheds a large number of eggs at once, especially towards the end of the spawning process. The refuse thrown overboard consisted of small haddocks, dabs, gurnards and whiting. There were also half a basketful of common whelks; *Cancer pagurus*, many; whelk spawn, quantities; *Asterias rubens*, many; *Solaster papposus*, many; *Alcyonium digitatum*, quantities.

Second haul, 11.30 a.m. At the beginning of this shot we towed S.E. ½ E., depth 12½ fathoms. Just before hauling we got 11 fathoms. When the fish were on the deck I saw that we were now on the small plaice grounds. The plaice kept for market were sorted by the crew into two classes, according to their size, and the smallest were thrown overboard. I found that the smallest saved was 11 in. long, the smallest in the whole catch was 6½ in. long. After the valuable fish had been picked up the rest were left for me to examine: I found there were about two baskets of plaice, the largest being 10 in. long; all these were shovelled overboard, with a few small haddocks and numbers of small dabs. The fish kept were:—

1½ baskets large or medium plaice.
1½ „ small plaice.
2 „ haddock.
½ „ dabs.
18 pair of soles, none under 8 in.
1 coal fish, 1 *Trigla hirundo*.
5 turbot, 11½ in., 13 in., 14 in., 14 in., 19½ in.
3 brill, 11 in., 13 in., 13 in.

It is evident that the plaice thrown overboard by the captain of this vessel would have been all taken to market by many captains, because I have seen numbers of plaice from 6 to 10 in., in the market at Grimsby.

Third haul, 5.30 p.m. During this shot the vessel was steered first to the S. and we passed near the Amrum Bank, sounding 8 fathoms, coarse sand; then we steered to the W.S.W. As soon as the other trawl was shot, the men began picking out and gutting the fish, shovelling over the worthless fish as they proceeded, to get them out of the way. Some of the small plaice and dabs first thrown over were, therefore, alive: whiting and grey gurnard were also rejected. The fish kept were:—

| | | |
|---|---|---|
| 1 | baskets | medium plaice. |
| $3\frac{1}{2}$ | " | small " |
| 1 | " | haddocks. |
| 1 | " | cod and dabs. |
| 32 | pair of | soles. |

The smallest plaice kept was 10 in. long: many of those thrown overboard were over 8 in. In reckoning the number of soles, only the larger are counted as pairs, a good many smaller, called slips, not being counted, although taken to market. There were also 28 brill, the largest of which was 17 in. long. I measured and examined these carefully. 21 of them were immature females, the smallest being 11 in. long. Leaving out fractions of an inch, 5 of these were 11 in. long; 9, 12 in.; 5, 13 in.; and 2, 14 in. Two were mature females, $15\frac{1}{2}$ in. and 17 in. respectively. The remaining 5 were males, all immature, though they would probably have become ripe later in the season: 4 of them were 11 in. long, one 12 in. In examining brill and turbot on board ship, I have put down all females as immature which had no yolk in the roe, judging that they would not have spawned this season, while those in which the roes were in process of maturation I have called mature, though many of them had not begun to spawn, and probably had never spawned in their lives when caught. Of these 28 brill then, 9 were under 12 in., and 21 females and 5 males were immature. The turbot were 5 in number, 3 of them immature females, 2 mature males. The females were $11\frac{3}{4}$, $12\frac{1}{4}$ and 14 in. long, the males $11\frac{3}{4}$ and 13 in. long. There were also taken 2 specimens of *Trigla hirundo*, known to the Grimsby fishermen as latchets, to the Plymouth men as tubs; these were large mature fish; and 1 lemon sole $8\frac{3}{4}$ in. long.

Fourth haul, 11.30 p.m. During this haul the vessel was steered somewhat away from the coast into deeper water, namely, 12 to 13 fathoms. It being dark when the trawl came up, I could not examine the fish very completely. As in other similar cases, I contented myself with making a note of the fish saved according to the information given me by the mate: they were:—

9 baskets of haddocks.
1 „ „ medium plaice.
1 score cod.
11 pair of soles.
1 turbot, 2 small brill.
2 latchets.

Small plaice occurred in insignificant numbers.

Fifth haul, 6. a.m., June 7th. Soon after the trawl was shot, at 12.25 a.m., the Amrum Light was seen just on the horizon, about 20 miles distant. The vessel was steered towards the land, and just before hauling we sounded 10 fathoms, near the edge of the Amrum Bank. The fish of this haul were also not completely examined by me; there were saved:—

3 baskets medium plaice.
5½ „ haddock.
18 pair of soles.
Nearly a basket of turbot and brill, some small.
3 large cod, some latchets.
Very few small plaice.

Sixth haul, 9 a.m. The trawl was hauled up after being down about two hours, in consequence of an accident in putting over the buoy. The captain gave orders to put out the usual buoyed flag-staff to mark this ground, where the fish was fairly plentiful, and when the anchor and line belonging to the apparatus were thrown overboard they were caught by the trawl, and it became necessary to haul.

The largest plaice was 15 in. long, the smallest 8½ in. There were 11 turbot and 15 brill, 3 turbot and 1 brill being under 12 in. Of latchets, 11 were taken; one I opened was a female approaching ripeness, with about 6 sand-eels in the stomach. The latchets were not considered very valuable fish: none were thrown overboard, but a considerable number were eaten on board: the other fish taken for cooking were dabs, whiting, and roker, and occasionally small plaice. The fish thrown overboard from this haul were plaice up to 11 in., dabs up to 11½ in., and also some grey gurnard and whiting. The other fish saved were:—

3 baskets small plaice.
2 „ medium plaice.
1 „ codling and dabs.
½ „ gibbed haddock.
1½ „ kit „

Seventh haul, 2 p.m. The depth where the buoy was put down was 12 fathoms. In this haul there were 4 turbot and 6 brill under 12 in., out of a total of 18 turbot and 24 brill: this is nearly 25 per cent. One brill, about 8 in. long, was thrown overboard dead. There were 18 pair of soles, none under 8 in., few, if any, under 10 in. There were 8 latchets. Of the rejected fish the plaice were $7\frac{1}{4}$ to 10 in., the haddock about $11\frac{1}{2}$ in., the whiting about 13 in., and a number of grey gurnard were also thrown over the side. There were saved:—

2 baskets of small plaice.
2 „ medium „ 12 to 15 in. long.
2 „ haddock.
$\frac{1}{2}$ „ codling and dabs, 1 large cod.

It is difficult to estimate exactly the number, or quantity, of small plaice thrown overboard from this haul, but roughly, there were about 2 basketfuls, besides the dabs, gurnards, small haddock and whiting.

When the trawl came up, I was called to see a small sole, caught in a crevice of the ground rope. It proved to be a *Solea lutea*.

I did not see a sole less than 9 or 10 in. in length all the voyage and believe that, if caught at all, they escape through the meshes. Several of the smaller that are caught are nearly through the meshes when the net is hauled and are dragged through by the men, by hand, as the net comes up.

Eighth haul. Trawl up at 8 p.m., after fishing round the buoy. There were 90 turbot and brill, all rather small, but I only noted 2 turbot and 3 brill under 12 in. Of plaice, the smallest in the haul was $7\frac{1}{2}$ in. long; 2 baskets of the medium size were saved, they were from $12\frac{1}{2}$ to $15\frac{1}{2}$ in. long; also 2 baskets of small, 10 in. to $12\frac{1}{2}$ in. About 3 basketfuls were thrown overboard. There were 30 pairs of soles, the smallest $11\frac{1}{2}$ in. long. As usual, there were some latchets, and 1 *Acanthias vulgaris* was taken. 2 baskets of haddock were saved.

Ninth haul, 2 a.m., June 8th. At the commencement of this haul, the Amrum Light was seen on the horizon, bearing E. by N. and distant about 20 miles; this gives, with sufficient accuracy, the position of the fishing ground. A lantern was attached to the top of the buoyed flag-staff, at dusk, the previous evening. The fish saved were:—

3 baskets medium plaice.
5 „ small.
2 „ gibbed haddock.
4 „ kit „
58 pair soles.
70 turbot and brill.
12 latchets, 2 cod, 10 codling.
$\frac{1}{2}$ basket dabs.

2 „ gibbed haddock.
$\frac{1}{2}$ „ codling and dabs.
3 large cod.
30 pair of soles.

Tenth haul, 8 a.m., June 8th. There were very few small plaice this haul and few brill, but turbot and haddock were plentiful; soles were also scarce. The vessel had been further to the westward, although the depth, namely, 10 to 12 fathoms, had not been much greater. I made a careful examination of the turbot. There was one ripe female, 24 in. long and several ripe males. I fertilised the spawn from this specimen and threw it overboard, that it might not be wasted, as the only bottle available already contained fertilised turbot spawn. There were 9 immature females, the smallest 13½ in., the largest 15½ in., and 1 female approaching maturity, 14¾ in. long; 12 mature males, the smallest 13 in., the largest 16 in. long. There were 7 brill, rather small. The rest of the fish saved were:—

2 baskets gibbed haddock.
4½ ,, kit ,,
2 ,, medium plaice
½ ,, small ,, 10½ to 12 in.
11 pair of soles.
14 large latchets, 2 or 3 small.
1 basket of cod.

Eleventh haul, 2.30 p.m., June 8th. This haul we again got more brill, soles and small plaice, and fewer haddock, having steered towards the land again. 3 small plaice, put into a tub of clean water after the men began to gut the fish, lived vigorously for some time, until they were thrown overboard. Many of the small plaice were alive when the first shovelfuls were thrown over. The smallest of them was 6½ in. long and there were numbers 7 in.; one of the latter measured 2½ in. across the broadest part of the body, excluding the fins. The mesh at the cod end of the trawl is nearly 3 in. in length when elongated and it seems strange that plaice of this size do not escape. The reason is that the skeleton is rigid, and the strong anal spine acts as an obstacle; the young plaice, too, has no instinct towards working its way through an aperture as the sole has, and none of the required agility—its only instinctive movement, when disturbed, is to flap its body up and down. The smallest fish in the haul was a dab 4½ in. long, an immature female.

There were 47 turbot and brill—of these, 5 turbot, and 9 brill, were under 12 in. The smallest turbot was 8½ in. long, and its stomach contained 2 sand eels, and 2 small dabs. I examined a sample of the refuse: it contained 27 plaice under 8 in., and 40 over that limit. The rest of the fish saved were:—

4 baskets medium plaice.
6 ,, small ,,
½ ,, gibbed haddock.
1½ ,, kit ,,
½ ,, whiting.
32 pair of soles, the smallest 10½ in.; none thrown overboard.

Twelfth haul, 8.30 p.m., June 8th. At 7.45 p.m. we sighted the island of Heligoland and then turned round and steered north. We lost the buoy, the day having been very foggy, and were unable to find it again. A large specimen of the tope, *Galeus vulgaris*, was caught in this haul; it was a male and measured 3 ft. 8½ in. The fish saved were:—

5 baskets of small plaice.
3 „ medium „
2 „ kit haddock.
1 „ gibbed „
½ „ soles.
24 turbot and brill, rather small.

A quantity of small plaice and dabs thrown over.

Thirteenth haul, 2 a.m., June 9th. At 9.30 p.m., at the commencement of this haul, the Amrum Light was seen, bearing E. by N., and Heligoland Light, bearing S. by W. I was not on deck when the fish were sorted, but some of the smallest were saved for me; they were 6 plaice, 5 in. to 6¼ in. in length; 21 dabs, 2 of them 2¼ in. long, the rest 3¾ in. to 6½ in. The fish kept for market were:—

7 baskets small plaice.
3 „ medium „
1 „ gibbed haddock.
3 „ kit „
50 pair soles.
21 turbot and brill.
1 latchet, 1 cod.

Fourteenth haul, 8.30 a.m., June 9th. We steered in to the eastward, to see if there were more soles to be got nearer the land and at 8 a.m. sounded 9½ fathoms. At this time there were five steam trawlers in sight, one smack, and six German sailing vessels of small size, of a kind called "snibs" by the Grimsby fishermen. There were 60 turbot and brill altogether this haul. I examined 19 brill and 5 turbot. Of the brill, 11 were immature females, the smallest 11¼ in., the largest 13½ in. in length. The other 8 were males, the smallest 10¾ in., the largest 17½ in. long, and all mature except one at 11¼ in., which would probably have become ripe this season. Of the whole 19, 5 were under 12 in.—4 males and 1 female. Of the turbot, 1 at 31¾ in. was a spent female, 1 at 20¾ in. was a mature but not ripe female, 1 at 12¼ in. was an immature female and 2, 12¾ in. and 14 in., were mature males. The rest of the fish kept for market were:—

2½ baskets medium plaice, 12½ in. to 16 in.
5 „ small plaice, 9¼ in. to 12½ in.
1 basket kit haddock.
½ „ gibbed haddock.
½ „ codling and dabs.
3 large cod.
30 pair of soles.

The soles in this and other hauls were ripe and spawning. As usual, a lot of small plaice, gurnard, and dabs were thrown overboard. The soles were more plentiful than was usual for a day haul.

Fifteenth haul, 12.30 p.m., June 9th. Just before this haul we sounded 10½ fathoms. The fish kept were:—

2 baskets of small plaice.
1½ „ medium plaice.
1½ „ haddock.
½ basket of dabs.
½ „ whiting.
20 pair of soles.
34 turbot and brill, many under 12 in.
About 12 latchets.

The smallest brill was 9¼ in. long. The smallest dab saved was 9½ in. long. I was told that the last time the vessel sold her fish the dabs fetched 10s. a box, which is more than the usual price of small plaice. Whiting were saved for the first time this haul, as they do not keep well for many days in the fish-hold.

I examined half a basketful of the stuff thrown overboard. It contained:—

101 male plaice, smallest 6⅛ in., largest 10¼ in.
46 female plaice, smallest 6⅛ in., largest 9¾ in.
18 male dabs, 6½ in. to 9½ in.
17 female dabs, 5¾ in. to 9 in.
7 *Trigla gurnardus.*
*Trigla cuculus.*
1 *Raia clavata,* 11¼ in. across the pectorals.

Sixteenth haul, 8.30 p.m., June 9th. On this occasion I timed the various stages in the operation of hauling one trawl and shooting the other. The after stopper, which fastens the wire trawl-rope to the quarter of the vessel, to keep it clear of the propeller, was let go at 8.30 p.m. The steam winch was then set in motion and the beam of the trawl was on the rail at 8.40. By 9 o'clock the cod end was hoisted up, the fish emptied out of it and the other trawl shot.

This haul we steered somewhat to the westward, to get away from the small plaice; but the captain said he was afraid we should get away from the soles, too. The catch was not a large one:—

1½ baskets medium plaice.
1 basket small plaice.
1 „ gibbed haddock.
2 baskets kit haddock.
35 turbot and brill.
25 pair of soles.

2 ripe female sprats, 1 hake, and 1 *Acanthias vulgaris* were also taken. About 2 basketfuls of small plaice, dabs, and gurnard thrown over.

Seventeenth haul, 2.30 a.m., June 10th. During this haul we steered again towards the land, with the result of getting more small plaice and more soles, and fewer haddock. The fish saved were:—

4 baskets medium plaice.
11½ „ small plaice.
2 „ haddock.
1 basket codling and dabs.
48 pair of soles.

A few brill and turbot, and a dozen latchets. About 20 basketfuls of small plaice, &c., thrown over.

Eighteenth haul, 8.30 a.m., June 10th. At 8 a.m. Heligoland was plainly visible, bearing S. by W., and about 14 miles distant. The fish saved were:—

4 baskets medium plaice.
7½ „ small plaice.
½ „ gibbed haddock.
2 „ kit haddock.
14 pair of soles, the smallest 9⅞ in.
About 27 turbot and brill.

The smallest plaice was 6¾ in. long. There was a quantity of soft dark-coloured fine sand among the fish.

Nineteenth haul, 2.30 p.m., June 10th. At 1 p.m. Heligoland was bearing S.S.W. The fish were on deck at 2.50 p.m., and at 3.10 many of the small plaice, dabs, &c., were being shovelled overboard, and many were alive. Those shovelled over towards the end of the work of sorting and gutting are nearly all dead. I counted the sexes in a number of the larger or medium-sized plaice, and found 99 females to 43 males, the largest female being 16¾ in., the largest male 16¼ in. The smallest plaice in the haul was 6 in. long. According to the mate's reckoning, there were only 8 pair of soles; I counted 32 soles, the mate neglecting the slips. The small plaice were very abundant, the other fish saved being:—

4½ baskets medium plaice.
13 „ small plaice.
1 basket haddock.
1 „ dabs and codling, 1 large cod.
14 turbot and brill, 1 small turbot being only 9 in. long.

Twentieth haul, 8.30 p.m., June 10th. We steered to the north and somewhat nearer to the land this haul, in order to find more soles: we were out of sight of Heligoland. We sounded $7\frac{1}{2}$ fathoms some time before 6.45 p.m., and at that time 10 fathoms, the ground being sharp gravelly sand. There were a large number of German "snibs" in sight. These vessels are of shallow draft, only partially decked, and smack rigged. They carry small trawls, only about 20 feet long, which they pull up by hand. They must take a large number of the small plaice, but whether they destroy them or not I do not know. Probably they fish principally for the sake of the soles.

This haul produced more soles and fewer plaice than the previous one, which was taken further to the southward:—

1 basket medium plaice.
6 ,, small plaice.
33 pairs of soles.
1 turbot 9 in. long, 1 turbot $9\frac{3}{4}$ in.

Twenty-first haul, 3 a.m., June 11th. As usual in a night haul, soles were taken this time more abundantly: no detailed observations on the fish were made by me. The marketable part of the catch comprised:—

1 basket medium plaice.
5 ,, small ,,
2 ,, haddock.
50 pairs of soles.
19 turbot and brill, none large.
3 latchets, a few whiting, dabs, and codling.

Twenty-second haul, 10 a.m., June 11th. This was the last haul: we started at full speed for Grimsby at 10.20.

At 9 a.m. Heligoland was in sight, bearing S. by W. 15 to 18 miles distant and I counted 25 foreign "snibs" in sight.

This haul there were taken 25 turbot, 8 brill. I examined a number of them, namely, 15 turbot and 3 brill. Of the former 12 were mature males, 6 of them 13 in. long; 2, 14 in.; 1, 19 in., and 3, 20 in. Of the 3 females, one 15 in. long was immature, two 22 in. long were mature. Of the brill two were mature males 10 in. and $14\frac{1}{2}$ in. long, the third was an immature female 12 in. long.

The rest of the fish saved were:—

$3\frac{1}{2}$ baskets medium plaice.
4 ,, small ,,
$3\frac{1}{2}$ ,, haddock.
10 soles—4 large, 6 slips.
Some whiting, latchets, and cod.

In one haddock's stomach I found *Trophonia,* whitings, and a dab; in another, brittle stars.

I landed at Grimsby on the afternoon of June 12th and on June 13th examined at Cleethorpes some of the fish I brought from the steamer on which I made the voyage. Among these were 9 soles, of the size at which they are called slips, that is to say, the smallest soles caught. They were $10\frac{1}{4}$ to $11\frac{1}{4}$ in. in length, and all of them were mature males.

I also brought a basket of the refuse from the last haul. It proved to contain :—

105 male plaice, smallest $6\frac{1}{2}$ in., largest $11\frac{1}{2}$ in., next largest 10 in.
71 female plaice, smallest $6\frac{3}{4}$ in., largest $11\frac{1}{8}$ in., next largest 11 in. and $10\frac{1}{2}$ in.
31 male dabs, $5\frac{3}{4}$ in. to $10\frac{1}{4}$ in.
21 female dabs, 5 in. to $10\frac{3}{4}$ in.
6 *Trigla gurnardus*, $9\frac{1}{2}$ to $11\frac{1}{2}$ in.

I examined the ovaries of a few of these fish microscopically:

Plaice 8 in. long, ovary small, ova yolkless, no opaque masses.
„ 8 in. long, „ „ „
„ $8\frac{1}{4}$ in. „ „ „ „
„ $8\frac{3}{4}$ in. „ „ „ „
„ $9\frac{1}{4}$ in. „ ovary small, but opaque masses very distinct and numerous
„ $10\frac{1}{4}$ in. „ one or two dead eggs in ovarian tissue.
„ $10\frac{3}{4}$ in. „ ovary 2 in. from anterior end, 3 $\frac{5}{16}$ in. from posterior end of ventral fin. No opaque masses.

Plaice $10\frac{5}{8}$ in. Opaque masses numerous, small, nearly absorbed.
„ 11 in. Opaque masses and dead yolked eggs very numerous and conspicuous.
Dab $7\frac{5}{8}$ in. Probably spawned, but ovary small and transparent, no opaque masses or yolked eggs.
„ $8\frac{1}{4}$ in. Ovary $1\frac{3}{4}$ in. from anterior end, $2\frac{1}{2}$ in. from posterior end of ventral fin. Almost certainly recently spawned, some partially yolked eggs present, but not dark and opaque as in the plaice.
„ $7\frac{5}{8}$ in. Ovary half as long as the ventral fin, red in colour, contained some half-ripe eggs, but not dead yolked eggs as in the plaice.

I must postpone the discussion of these observations until a future occasion.

# Faunistic Notes.

JANUARY TO JUNE, 1895.

By

E. J. Allen, B.Sc.,

Director of the Plymouth Laboratory.

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THE following notes on the collecting work carried out during the period from January to June, 1895, follow the lines of Mr. Garstang's notes for 1892 * and 1893.† In putting the observations on record, I should like to thank the various workers at the Laboratory during the period covered, for the help which they have given. My own part of the work has consisted chiefly in keeping the record, and in endeavouring to give a certain amount of continuity to the whole. At the same time the final responsibility for the names adopted must be my own.

What strikes one perhaps most forcibly in keeping a detailed record of collecting operations such as are carried out by the Association, and comparing it with previous records and observations, is the great relative variation in the abundance of different forms from year to year. In any particular year, animals which at a given season are usually quite common, may be almost entirely absent, whilst other forms usually regarded as rare may be taken in great abundance. Several instances of this kind will appear in what follows, and it is from this point of view that such records are likely to be of the utmost value, if continued from year to year. It is only by their means that the modifications of the fauna and flora of any district, due in the first place to the direct action of physical conditions, and in the second to the inter-relations of the various organisms which compose it, may be expected to receive anything like a complete explanation.

* This Journal. Vol. ii. N.S. p. 333.
† ,, ,, Vol. iii. N.S. p. 212.

*Tubularia indivisa* has been unusually abundant, and several colonies with polyps of exceptional size for this locality were taken near the Asia Rock, during the latter half of March. This species was also growing in profusion on the rocks below West Hoe Terrace about the same time. *Tubularia indivisa,* of a more luxurious growth and redder colour than that found in the Sound, was taken on May 8th from beneath the overhanging shelf of rock below the remains of the old lighthouse at the Eddystone. It was growing there in considerable quantity, side by side with a species of *Aglaophenia,* which will be described by Prof. Nutting.

*Tubularia larynx,* which appears to have been common in the Sound in former years, has not been so during the present season.

*Garveia nutans,* which has been regarded as a rare form at Plymouth, has been plentiful this spring. It was continually found on the stones dredged in Millbay channel, and on April 8th numerous colonies, covered with gonophores, were growing on the rocks under West Hoe. This species has not, I believe, been previously found at Plymouth between tide marks.

A small species of *Eudendrium,* of very delicate habit, and at once recognisable by the milk-white colour of its polyps, which Prof. Allman is inclined to regard not as *Eudendrium capillare,* which it resembles in some points, but as a new species, was found in large quantities on stones taken from Millbay channel, and bore gonophores during April.

On the 25th and 26th of April, a species of *Syncoryne,* resembling *Syncoryne mirabilis* of Agassiz, bearing medusæ of two kinds, was found by Mr. Garstang at Devil's Point and Garden Battery. This species will be described by Mr. Garstang in detail.

On May 9th another species of *Syncoryne,* resembling *Syncoryne eximia,* but of rather more delicate habit, with the tentacles already formed on the zooids, was found growing on the roots of Laminaria on a buoy moored near the Eddystone.

The interesting hydroid *Corymorpha nutans* has again been obtained. The last recorded instances of its capture at Plymouth is by Mr. Heape,* on May 17th, 1887, in about three fathoms, below Fort Tregantle, in Whitsand Bay. On May 20th of the present year, we succeeded in obtaining three specimens with the dredge, off the same fort, in about nine fathoms, and one mile from shore. One of the specimens had medusæ attached. On the following day, May 18th, our fisherman, Roach, tried with the dredge a patch of sand at the east end of the Breakwater, and succeeded in taking two specimens. From the abundance in which the medusæ of this species occur here during

* This Journal. Vol. i. N.S. p. 394.

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the spring and early summer, it seems probable that the hydroid grows in large numbers somewhere in the neighbourhood, and it is curious that it should be so seldom taken.

Medusæ were very late in appearing this season. During January not a single one was seen, and only one or two Leptomedusæ were taken occasionally in the latter half of February. It was not until the middle of March that they began to be met with in any numbers, when the tow-nets contained a good many specimens of the Anthomedusa, *Amphicodon amphipleurus* of Haeckel (March 15th and onwards), each having numerous medusa buds springing from the base of the tentacle bundle. A few specimens of *Corymorpha nutans* (*Steenstrupia rubra*) also appeared about this time. Leptomedusæ (*Phialidium* sp.) were still found in small numbers, but were not plentiful. Towards the end of March they became numerous.

During April *Amphicodon* generally showed gonads developing on the manubrium, and in May (first seen May 9th) the young hydra form was found inside the umbrella.

At the beginning of April two species of *Tiaropsis*, which will be discussed in detail by Mr. Garstang, were present, and the larger species continued to be taken, the specimens gradually increasing in size, until the end of May. *Sarsia pulchella* and *Margelis* (*Bougainvillia*) *ramosa*, L. Agassiz, both of large size, were fairly common during May. Specimens of *Rathkea octopunctata* were also taken during the same month.

From May 21st onwards, medusæ of the Phialidium group, bearing the parasitic *Halcampa* sp. inside the umbrella, were common.

The first Ephyra was observed on February 19th, but Ephyrae did not become plentiful until the beginning of March.

A month later only Ephyrae of the largest size were taken, and on May 28th the first fairly grown Aurelia (about 3 in. diameter) was seen.

On April 29th a small specimen of *Chrysaora isosceles* (about $\frac{3}{4}$ in. diameter) was taken, and towards the end of May fair-sized specimens of this medusa were common.

The Lucernarian *Depastrum cyathiforme*, which has been taken twice before at Plymouth,* once at Drake's Island and once under Rame Head, has been found on two occasions this year; on February 12th on the shore below Mount Edgcumbe, and on May 15th below Mount Batten.

*Bolina hydatina*, referred to by Mr. Garstang† as having been noticed during May, 1892, and again in May, 1894, but as being apparently

* This Journal. Vol. iii. p. 216.
† This Journal. Vol. iii. p. 216.

absent during 1893, has been taken this year on several occasions, as before, during the latter half of May.

Large colonies of *Alcyonium digitatum* have again been growing on the iron piles of the Promenade Pier, a position in which they were found last year.

Post-larval stages of *Arenicola* similar to those described by Dr. Benham * in this Journal, which have previously appeared in February, were not found until nearly a month later than usual, the first recorded being taken on March 25th. A corresponding lateness in the appearance of the regular constituents of the floating fauna, as compared with previous records, has been very marked during the early part of this year.

A specimen of *Sipunculus nudus* about 5 in. long was brought to the Laboratory on April 2nd by a fisherman, having been taken whilst trawling.

On the 5th of the same month, our own man was on board a Plymouth trawler, obtaining fertilised eggs of flat-fishes, when another specimen of about the same size was taken ten miles south of the Eddystone light.

Amongst the Nudibranchiata large specimens of *Aplysia punctata* (5–6 inches long when extended) have been abundant in the Yealm River, and have been spawning freely in the tanks during May and June. *Hero formosa* has been found in considerable numbers six miles south of the Mewstone, and *Triopa claviger*, of which two specimens have been previously recorded at Plymouth,† has again been taken off the Mewstone. Four specimens were found on a mass of the Polyzoan *Lepralia foliacea* on May 28th.

On February 6th Mr. Sumner found on the dredging from Millbay channel two specimens of *Cuthona aurantiaca* (A. and H.), a form which has not previously been taken at Plymouth.

The remarkable scarcity of the common shrimp *(Crangon vulgaris)* in the Sound, during the past six months, is a fact worth putting on record. On spots where one haul of the trawl in an ordinary year could have been relied on to bring up many hundreds of shrimps, we could only obtain a dozen or so at each haul during the early months of the year. This scarcity still exists, though the numbers appear to be increasing. It is difficult to suggest a cause for this immense diminution in the numbers of so common an animal. The shrimp fishermen, I understand, account for the fact by the presence in the Sound during January of large shoals of small whiting, many of which fish, when caught, were gorged with shrimps. My attention was not

* This Journal. Vol. iii. N.S. p. 48.

† Garstang. This Journal. Vol. i. N.S. p. 455.

drawn to the matter until it was too late to make any attempt to confirm the latter statement.

A fact of a similar nature, has been the almost entire absence from the neighbourhood of the common squid (*Loligo Forbesii*). This animal is largely used by the fishermen as bait, but for the first six months of the year it was impossible to procure even individual specimens, and the fishermen have been put to great straits to get bait of any kind for their work.

# Additional Evidence on the Influence of Light in producing Pigments on the Lower Sides of Flat Fishes.

By

J. T. Cunningham, M.A.

## I. An Observation on Plaice and Flounders.

In a communication to the Royal Society (*Phil. Trans.* vol. clxxxiv. 1894, and in this Journal, vol. ii. no. 1), I described a series of experiments in which light was directed upon the lower sides of flat fishes, by means of a tank with a glass bottom, and a mirror placed beneath it. I have now to record an observation which confirms my previous results in a most striking manner. Curiously enough, the effect I am about to describe, in some respects even more important as evidence than those obtained in my experiments, was observed accidentally, or at least incidentally, and was due to conditions which had been quite unintentionally produced.

On December 31st, 1894, I examined all the flat fishes which had been kept in a certain tank, for the purpose of ascertaining their rate of growth. These fishes were five in number, namely:

| | | | |
|---|---|---|---|
| 1 plaice . | $8\frac{1}{4}$ in. long. | 1 flounder . | $6\frac{7}{8}$ in. long |
| 1 " . | $7\frac{1}{4}$ " | 1 " . | $8\frac{5}{8}$ " |
| 1 sole . | $5\frac{3}{4}$ in. long. | | |

There were no other flat fishes in the tank, which was one of the table-tanks in the Laboratory of the Association, at Plymouth. It was 5 ft. long, 2 ft. 6 in. wide and 15 in. deep, and its sides and bottom were of slate, the front of glass. I was surprised to notice that all these flat fishes were partially pigmented on their lower sides. At first this appeared to be a complete nullification of the conclusions drawn from my previous experiments, but further examination of the matter gave it a different interpretation.

In the sole there was very little pigmentation on the lower side, only a little at the base of the tail, and on the lower surface of the tail, but in the plaice and flounders the pigmentation extended continuously over the marginal region of the body and the proximal part of the dorsal and ventral fins. The extent of the pigment in the smaller flounder is shown in Fig. 1. The pigmentation of the outer half of the marginal fins was slight. In the larger flounder the pigmented area on the surface of the body was broader; the central area was unpigmented, with the exception of a narrow patch about the middle of the lateral line, as in the smaller specimen. In the two plaice the pigmentation was not quite so intense and not quite so extensive. In both it was absent, or very nearly so, from the surface of the marginal fins, and from the anterior part of the body, with the exception of a small

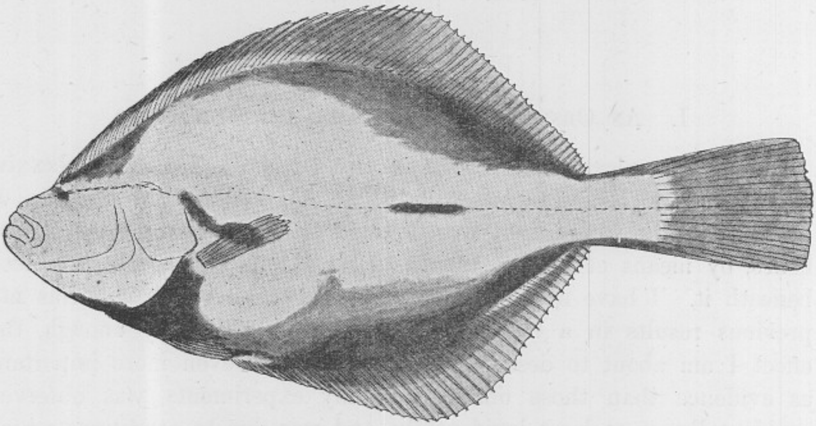

Fig. 1.—Under side of Flounder, showing pigmentation.

patch on the bony ridge of the head in the smaller specimen. In both it was present in the regions of the interspinous bones in the posterior three-fourths of the body, both dorsally and ventrally, and also over the whole lower surface of the caudal fin, absent from the central region of the body entirely; there was no patch on the lateral line, as in the flounders.

It will be clear, therefore, that there was a most remarkable similarity in the distribution of the pigment in these four specimens, which suggests a common cause acting in all of them, and not indefinite "variation." This common cause was access of light to the pigmented areas. There was no sand or gravel at the bottom of the tank, and the fish were resting on the bare slate. The lower surfaces of the fish were not perfectly flat, and therefore certain areas were, when the fish were at rest, in contact with the slate, while other areas were separated from the slate by an interval. The areas of contact were shown by dropping the smaller flounder, in the moist fresh state, on a surface of dry slate, when the areas in contact moistened the slate, while the part of the slate not touched by the fish remained dry.

Fig. 2 is a diagram of the impression thus produced on the slate by the fish, and it will be seen that it is a remarkably exact negative of the distribution of the pigment on the lower surface of the fish. The projection of the area of contact towards the dorsal edge of the fish is not so extensive as the unpigmented area on the dorsal region of the body of the fish, and the tail is in contact with the slate. But in view of the exact correspondence in other respects, these differences are easily explained, and do not invalidate the evidence. The white patch

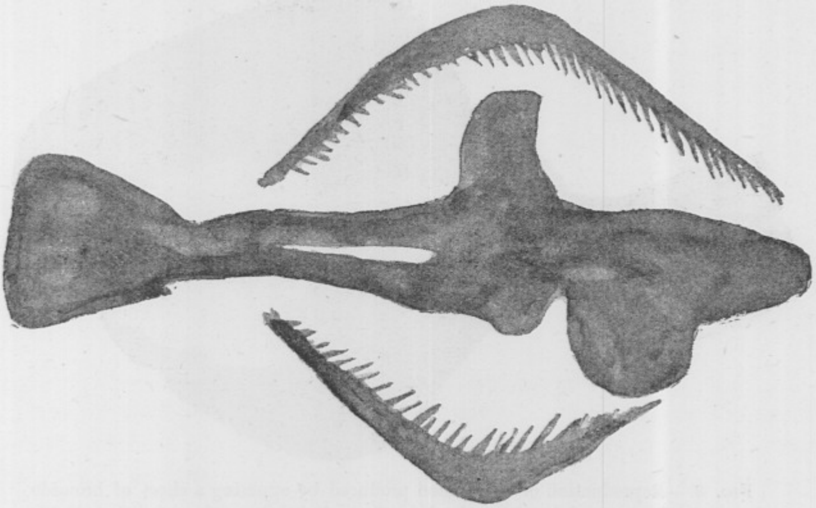

FIG. 2.—Impression of under side of Flounder on dry slate.

in Fig. 2, corresponding to the area of pigment on the lateral line, and the remarkable correspondence of the area of contact ventrally with the outline of the pigmented area in the fish, as shown in Fig. 2, are sufficiently striking. With regard to the isolated patch of pigment on the lateral line, a difficulty arises. Since this small area is an island surrounded everywhere by surfaces in contact with the bottom, how could light reach it?

In order to prove that light does reach the pigmented areas, I had recourse to photographic action. The same flounder was placed, while still alive, on a sheet of bromide printing-paper in the dark room, and then exposed for a few seconds to daylight, to light coming horizontally. The result of one such experiment is shown in Fig. 3. Here, again, the darkened area of the paper corresponds with remarkable exactness to the pigmented area of the fish, and, most remarkable of all, there is a small darkened patch corresponding to the isolated pigmented patch on the lateral line of the fish. In this particular photographic print the outer region of the bromide paper, beyond the edges of the fish, is lighter than the outer part of the area covered by the fish. This is simply due to the over-exposure of the uncovered area of the paper, causing a partial reversal of the photographic effect. It must be concluded that the rays of light which reach the small depression on the lateral line of the fish pass parallel to the surface of the fish, and therefore do not fall upon it; but when they reach the edges of the depression they are slightly refracted, and so

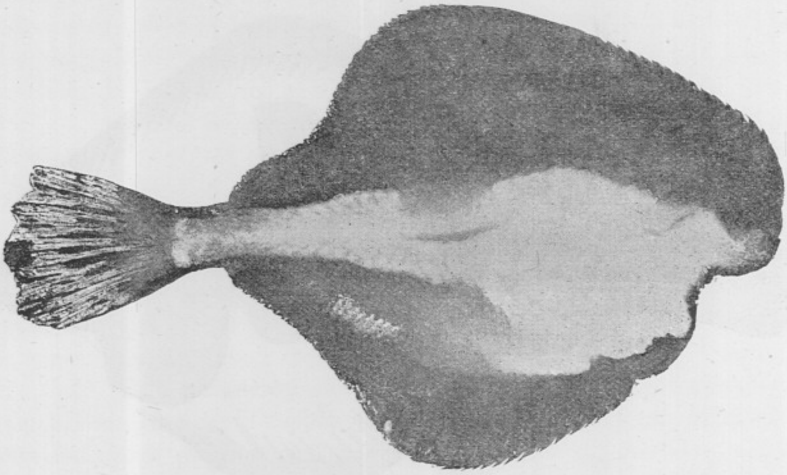

FIG. 3.—Reproduction of impression produced by exposing a sheet of bromide photographic paper, with a Flounder lying upon it, to the action of diffuse light, and subsequently developing.

fall upon the surface of the skin in the depression, and give rise to pigmentation. It is possible that this explanation may be corrected by physicists, who know more of the properties of light-rays than I do; but the proof in the photograph that light does reach the depression, and produce an effect there which is absent from the surrounding area, is quite sufficient for my argument.

It will probably be admitted that what applies to one of the fish applies to all. In any case, sufficient examination was made to show that the differences in the amount of pigmentation corresponded to differences in the shape of the lower surfaces of the fish. The lower side of the sole was flat, and in contact everywhere except at the base of the tail. When the fish were alive their caudal fins were usually held slightly elevated above the slate bottom, which accounts for the pigmentation of the lower side of that fin.

It is now necessary to give the history of these fish. (See the previous number of this Journal, vol. iii. p. 273.) They were the survivors of a number put into the tank in the summer of the year 1893, and judged to be hatched in the early part of that year. In April and May were put in five soles, about 1.5 cm. long, and a few flounders from 1.0 to 1.5 cm. long. In June a few young turbot and brill, in the pelagic transformation stages, were put in. In July there were added seven plaice, 6.5 to 8.5 cm. long, and judged to have been hatched the preceding January. On October 19th there were found to be in the tank seven plaice, one sole, three brill, three turbot, and several flounders, but no note was made of the presence or absence of pigment on the lower side. The fish were simply reared in order to see their growth, and it was not supposed that any conditions affecting pigmentation were present. On April 4th, 1894, some of the fish died, and the notes of their condition taken at the time are as follows:

One turbot 10.8 cm. long, a little pigment on the lower side, on the marginal fins, and within their bases.

One brill 11·3 cm. long, pigment on lower side near bases of marginal fins.

One plaice 16·7 cm. long, no pigment on lower side.

One flounder 12 cm. long, some pigment on lower side near bases of fins.

One flounder 11 cm. long, no pigment on lower side.

Thus, in three out of five of these specimens there was some pigment on the lower side in the same region as in the fishes above described from the same tank. But at this time I did not pay much attention to it, and thought it was only an instance of casual variation.

The five fish first described had thus been living in the tank about a year and a half. The tank having a glass front, and being at a height of about 5 feet from the ground, opposite a north window, many of the rays of light entering it must have been nearly horizontal. The glass front, however, did not extend quite to the bottom of the tank, the lower 4 inches of the front being formed of slate. Although it is difficult to make an exact comparison, it certainly seems that the pigmentation was produced more constantly and more rapidly in the unintentional experiment here described, than in those recorded in the previous memoir, which I took so much trouble to arrange. Thus the survivors of the specimens of the brood of 1892, reared in the glass-bottom tank, died on October 20th, 1893, and had therefore been exposed to light very nearly as long as the five described in this paper. They were ten in number, and four of them had no pigment at all on the lower sides. It cannot well be suggested, in explanation of this, that light is not the cause of the pigmentation, but simply the absence of mechanical contact over the parts of the skin which did not touch the bottom in the slate tank. For, in the first place, the same reason would apply to the fish in the glass-bottom tank, where there was no sand, and the marginal parts of the body were equally separated from the bottom; and, in the second place, in the experiments with the glass-bottom tank and mirror, the pigment when developed was most abundant, precisely in those more central regions of the body which were in contact with the glass bottom. I can only suggest at present, that light reflected from rather dark coloured surroundings, is more efficient in producing the pigment than that coming directly from a window and reflected by a silvered mirror. Mr. Poulton has shown how remarkably the colour of lepidopterous pupæ is affected by the colour of the surroundings to which the caterpillars are exposed during pupation.

## II. An Experiment on a Piebald Plaice.

In the previous number (p. 271) I described a piebald specimen of the plaice, and suggested the possibility that if the lower side were exposed to light the unpigmented area on the upper side would, *pari passu*, become pigmented. This result was the logical consequence of the hypothesis I put forward in explanation of the fact that, in such specimens, part of the upper side remains unpigmented, while continuously exposed to light in the same way as normal specimens. After writing the contribution to which I refer, I instituted the experiment with the same specimen, not, I must confess, with very sanguine hopes of its success. The specimen had lived in the aquarium from October 3rd to the month of December, without showing any change in pigmentation. I then placed it in a large bell-jar, without any sand, gravel, or other objects in the water, and placed the jar over a mirror in front of a south window. The top and front of the jar were shaded with black paper, so that the upper side received little light, the lower side a great deal. I left the Laboratory on February 2nd, in order to take charge of the east coast work at Grimsby, and Mr. Allen, the new Director of the Laboratory, kindly consented to take this and other experiments of mine under his care. I am most grateful to him for the fidelity with which he executed this trust. When I returned to Plymouth, on June 17th, I found the plaice still alive and in good health. The fish, on examination, was found to be 7 inches long. On the lower side, where previously there was no trace of pigment, there were numerous small patches, scattered principally, but not exclusively, over the peripheral, or interspinous regions. In the area of the upper side, which was previously unpigmented, there were numerous small pigment spots. It is true that the amount of pigmentation thus produced was not great, but it was perfectly distinct and evident, and the duration of the experiment was less than six months. It will easily be seen that this is a most remarkable result—the most remarkable of all that I have obtained in the course of these researches. It is not often in biological investigation that the result of an experiment so exactly corresponds to the prediction, and it affords very strong evidence that the view I advocated of the meaning of the occurrence of unpigmented areas on the upper sides of flat-fishes, approximates closely to the truth. It may be objected that possibly the formation of pigment would have occurred equally if the lower side had not been exposed to light, and it would be desirable to keep other piebald specimens for a length of time under normal conditions. But it can scarcely be maintained that the unpigmented area, when the fish was free, had been shielded from light, and that pigment would have been produced in the aquarium merely in consequence of the exposure of the upper side alone. We have no facts to indicate that the peculiar distribution of pigment in these specimens undergoes changes in the lifetime of the individual, in a state of nature, or in the aquarium, under ordinary conditions. We can only hold, at present, that the pigmentation is constant for the individual, under the usual conditions, although in the face of the result here recorded, it will be advisable to test this assumption. I hope, at some future time, to publish figures shewing the specimen before and after the experiment; but in the mean time have thought it well to place the result on record.

# The Reproduction of the Lobster.

By

E. J. Allen, B.Sc.

Director of the Plymouth Laboratory.

*The Habits and Development of the Lobster, and their bearing upon its Artificial Propagation.* By Francis H. Herrick, Professor of Biology in Adelbert College. *Bulletin of the United States Fish Commission*, vol. xiii. 1893.

*The Reproduction of the Lobster.* By Francis H. Herrick. *Zoologischer Anzeiger*, xvii. August, 1894, and xviii. June, 1895.

*Lobster Reproduction.* By S. Garman, Mus. Comp. Zool. Cambridge, Mass. U.S.A. *Zoologischer Anzeiger*, xviii. Feb. 1895.

*Der Helgolander Hummer ein Gegenstand deutscher Fischerei*, von Dr. Ernst Ehrenbaum. *Wissenschaftliche Meeresuntersuchungen herausgegeben von der Komm. z. wiss. Untersuch d. deutschen Meere in Kiel u.d. Biol. Aust. auf Helgoland*, Neue Folge, heft i. 1894.

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Amongst the numerous subjects which have occupied the attention of the fishery authorities of the United States, that of the great decline in the productiveness of the lobster fishing industry has received much consideration, and several competent naturalists have, in consequence, devoted themselves to a scientific study of the habits and life-history of the American species. This species *(Homarus Americanus)* is so nearly allied to the European lobster *(Homarus vulgaris)*, that the results arrived at for it, with regard to such questions as the time of year at which spawning takes place, the length of time during which the eggs are carried by the female attached to the under side of the abdomen, and the time of year at which the eggs are hatched, might be expected to apply, to some extent at least, to the latter. That this is so, appears to be abundantly proved by Dr. Ehrenbaum's study of the lobsters which frequent the shores of Heligoland, and certain observations which I have been able to make on lobsters taken in the neighbourhood of Plymouth during the last two years, in the course of my work on the nervous system of the embryo, also tend to confirm this view.

In America, the investigation of the subject seems to have been carried on independently, at about the same time, by Herrick and

Bumpus, working at the U.S. Fish Commission Station, at Woods Holl, Mass., and by Garman, in connection with the State Fish Commission, of Massachusetts. It would appear that Herrick's work was commenced during the season of 1889, his most important results being published in May, 1891,* whilst Garman turned his attention to the subject in 1890, and reported his conclusions to the Massachusetts State Fish Commission, in December, 1891. On most points of importance, the independent researches of these different investigators are so much in accord, that there can be little doubt as to their correctness.

The time of year during which eggs are laid by the American lobster appears, from Herrick's recent papers † to be less restricted than had previously been supposed. As the result of his earlier work, he was of opinion that the period of egg-laying was confined to the summer months, and that the eggs were carried by the female until the summer following, when they were hatched. A similar view is also taken by Garman. This statement of the facts, however, Herrick now regards as only partially true, for, whilst the greater number of females deposit their eggs during the months of June, July, and August, a considerable number—probably, at least, ten per cent.—lay eggs during the autumn, winter, and spring months.‡

For eggs laid during the summer, Herrick, Bumpus, and Garman agree as to the time occupied in development. They are carried by the female from ten to eleven months before being hatched, this event taking place, in the majority of cases, during June and July of the year following that in which they are laid. During the first few weeks development proceeds rapidly, the eyes being already visible after a month from the time of laying. As the colder weather comes on the process is much retarded, and advance is slow during the winter. According to Herrick, however, the period of fosterage varies considerably in eggs not produced in the summer, some of which may hatch in the fall, and possibly in the winter months.

On these points Ehrenbaum is able to give valuable information concerning the Heligoland lobsters. Special opportunities for the study of the subject are afforded at this place, as the fishermen and dealers keep great numbers of lobsters in large, floating cages for considerable periods, especially in summer. In these cages, however, the females do not, in the majority of cases, deposit their spawn, probably on account of their being shut up in a confined space with a number of their

* *Johns Hopkins Univ. Circulars,* vol. x. no. 87, and *Zool. Anzeiger*, nos. 361 and 362.

† *Zool. Anzeiger*, August, 1894, and June, 1895.

‡ Nielsen states that, in Newfoundland, the larger lobsters spawn from the middle of June till the middle of August, whilst the smaller do not lay until the latter part of October and November. (*Annual Report, Newfoundland Fisheries Commission*, 1889, p. 12.)

fellows. In cases where the ova are mature, but are not shed, a curious physiological process is set up, the yolk of the unlaid eggs being re-absorbed, and passing into the blood. The blood, in this way, becomes dark green, or almost black, and the dark colour is visible through the thin membranes, especially on the under side of the abdomen. Such animals are known as "black" lobsters, and, if the process has been allowed to proceed far, they are unsaleable. The first appearances of this blackening are, therefore, carefully watched for by the owners of the cages, in order that the animals may be sold before they become valueless. "Black" lobsters begin to appear about the end of July. Ehrenbaum states also, that, in individual cases, lobsters in the cages have spawned, the dates given being 20th, 23rd, and 26th July, the first days of August, and the 28th August. He is also able in two cases to give direct information as to the time the female lobsters carry their eggs. In the first case, eggs spawned during the early days of August, 1892, commenced to hatch on the 20th July, 1893. In the second case, the eggs were laid on the 28th August, 1893, and the majority of the larvæ hatched on the 21st July, 1894. This would give about eleven months as the period of incubation. It should be noted, however, that the lobsters must have been kept in a state of confinement during the time that the eggs were developing.*

My own observations on our English lobster *(Homarus vulgaris)*, although not made systematically for the purpose of determining these points, but, rather, from the necessity of examining numerous egg-bearing females at different times of the year, in connection with other investigations, agree with those of Ehrenbaum in pointing to the conclusion that, on the whole, the history of the reproduction of this species is similar to that of the American representative of the genus.

Females with newly-laid eggs were first obtained during the latter half of July, but out of a large number of lobsters examined, only two specimens in this condition were found. During August and September my work on the subject was interrupted, but on taking it up again in October (1893), females carrying eggs were plentiful, but all the eggs were either in the nauplius stage, with no eye-pigment yet deposited, or in stages in which eye-pigment was just commencing to be seen. These facts, namely, that newly-laid eggs were scarce during the

* In the sixth *Annual Report of the Fishery Board for Scotland*, p. 196, Prof. Ewart and Dr. Fulton state that in Rothesay Aquarium, a female, with ova, being placed in the tanks in August, 1886, hatching was only completed in August, 1887, some of the young lobsters being hatched as early as April. It seems fairly certain from this result, that confinement tends to produce an abnormal rate of development, as, in the case of lobsters captured when the eggs are nearly ready to hatch and placed in the tanks of the Plymouth Laboratory, hatching is usually completed within a week, at most, from the time it commences.

latter half of July, whilst they were numerous, but all were at least in the nauplius stage, in October, would seem to show that August is the month during which most of the females spawn. Development during the winter months took place very slowly.

The first lobster which I was able to obtain during the following year with eggs on the point of hatching, was brought to the Laboratory on the 20th of March, and larvæ were set free on the 29th of the same month. This lobster, which was stated to have been taken in deep water off the Eddystone, appears, however, to have been quite exceptional, for, in spite of repeated endeavours, no specimen could be again procured with ripe eggs until the middle of May. From this time they became more frequent, the largest number being obtained in June. By the middle of July only occasional specimens were seen, whilst after the end of that month no more could be obtained. During the last fortnight of July the two seasons appeared to overlap, very few lobsters being in berry at all; whilst of those which were, the number having ripe eggs appeared to be about equal to that of those whose eggs were newly spawned.

On the whole, therefore, it is probable that, in this district, the majority of lobsters lay their eggs during August, and the majority of eggs are hatched during June, the period of fosterage being at least ten months.

Coming to the question of the interval which elapses between the hatching of one brood of eggs and the laying of the next, the authors are agreed that this must be at least a year, whilst Ehrenbaum would make it considerably longer. The reasons brought forward by the American naturalists in support of their conclusions on this head are, in the first place, the immature condition of the ovaries of females which have recently hatched their eggs, and the slow rate of maturation of the eggs in the ovary, which render it impossible that the eggs should be ready for laying during the summer in which a brood has hatched; and, secondly, the fact that during the winter months a large proportion of the females captured do not carry eggs.

As already stated, Ehrenbaum makes the interval much longer, and considers that, on the average, a female lobster produces eggs only once in four years. This result is so extraordinary, and if the conclusion can be maintained, is so important, that it is worth while stating in full the evidence on which it is based, and I give, therefore, the following translation of Ehrenbaum's remarks on the subject:

"If eggs were laid every year, then, in consequence of the long duration of the hatching period, females bearing no eggs on the abdomen would seldom occur, which is by no means the case. It can rather be proved with tolerable certainty that the intervals between two consecutive spawnings extend over two, three—or, indeed, more—generally over four years. . . .

"The report by J. C. Ewart, on the Scotch lobster fishery, already referred to (6th Annual Report of the Fishery Board for Scotland, 1888, p. 196), contains the statement that, according to the testimony of the lobster fishermen, about 30 per cent. of all the lobsters caught are females bearing spawn. But as males and females are represented in about equal numbers in the catches—I have found 2,200 males to 2,030 females,* in an enumeration extending over the whole year—according to the statement made above, about 60 per cent. of all the females carry eggs, which would indicate an interval of scarcely two years between two consecutive spawnings.

"The matter was of sufficient interest and importance to justify closer investigation, and I have therefore made statistical observations extending over the whole year, whenever suitable opportunity offered, on the number and percentage of egg-bearing females in the catches. In doing this I have not counted the individual catches, but those collected by the dealers in the lobster cages, and have obtained the following results:—†

| Date. | Total Number. Males. | Total Number. Females. | Females with Eggs. Number. | Females with Eggs. Per cent. | Eggs newly laid. | "Black" Females. | Eggs far developed. | Remarks. |
|---|---|---|---|---|---|---|---|---|
| 1892. July 25th | 38 | 21 | — | 35·2 | — | — | — | All just before or just after moulting. |
| | 15 | 61 | 29 | | 2 | — | — | |
| Aug. 13th | 86 | 75 | 35 | 46·6 | 4 | 7 | — | |
| Sept. 14th | 97 | 91 | 40 | 44·0 | — | 7 | — | |
| Nov. 8th | 123 | 78 | 23 | 29·5 | — | — | — | Unsorted catches. |
| Dec. 7th | 207 | 162 | 31 | 19·1 | — | — | — | ,, ,, |
| ,, 10th | 94 | 67 | 9 | 13·5 | — | — | — | ,, ,, |
| ,, 14th | 61 | 102 | 25 | 24·7 | — | — | — | ,, ,, |
| ,, 20th | 276 | 160 | 27 | 16·9 | — | — | — | ,, ,, |
| 1893. Feb. 20th | 310 | 212 | 49 | 23·1 | — | 4 | — | ,, ,, |
| May 17th | 277 | 270 | 46 | 17·0 | — | — | 5 | ,, ,, |
| June 13th | 246 | 309 | 64 | 20·7 | — | — | — | Caught since May 17th. |
| July 13th | 111 | 138 | 64 | 46·4 | — | — | 21 | Caught since June 13th. |
| ,, 25th | 106 | 171 | 45 | 26·3 | 2 | — | 3 | Unsorted catches. |

"For the better understanding of these figures, the following must be mentioned:—

"The "black" females are reckoned as egg-bearing, since, under natural conditions, *i.e.*, if they had not been confined in the cages, they would have spawned.

* Herrick found, however, among about 3,000 animals, a slight excess of females.

† Herrick (*Zool. Anz.* 1891, p. 134) has given a similar table, which, however, does not give the same result.

"As regards the first three entries, which relate to July 25th, August 13th, and September 14th, 1892, it cannot be maintained that the catches still retained sufficiently closely the natural composition which they possessed when first taken. In the summer the dealer sorts his wares, in order to render selection for sale more easy. He divides the small from the large, puts such lobsters as are about to moult in a special part of the cage (it is in this way that the animals enumerated on the 25th July, 1892, are divided), and prefers to sell the females without eggs on the abdomen first, in order to guard against their becoming "black." The latter circumstance is the cause of the percentage of egg-bearing females, in the first three entries on the list, being somewhat higher than in the following. In calculating the mean, however, this is hardly noticeable. The last ten enumerations are all made, on the other hand, on material which had not yet been sorted, and which therefore possessed the original constitution of the catch. Care was also taken that nothing should be counted twice, for each time new cages which had not previously been looked through were examined.

"Reckoning the whole thirteen entries, the mean percentage of egg-bearing females is 25·4 per cent.; the last ten, it is only 23 per cent.

"It will not, therefore, be an error to maintain that never more than the fourth part of the female lobsters capable of reproduction actually carry eggs; or, in other words, that a female lobster, as a rule, actually produces eggs only once in every four years." *

Few will be inclined to object to the author's exclamation, "Das ist eine Thatsache, die allerdings zu denken giebt!" but whether, as a result of the thinking, all will be ready to accept the conclusion arrived at, is another question. At first sight, the argument presented appears to be conclusive, but a little consideration will, I think, lead to the conclusion that at least one other explanation of the facts is possible, for it must be borne in mind that Ehrenbaum was not dealing with the number of lobsters living in the sea, but with the number caught in the traps. It is, to say the least, not improbable that a female bearing eggs would be much more wary of entering a trap than one not so encumbered, especially if the trap already contained other lobsters, including females without eggs. The pugnacious habits of these animals are matters of common experience, and I have, on several occasions, known two of them, confined in one tank, continue their

* "A false interpretation of the facts can only be possible in so far that perhaps, sometimes, females may have been counted as 'not egg-bearing,' although they were slightly under 24 c.m. (9½ inches) long, and therefore not yet capable of reproduction. So far as could be judged by the eye, however, the young animals not yet capable of reproduction during the enumeration, were always left on one side."

warfare until one or the other has been killed. The loss of claws and legs is of quite frequent occurrence; and the fisherman, before confining lobsters in a store-pot, invariably cuts the pincer muscles of the big claws, in order to prevent them injuring each other. Even if no instinct corresponding to maternal jealousy exists amongst these animals, a female bearing eggs is placed at such a physical disadvantage, that it is not unlikely that she would be more cautious of entering a confined space with other lobsters. At any rate, this consideration should be borne in mind when drawing conclusions from the results arrived at by Ehrenbaum.

An examination, made at the end of July, of the ovary of a female whose brood had just been hatched, did not appear to me, in itself, to offer evidence for or against the view that eggs would not be laid even during the same summer. The ovaries were found to extend from the anterior end of the œsophagus to the middle of the third segment of the abdomen. The eggs were of a dark green colour, and in a lobster 30.5 cm. long, many of them had a diameter of as much as 1.2 mm. If no further evidence of a different kind were forthcoming, one would, I think, have been inclined to expect that these eggs would be laid during the same summer. It seems to be very important for the settlement of these questions that the rate of development of the eggs in the ovaries of lobsters kept under conditions as normal as possible should be determined, but this, of course, involves many difficulties. It could, probably, only be satisfactorily undertaken where the lobsters could be confined in a large tidal pond from which they were unable to escape but from which the water could at intervals be drawn off completely.

The number of eggs laid by a lobster becomes very much greater as the age of the animal advances. This appears to be true, both of the American and European species. A female 8 inches long, according to Herrick, carries from 3,000 to 9,000 eggs, whilst in one measuring 16½ inches, the number was 85,000. As the result of an examination of nearly a thousand individuals, this author finds that "the numbers of eggs produced by a female lobster at each reproductive period vary in geometrical series, while the lengths of the lobsters producing these eggs vary in arithmetical series."

Thus an American lobster

| | | | | | |
|---|---|---|---|---|---|
| 8 | inches | long | produces | 5,000 | eggs. |
| 10 | „ | „ | „ | 10,000 | „ |
| 12 | „ | „ | „ | 20,000 | „ |
| 14 | „ | „ | „ | 40,000 | „ |
| 16 | „ | „ | „ | 80,000 | „ |

Ehrenbaum finds a similar state of things in the Heligoland lobster, although the actual number of eggs on individuals of the same length appears to be less in the European than in the American species. The following table gives the German naturalist's chief results on this head*:

| Total length of Lobster. | Number of eggs counted. | Estimated number of eggs, including those lost after animal is caught. |
|---|---|---|
| 25.4 cm. (10 inches) | 7,026 | 8,000 |
| 28.1 cm. ($11\frac{1}{16}$ ,, ) | 7,376 | 8,000—8,500 |
| 29.1 cm. ($11\frac{1}{2}$ ,, ) | 8,420 | 9,009—9,500 |
| 29.5 cm. ($11\frac{5}{8}$ ,, ) | 13,532 | 14,000 |
| 29.2 cm. ($11\frac{1}{2}$ ,, ) | 10,330 | 11,000 |
| 31.0 cm. ($12\frac{2}{5}$ ,, ) | 16,800 | 17,500 |
| 31.1 cm. ($12\frac{1}{2}$ ,, ) | 10,307 | 11,000 |
| 35.5 cm. (14 ,, ) | 20,016 | 22,000 |
| 37.3 cm. (15 ,, ) | 29,000 | 32,000 |

An account of the number of eggs produced by the individual leads to the consideration of what Herrick calls the "law of survival of the larvæ." From the figures given for the American species, it is evident that the total number of eggs produced during the entire life of a female which reaches the length of 16 inches, must be very large, even should Ehrenbaum's conjecture that spawning takes place only once in four years prove to be correct. The question which presents itself is, what proportion of this large number of eggs must develop into sexually mature lobsters, in order to maintain the species in its existing numbers; and the answer to this question would be completely given if we knew (1) the relation of the total number of females existing to the total number of males, and (2) the number of eggs produced on the average by a sexually mature female during the whole of her life; for it is only necessary that each female should give rise to two sexually mature individuals in order to accomplish the result, if the number of males is not greatly in excess of the number of females.

It is known, from observation, that the males are not greatly in excess, but the average number of eggs produced by females during the course of their lives is more difficult to ascertain, as we have no knowledge of the number of individuals destroyed at different ages. Many, no doubt, of those which lay their first brood are destroyed before the eggs are hatched, whilst of those which survive, a constantly diminishing number produce a second, third, or fourth lot of young. This, however,

* In comparing Ehrenbaum's figures with those of Herrick, it must not be forgotten that those of the latter author are based on an examination of nearly a thousand individuals, whilst those of the former are in each case the result of counting the eggs of a single female.

is in part compensated by the fact that the number of eggs produced increases so rapidly with the increase in size of the lobster.

Herrick makes the exceedingly moderate statement that, taking into account "the fact that the species, as a whole, does not appear to be maintained at present at an equilibrium, but rather to be actually on the decline, a little reflection will convince anyone that the destruction of the young of this species in nature, must be much greater than that entailed by the survival of 2 in 10,000."

But this estimate appears, from a consideration of all the facts, to be considerably too low, and we should, I believe, be well within the mark in placing the figures at 2 in 30,000. It must not be lost sight of that the number of eggs that it is necessary for a female to produce to maintain the species at an equilibrium, in other words, the number of eggs actually produced by each female, had become a fixed quantity before there was any interference on the part of man in the way of lobster fishery, as we must suppose that the species was then adapted to its conditions. But, since the introduction of lobster-fishing has done nothing to increase or diminish the dangers to which the larva is exposed after it has become free,* the number of eggs now produced, on an average, by a female lobster during her lifetime, will give us an indication of the minimum number of eggs necessary, in order to ensure the survival to sexual maturity of two individuals.

From the *Report of the Newfoundland Department of Fisheries* for 1893, p. 39, it appears that from a total of 96,098 female lobsters taken from 1890 to 1893, the number of eggs collected was 2,247,908,000, which would give an average of 23,000 eggs for each female. This is the average number of eggs actually carried. But a female with 23,000 eggs would, according to Herrick's results, have a length of more than 12 inches, and would, therefore, from the known average age at which spawning commences, be carrying, at least, her second brood. Under these circumstances 30,000 eggs, on the average, to each female during her lifetime, must be well within the mark and the number of survivors necessary, therefore, to maintain the species cannot be more than 2 to every 30,000 eggs.

As Herrick points out, attempted remedial measures, which are confined to the mere hatching of lobster eggs, and turning the larvæ immediately into the sea, can have but little practical effect. The rate of destruction will be at least as great as in the case of larvæ hatched by the parent, and, on the estimate given above, two, at most, will survive out of every 30,000. This method of attempting to benefit the lobster industry has been extensively used in Newfoundland, and it is

* It may, of course, be maintained that the capture of other fish has tended to reduce he number of enemies of the larvæ.

interesting to calculate what the probable effect of the operations there being carried on is likely to be.

From the *Report of the Newfoundland Department of Fisheries* for 1893, it appears that the largest number of ova dealt with in any one year was 696,517,690, in 1891. Calculating the number of survivors at 2 in 30,000 (as a matter of fact, 20 per cent. were lost before hatching, a much greater number than would be lost under natural conditions), this would give 46,434 adult lobsters added to the neighbourhood. Even if all these 46,434 were caught, the percentage of increase on the whole fishery (a little over 5,000,000 in 1893) would be 0·9 per cent.

A consideration of the steps by which this conclusion has been reached will, I think, leave the impression that it is still far too high, and that a very much smaller percentage would much more nearly represent the truth. As to whether the result is sufficient to justify the trouble and expense involved in bringing it about, I will not venture to express an opinion.

If the larvæ could be reared through their early pelagic stage and not liberated until their natural instincts lead them to seek the bottom and hide themselves, the result would, as Herrick maintains, be probably very different; but if this could be successfully done on a large scale, as no doubt it might be if sufficient capital were put into the undertaking, there seems no reason why the young lobsters should not be reared to the adult stage, and to marketable size, and not turned into the sea at all. An undertaking of this kind, carried out on a scale similar to that upon which oyster-farming is conducted on the Continent, might very probably be made a success.

# Additional Observations on the Nerve-Elements of the Embryonic Lobster.

By

E. J. Allen, B.Sc.
Director of the Plymouth Laboratory.

In Vol. III., No. 3, p. 208, of this Journal, a summary was given of certain observations made in the Plymouth Laboratory on the nerve-elements of the embryonic lobster. A more detailed description of these elements, with figures, appeared in the *Quarterly Journal of Microscopical Science,* vol. 36, 1894. The observations have since been extended, and the following summary of the additional results may not be without interest.

In the detailed paper a pair of elements (Element B) was described occurring in the ganglia Thorax II., Th. V., and Th. VIII., each of which consisted of a cell lying in the lateral mass of ganglion cells, which gave off a fibre decussating with its fellow of the opposite side, and then running forward to the brain. Before leaving the ganglion in which the cell lay, the fibre gave off a pair of branches, one going to the ganglion immediately in front, the other to the ganglion immediately behind, the branches breaking up in the neuropile of each of these ganglia. Thus Element B, in Th. II., sent a branch to Th. I. and to Th. III.; Element B, Th. V., sent branches to Th. IV. and Th. VI.; Element B, of Th. VIII., sent branches to Th. VII. and Th. IX., the main fibres running forward to the brain.

A precisely similar element has since been found in Th. XI., sending branches to Th. X. and Abd. I., so that the series is now complete for the thorax, and each of its ganglia appears to be influenced by these elements, the fibres of which arboresce in a particular region of the brain.

A number of additional motor fibres, which cannot well be described without drawings, have also been observed in the thorax, some of which resemble those figured in the former paper, whilst others differ from them in essential details. Some of these motor elements send their fibres out of the cord through the anterior nerve roots, others through the posterior.

The motor elements previously described are all characterised by the fact that the fibre leaves the central nervous system through one of the roots of that ganglion in which the cell attached to it is situated. The portion of the element which lies within the central nervous system is therefore entirely confined to one ganglion. In a number of elements, which have since stained, whilst the cell lies in one ganglion, the fibre passes out of the cord by the nerve-root of some other ganglion. In one such element, the cell lies in the anterior portion of the central mass of ganglion cells of Th. VII., and gives off a fibre which runs outwards and then upwards, to Th. VI., where it passes out by the posterior root of the ganglion. The fibre gives off a stout arborescent branch in Th. VII., and a straight transverse branch in Th. VI., which passes across to the opposite side of that ganglion.

Of elements belonging to new types, perhaps the most interesting are those which, taking origin in a single cell, have two or more branches, which pass out of the central nervous system by the nerve-roots of different ganglia. For example, a cell lying in the anterior portion of the lateral mass of ganglian cells of Thorax VIII., gives off a moderately fine fibre, which very soon bifurcates, one branch passing immediately out of the ganglion through the anterior nerve-root, whilst the other runs forwards along the ganglionic cord. The forward branch pursues a perfectly straight course until it reaches Th. III., where it gives off a branch, which passes out through the posterior root of that ganglion. After giving off this branch the fibre continues to Th. II., where it turns and leaves the ganglion through the posterior root. Hence this element, the cell of which lies in Th. VIII., supplies fibres to at least three nerve-roots of different ganglia, namely, the anterior nerve-root of Th. VIII., the posterior root of Th. III., and the posterior root of Th. II., and all these fibres have their origin in a single cell.

In the *Abdominal Ganglia*, staining of nerve elements can be obtained in two ways. In the case of embryos in the early or medium stage, fibres which have taken up the methylene blue in the thorax, often continue to absorb the colouring matter in the abdomen, and the cells with which they are connected are thus brought to light. The best results for the abdominal ganglia can, however, be obtained by special preparation of embryos, which are very near the hatching point. In such embryos the abdominal ganglia may be dissected out from the surrounding tissue by careful manipulation with needles. Special care must be taken not to injure or stretch the ganglia, and their continuity with the ganglia of the thorax should be maintained. If the embryo, thus prepared, be placed with the dorsal surface uppermost in very dilute methylene blue, satisfactory staining of many of the elements of the abdomen will soon take place.

The elements of the abdomen belong to types similar to those described for the thorax.

In each ganglion a pair of elements exists, taking origin in two ganglion cells lying upon opposite sides. Each cell gives off a fibre, which after decussation with its fellow, passes to the opposite side of the ganglion, and gives off a branch to the neuropile. It then turns forward and runs along the cord to the brain. In this way each of the ganglia of the abdomen is placed in direct communication with the brain.

In the sixth abdominal ganglion two pairs of elements of this type occur, thus pointing to the composite nature of the ganglion.

A considerable number of motor elements, consisting of a cell in one of the ganglia, and a fibre which passes out of the central nervous system, have stained in the abdomen. These are of two kinds; first, those in which the element is confined to a single ganglion, the fibre passing out through one of the roots of the ganglion in which the cell lies, and secondly, those in which the fibre leaves the central nervous system by a nerve-root of a ganglion other than that in which the cell lies. These will be described in detail in a later paper.

Further observations have also been made on the sensory nerve elements, which have their origin in cells lying outside the central nervous system. These fibres, on entering a ganglion, make a characteristic Y-shaped bifurcation, sending one branch forwards and the other backwards along the cord. These branches have been traced for considerably greater distances than was previously possible, the forward one having been seen to pass through at least nine or ten ganglia. In all probability, all these forward branches go in every case to the brain. The backwardly directed branch has never been actually traced through more than two or three ganglia, and no indication has been obtained as to the locality or nature of its termination.

A detailed account of the observations here recorded will be published in the *Quarterly Journal of Microscopical Science.*

# Notes and Memoranda.

**On a Specimen of Leptocephalus Morrisii.**—During the first week of June of the present year, a specimen of *Leptocephalus* was brought to the Laboratory by a boy, who had found it under a stone on the shore, in a small cove in front of the building. The beach in this cove consists of broken fragments of limestone. The specimen was alive when brought up, and was preserved in formaldehyde. When I examined it a few weeks later it was entire and in excellent condition, and retained its transparency to a considerable degree in the preserving liquid. The specimen is 11.25 cm. long ($4\frac{1}{2}$ in.); the greatest dorso-ventral breadth of the body, a little behind the anus, is 7 mm.; the breadth in the same direction at the back of the head is 5 mm. The dorsal line rises slightly behind the head. From the tip of the lower jaw to the anus the distance is 5.25 cm., from the tip of the snout to the commencement of the dorsal fin is 3.6 cm. Thus the point at which the dorsal fin commences is nearer to the anus than to the pectoral fin, although, in the fully developed conger, the dorsal fin extends forwards to a point in front of the posterior extremity of the pectorals. In this respect the larval form more resembles the adult common eel (*Anguilla*) than its own parent. The greatest lateral thickness of the body is just behind the head, and does not exceed 2 mm. Behind the anus it is narrower still. The head, however, is not much compressed laterally, but is rather broad, and flat on the dorsal surface. The length of the head is 8 mm., measured from the tip of the snout to the gill opening; its breadth is 3 mm.; its vertical height at the level of the eyes, 4 mm. In characters the head resembles that of the conger very closely. The eyes are large, the exposed front being silvery, except along the dorsal edge, where there is a streak of black pigment. The anterior tubular nostrils and the posterior open ones are present, as in the conger, and the gill opening is a reduced slit in front of the base of the pectoral, as in the latter. The upper jaw is a little longer than the lower, and the angle of the mouth is below the middle of the eye. No bones can be seen in the interior of the body by this examination of the entire animal without further preparation; the myotomes are distinct, numerous, and narrow antero-posteriorly. There are simple, slender, permanent fin rays in the longitudinal fin; I counted 480 of these, but at the anterior extremities of the fin they were too indistinct to be counted accurately. The end of the tail has the same shape as in the adult conger, the fin passing continuously round it, and the rays being arranged symmetrically and somewhat more elongated than in the dorsal and ventral parts of the fin. The pectoral fin is 3 mm. long.

There is a single linear series of black dots along the middle of each side, each dot being a single stellate chromatophore. There are a few additional chromatophores below the principal series, and also a row along each side of the middle ventral line of the abdomen. At the base of the longitudinal fin, there is a series of chromatophores on each side, one to each fin-ray, continued round the end of the tail to a point about ½ in. from the apex of the tail dorsally, but there are none on the rest of the dorsal edge of the body.

In most respects, as may be seen on comparing the above description with Couch's figure, our specimen agrees well with the latter. The characters of the head are not, however, well brought out in that figure. Judging from our specimen, the eyes are too small, and the character of the mouth and jaws is not shown; the whole head is also too small. In Couch's figure, too, the body increases more in breadth towards the middle region and in the posterior half than in our specimen, in which the dorso-ventral breadth remains almost uniform in the middle two-thirds of the body, decreasing anteriorly and posteriorly.

Further anatomical examination must be deferred to some other opportunity. I will only add here that the character of the larva suggests to myself the idea that it corresponds to special conditions of life, as is the case in other larvæ, and that these special conditions are not of the pelagic kind. The head is, to all intents and purposes, the head of a conger, and the like may be said of the longitudinal fin, with the reservation mentioned above. The body is compressed, colourless, transparent, and boneless, and these qualities would, I think, be fostered, if not produced, by the habit of living under stones and in narrow crevices, with comparatively little exertion of the trunk musculature.

J. T. CUNNINGHAM.

**Cuthona ? aurantiaca.**—I am glad to be able to add this beautiful species to the *Nudibranchiate* fauna of Plymouth. Two specimens were found amongst some dredging from the Millbay channel, on February 6th, 1895. On the same stone there was a colony of *Antennularia ramosa*, which most likely formed the food of the *Nudibranch.* One of the specimens had deposited spawn on the same stone. The interest of this lies in the fact that Alder and Hancock mention this animal as spawning in June and July, whereas this specimen spawned on or about the 6th February. I think there can be no doubt that this spawn belongs to the *Eolid*, as it exactly answers Alder and Hancock's description of it, and, moreover, no other *Nudibranchs* were found in the dredging. During the short time I kept these animals alive, like so many other *Eolids*, they exhibited a partiality for floating on the surface of the water, foot uppermost.

J. C. Sumner.

# Director's Report.

THE issue of the present number of the Journal, which commences Volume IV. of the New Series, has been delayed in consequence of the publication of the Special Number containing Mr. Holt's memoir on "An Examination of the Present State of the Grimsby Trawl Fishery, with especial reference to the Destruction of Immature Fish," which was issued to members in June. I am glad to be able to state that this special number has met with a most favourable reception. It is recognised on all hands that Mr. Holt's memoir constitutes the most serious and successful attempt which has been made for some time past, to place before the general public an accurate and scientific account of the facts relating to one of our most important industries.

As the reports now published show, Mr. Cunningham has continued to carry forward the investigation of the North Sea fishing grounds, and his observations form an important contribution to our knowledge of the subject.

During the time which has elapsed since the appearance of the last regular number of the Journal, the work of the Association at Plymouth has suffered somewhat from the difficulty experienced in obtaining the services of a suitable naturalist to carry on the fishery investigations, which it had been hoped that Mr. Holt would have been able to undertake. The difficulty is, I am glad to say, no longer present, Mr. F. B. Stead, B.A., of King's College, Cambridge, having been appointed by the Council to carry on this branch of our work. An addition to the regular staff has also been made by the appointment of Mr. T. V. Hodgson to the post of Director's Assistant. A. J. Smith, from the Cambridge Morphological Laboratory, has held the position of Laboratory attendant since the beginning of April, and in a large measure has charge of the preservation of specimens for sale. It is hoped that by improving the quality of the specimens sent out by the Association, the demand for them will become greater and our usefulness in this direction extended.

Considerable expense has been incurred in overhauling the engines and pumps, and putting them into a state of proper working order.

The ejector, used for forcing water from the sea, has again been a source of trouble. The iron rod supporting the lower bucket of the automatic valve had rusted so seriously, that it was no longer able to bear the weight, and the bucket became detached. In order to repair this defect it was necessary to remove the cover of the lower chamber of the apparatus, an undertaking of some difficulty. The matter has, however, now been put right, the iron rod having been replaced by one of Muntz metal, which, it is hoped, will better resist the action of the sea-water. The engines and rotary pumps are also being put into a state of thorough repair.

The new system adopted for supplying the tanks in the Laboratory with sea-water has shown itself to be a decided improvement upon that originally used. It may be of interest to describe somewhat in detail the method now employed. Water is pumped from the sea at high tide—when possible, only at the highest spring tides—into one of the large underground reservoirs. From thence it is pumped twice daily into the tanks in the centre of the Laboratory upstairs. In the intervals between the pumpings (twelve hours) these tanks are allowed to empty themselves about one-half, the water running from them falling into the Aquarium below. The Aquarium, however, is supplied principally by a constant circulation of water from the second underground reservoir, which thus becomes gradually renewed by the water falling into it from the Laboratory. By this arrangement the water supplied in the Laboratory is such only as has not previously been used, whilst at the same time the water in the second reservoir and the Aquarium is constantly replaced by water from the sea.

There can be no doubt that the water now in the tanks upstairs is much better for delicate work than that in the general circulation of the Aquarium. Foraminifera, which formerly did not develop normally in the water, can now be satisfactorily reared, and colonies of hydroids have sprung up on the sides of the tanks. Two shallow wooden tanks, placed immediately under the windows on the south side, have been especially successful. Green weeds have sprung up all around their sides, together with a few tufts of red weeds, and numerous colonies of hydroids, serpulids, and compound ascidians. In these tanks the most varied animals, including Hydractinia, Sponges, Echinus, Aplysia, and Ascidians have remained quite healthy for several months, and appear to be still in the same condition. From this and other experiments which I have made, I feel little doubt that the direct action of sunlight upon a portion, at least, of the water is an important factor in keeping it in a satisfactory condition to support the more delicate forms of animal life. It is only in the presence of sunlight also that seaweeds will grow, and in an aquarium where these grow in quantity a much more abundant supply of the minute forms of animal life, which serve as food for the larger, is invariably found.

A commencement has been made on the work of re-arranging and completing the type collection of specimens in the Museum. Several groups are approaching completion, and it is hoped that before long we shall have a representative series of the fauna and flora of the neighbourhood.

Two valuable additions have been made to the Library through the kindness of Sir William Flower, and of the Director of the Royal Gardens at Kew. To the former we are indebted for a complete set of the *Philosophical Transactions of the Royal Society* from 1857 to 1886, and to the latter for a bound copy of Buffon's *Histoire Naturelle.* The Library is still very incomplete, and any addition to it will be much valued. Situated as we are, so far from London, and from any scientific library of importance, it is very necessary that our own supply of literature, both zoological and botanical, should be as complete as possible. A large number of standard works we, unfortunately, do not yet possess.

The outdoor work of the Association has been regularly carried on, and several captures of interest have been made. The sailing boat, *Anton Dohrn,* has been used for work in the Sound, and the small steam tug, *Lorna,* has been hired for work outside. This boat, however, although very suitable for short distances, is not sufficiently large to make expeditions of any length. A short account of the most noteworthy features of the fauna, and the most interesting captures which have been made, will be found in another part of the present number of the Journal.

We have been fortunate in obtaining from the Government Grant Committee of the Royal Society, a grant towards the expenses of boat hire in connection with an attempt to extend our dredging and trawling work to the deeper water lying between Start Point and the Eddystone. The unsettled weather of the past month has interfered, to some extent, with this work, but the results so far obtained give promise of the discovery of valuable collecting grounds, which would be within our reach if we had a suitable boat to visit them. These investigations will be continued at every available opportunity during the summer, and it is hoped that some, at any rate, of the results will be ready for publication in the next number of the Journal.

I am glad to be able to state that the number of workers who have made use of the Laboratory has somewhat increased. The complete list from the beginning of the year is as follows:—

J. C. Sumner, January 2nd to February 28th *(Echinoderm fauna).*

R. Assheton, M.A., February 1st to February 15th *(Elasmobranch development).*

E. S. Goodrich, B.A., March 20th to April 4th *(General Zoology)*.
L. J. Picton, March 20th to April 4th *(General Zoology)*.
T. H. Taylor, March 23rd to April 13th *(Polyzoa)*.
W. Garstang, B.A., March 21st to May 1st *(Tunicata)*.
G. W. Butler, M.A., April 3rd to May 17th *(Teleostean development)*.
Prof. C. C. Nutting, April 12th to May 20th *(Hydroids)*.
T. H. Riches, B.A., April 13th *(Nemerteans)*.
T. V. Hodgson, May 27th to June 9th *(Amphipoda)*.
Dr. P. Barthels, May 28th to June 8th *(Echinodermata)*.
W. Garstang, M.A., June 26th to July 31st *(Tunicata)*.
S. P. Bedford, June 29th to August 1st *(General Zoology)*.
J. E. Gray, July 2nd to August 1st *(General Zoology)*.
Prof. W. F. R. Weldon, F.R.S., June 29th *(Variation of Carcinus mœnas.*
Dr. A. Bethe, July 5th *(Nervous System of Crustacea)*.
J. Bancroft, July 8th to July 30th *(General Zoology)*.
G. P. Bidder, M.A., July 11th *(Sponges)*.
W. J. Beaumont, B.A., July 17th *(Faunistic investigations)*.
J. D. Gilchrist, Ph.D., July 20th *(Nervous System of Mollusca)*.

Amongst the workers we have been glad to welcome the three foreign naturalists who have visited us. Prof. Nutting, of the State University of Iowa, was engaged for some six weeks on the study of the Hydroids found at Plymouth, and succeeded in finding not only several species new to the Plymouth fauna, but also in making a number of interesting observations on the structure of the *Plumularidæ*, a family to which he is devoting special attention. It is hoped that the next number of this Journal will contain a paper by Prof. Nutting, embodying some of his more important results.

Dr. P. Barthels, from Prof. Ludwig's Laboratory in Bonn, was occupied chiefly in the preservation of *Echinoderms* for future study, whilst Dr. Bethe, from Prof. Hertwig's Laboratory in Munich, is engaged in a physiological study of the nervous system of *Carcinus mœnas,* side by side with an investigation of the minute anatomy of that structure. The latter researches are of particular interest, as they are being made with the aid of the new method which Dr. Bethe has devised for fixing methylen blue preparations with *Ammonium molybdate.* This method is, without doubt, destined to play a most important part in future studies of the minute histology of the nervous system of many forms. There can be no question that it is superior to any means yet devised for rendering the results of methylen blue staining permanent, and it has the immense additional advantage that sections of the preparations can be made after imbedding in paraffin in the usual way.

The list of persons working at the Laboratory also includes five students from Oxford and Cambridge, who have visited us during their vacations, and have engaged in general study of the animals found here, under the direction of Mr. Garstang. This is, I am convinced, a useful extension of the work of the Laboratory, as the study of living animals, under their natural conditions, has not in the past received that attention at the Universities which is due to it. The students who have worked here have, I believe, acquired a very valuable additional insight into their subject, and a few weeks spent, as it were, in the midst of a marine fauna, cannot but have a beneficial influence on their future studies. It is to be hoped that in future years many more students will visit us in this way, and that those who have been here already will return to carry on research.

Professor Weldon has been engaged in an attempt to determine the difference in the amount of abnormality in individual crabs at different ages. In order to do this, it has been necessary to fit up an apparatus, by means of which some 500 crabs can be kept in separate bottles, with a current of sea-water running through each bottle. To keep these bottles properly cleaned, and the crabs fed daily, has involved a very considerable amount of labour, and as, in addition to this, the individual crabs have to be measured at at least two different ages, the whole investigation is one which can only be carried on at the expense of a great deal of time and energy. Whatever conclusion, however, may be arrived at as the result of the measurements, there can be no doubt that the knowledge gained will be worth any trouble entailed in obtaining it.

On another page will be found Mr. Butler's account of his observations on the breeding of the soles in the Aquarium. As Mr. Butler points out, this is the first occasion since the Aquarium was opened that these fish have been known to produce fertilised eggs, and is probably the first time that such eggs have been obtained from specimens of this fish kept in confinement.

Considerable progress has been made in arranging certain groups for the type museum by the three gentlemen, Messrs. Garstang, T. H. Taylor and T. V. Hodgson, who have undertaken this work. There still remains much to be done, and it is hoped that other naturalists will be willing to take advantage of the arrangements made for helping with other groups.

E. J. Allen.

*August*, 1895.

# Marine Biological Association of the United Kingdom.

## Report of the Council, 1894–95.

### The Council.

The Council has met on ten occasions during the past year for the transaction of the business of the Association. The average attendance at the meetings has been 7·5. Meetings of Special Committees have also been held as occasion required.

For various reasons, it is proposed in the future to hold only four Council Meetings in each year, unless special occasion should arise for increasing their number.

Dr. A. Günther, F.R.S., who had been a member of the Council since its formation in 1884, resigned his seat in the course of the Session, owing to pressure of other occupations, and was elected a Vice-President of the Association. Mr. G. C. Bourne, of New College, Oxford, was elected to fill his place.

The Council has again to acknowledge the courtesy displayed by the Royal Society and the Linnæan Society, in permitting the meetings of the Association to be held in their rooms.

### The Plymouth Laboratory.

The defects in the large reservoirs, referred to in the last Report, have been made good by draining and cementing on the south side.

Some considerable trouble was given last year by a fracture in the large pipe which leads seawards from the ejector; this had been presumably caused by a vessel having dragged her anchor over it; the repairs, which necessitated the employment of a diver, have been carried out satisfactorily.

The Council is now able to give a satisfactory report of the condition of the buildings, fittings, and machinery of the Laboratory.

### The Boats.

During the past year the greater part of the work of collection of specimens at sea has been carried out by hired steam-tugs, supple-



Association has made an annual contribution to the Marine Fisheries Society (Grimsby) in return for the use and control of the Cleethorpes Aquarium by Mr. Holt.

The following interesting additions have been made to our knowledge of the Plymouth Fauna during the past year:

*Tiaropsis diademata.*
*Halecium tenellum.*
*Plumularia halecioides.*

mented whenever possible by the Association's sailing-boat, the *Anton Dohrn*. The small steam-launch *Firefly*, which was most serviceable for this purpose for many years, has been at last sold for breaking up.

The Council greatly regrets that there is no immediate likelihood of the Association procuring a suitable boat for deep-sea work.

## The Library.

All the most important annual publications relating to Sea Fisheries are now in the Library, both official publications of most Governments, and publications of fishery societies and local authorities. Several memoirs, containing the results of marine explorations, have been added during the past year, notably the two concluding volumes of the *Challenger* Reports; there have also been added memoirs from the German Plankton Expedition, the cruises of H.M.S. *Investigator*, in the Bay of Bengal, the Commission for Investigation of the German Seas, and the Bahama Expedition of the Iowa State University. The Association has also received, by gift and exchange, the publications of the Royal Societies of London and Edinburgh, the Zoological Society, the Royal Microscopical Society, the Society of Arts, and numerous other scientific societies, academies, and museums at home and abroad. To these, and to the many donors of books and papers, the Council take occasion to render the thanks of the Association.

## The Museum and Exhibition Series.

Although a good deal has been done in the Museum during the past year, much remains still to be done; and the Director has been fortunate in obtaining promises of assistance from various naturalists in this important work during the coming summer.

The series of specimens mounted for exhibition, to which reference has been made in the last two Reports of the Council, was shown at the meeting of the British Association at Oxford, in 1894, and is at present at the Scarborough Fishery Exhibition, together with a set of dredges, trawls, and tow-nets.

## The Staff.

Several changes have occurred lately in the Staff. Mr. E. J. Bles resigned the post of Director on October 11th, 1894; and Mr. E. J. Allen, B.Sc., University College, London, who had long been a worker at the Laboratory, succeeded him on January 12th, of this year.

Mr. Cunningham is at present stationed at Grimsby.

Mr. E. W. L. Holt was unfortunately compelled, by ill-health, to leave the Association's service in March last, and Mr. Stead has been appointed for the term of one year, to carry out, for the Plymouth district, statistical and other inquiries similar to those upon which Mr. Holt has been engaged at Grimsby.

Mr. J. P. Thomasson, to whose generosity the Association has been so largely indebted in previous years, has renewed his donation of £250, for fishery investigations on the North Sea for another year, commencing in March last.

## General Report.

Mr. Holt concluded his work at Grimsby in the winter, and has since then prepared an account of his observations on the North Sea Fisheries during the past three years, in a more popular form than the technical papers which he has contributed to the Journal. This summary, which gives a most valuable and unique picture of the present state of the Fisheries, and should prove of great value in the event of protective legislation, has been printed as a special number of the Journal, and reprinted for sale and distribution.

Mr. Cunningham has prepared for press a natural history of marketable sea fish, to appeal to a wider public than the Journal can attract, which will also be issued as a special number of the Journal, and reprinted for distribution and sale. This memoir is especially designed for the use of the Sea Fisheries' Committees controlling the fisheries of the English coast.

In addition to the preparation of this memoir, Mr. Cunningham has continued his investigations into the rate of the growth of fishes, and the minute structure of the eggs and ovary; he has also carried out further experiments in the relations between light and colouration of fishes.

The water in circulation at the Laboratory has lately improved very greatly in quality under a new system of working introduced by the present Director. Whether as a consequence of this or not, the soles in the aquarium have bred this spring for the first time; no previous record is known of soles having bred naturally in confinement.

After June 30th, the arrangement will terminate, by which the Association has made an annual contribution to the Marine Fisheries Society (Grimsby) in return for the use and control of the Cleethorpes Aquarium by Mr. Holt.

The following interesting additions have been made to our knowledge of the Plymouth Fauna during the past year:

*Tiaropsis diademata.*
*Halecium tenellum.*
*Plumularia halecioides.*

*Syncoryne mirabilis.*
*Aplidium zostericola.*
*Amaræcium punctum.*
*Distaplia rosea.*
*Circinalium concrescens.*

*Corymorpha nutans,* of which no specimens have been taken since 1887, has lately been captured on two occasions.

## Occupation of Tables.

The following naturalists have occupied tables in the Plymouth Laboratory during the past twelve months:

E. J. Allen, B.Sc., University College, London (Nervous System of Crustacea).
R. Assheton, M.A., Cambridge (Elasmobranch Development).
G. P. Bidder, B.A., Naples (Porifera).
E. T. Browne, B.A., University College, London (Variation of Aurelia).
G. W. Butler, B.A., Chertsey (Teleostean Development).
G. P. Darnell-Smith, B.Sc., Bristol (Physiology of Algæ).
W. Garstang, M.A., Oxford (Tunicata).
E. S. Goodrich, Oxford (General Zoology).
M. D. Hill, B.A., Oxford (Molluscan Ova).
J. J. Lister, M.A., Cambridge (Development of Foraminifera).
Prof. C. C. Nutting, State University, Iowa (Hydroids).
T. H. Riches, B.A., Plymouth (Development of Nemertines).
J. C. Sumner, Royal College of Science, London (Echinodermata).
T. H. Taylor, Yorkshire College, Leeds (Polyzoa).

Surgeon P. W. Bassett-Smith, R.N., Plymouth, and Mr. L. J. Picton, Oxford, have also made use of the Laboratory, without formal occupation of a table.

The following papers, either wholly or in part the outcome of work done at the Plymouth Laboratory, or by members of the Staff stationed elsewhere, have appeared during the past year, in addition to those published in the Journal:

Browne, E. T.—*On the Variation of the Tentaculocysts of* Aurelia aurita, Quart. Journ. Micr. Sci. xxxvii. 245.

Garstang, W.—*On the Gastropod* Colpodaspis pusilla *of Michael Sars,* Proc. Zool. Soc. November 20th, 1894.

Sumner, J. C.—*Description of a New Species of Nemertine,* Ann. and Mag. of Nat. Hist. ser. 6, vol. xiv.

Weldon, W. F. R.—*An Attempt to Measure the Death-rate due to Selective Destruction of* Carcinus mænas, *with Respect to a Particular Dimension,* Proc. Roy. Soc. lvii. p. 360.

## Donations and Receipts.

The Receipts for the past year include the annual grants from H.M. Treasury (£1000) and the Worshipful Company of Fishmongers (£400); and a special donation of £250 from Mr. J. P. Thomasson for the prosecution of fishery investigation. Other sources of income have been—the annual subscriptions (£135), composition fees (£25), rent of tables in the Laboratory (£39), sale of specimens (£205), and admission to the Aquarium (£66); the total amounting, with lesser sums, to £2178.

## Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1895–96:—

*President.*

Prof. E. Ray Lankester, LL.D., F.R.S.

*Vice-Presidents.*

The Duke of Argyll, K.G. K.T., F.R.S.
The Duke of Abercorn, K.G., C.B.
The Earl of St. Germans.
The Earl of Morley.
The Earl of Ducie, F.R.S.
Lord Revelstoke.
The Right Hon. Lord Tweedmouth.
Lord Walsingham, F.R.S.
The Right Hon. A. J. Balfour, M.P., F.R.S.
The Right Hon. Joseph Chamberlain, M.P.
The Right Hon. Sir John Lubbock, Bart, M.P., F.R.S.
Prof. G. J. Allman, F.R.S.
Sir Edward Birkbeck, Bart., M.P.
Sir Wm. Flower, K.C.B., F.R.S.
A. C. L. G. Günther, Esq., F.R.S.
Prof. Alfred Newton, F.R.S.
Rev. Canon Norman, D.C.L., F.R.S.
Sir Henry Thompson.
Admiral Wharton, R.N., F.R.S.

### Elected Members.

F. E. Beddard, Esq., F.R.S.
Prof. F. Jeffery Bell, F.Z.S.
G. C. Bourne, Esq., F.L.S.
Sir John Evans, K.C.B., Treas. R.S.
G. Herbert Fowler, Esq.
S. F. Harmer, Esq.
Prof. W. A. Herdman, F.R.S.
Prof. S. J. Hickson, F.R.S.
J. J. Lister, Esq.
Prof. W. C. McIntosh, F.R.S.
P. L. Sclater, Esq., F.R.S., Sec. Z.S.
D. H. Scott, Esq., F.R.S.
Prof. Charles Stewart, V.P.L.S.
Prof. W. F. R. Weldon, F.R.S.

*Hon. Treasurer:*

E. L. Beckwith, Esq.

*Hon. Secretary:*

E. J. Allen, Esq., The Laboratory, Plymouth.

*Dr.* *Statement of Receipts and Expenditure for the Year ending 31st May, 1895.* *Cr.*

| Receipts. | £ s. d. | £ s. d. | £ s. d. |
|---|---|---|---|
| To Balance from last year, being Cash in Bank and in hand (General Fund, and Bait Investigation Fund) | | | 10 1 5 |
| ,, H.M. Treasury | | | 1000 0 0 |
| ,, Fishmongers' Company (this includes £200 for the year 1895–96) | | | 600 0 0 |
| ,, To Special Donation, J. P. Thomasson, Esq. | | | 250 0 0 |
| ,, Annual Subscriptions | | | 135 9 0 |
| ,, Composition Fees and Donations | | | 25 15 0 |
| ,, Rent of Tables | £ 39 11 0 | | |
| ,, Sale of Specimens | 205 12 10 | | |
| ,, Sale of *Journal* | 19 9 8 | | |
| | | 264 13 6 | |
| ,, Sale of Monograph | | 3 10 0 | |
| ,, Sale of Launch *Firefly* | | 6 0 0 | |
| ,, Admission to Tank Room | | 66 17 0 | |
| ,, Interest on Investment | | 25 18 9 | |
| | | | 366 19 3 |
| | | | £2388 4 8 |

*Examined and found correct,*

STEPHEN E. SPRING RICE,<br>FRANK E. BEDDARD,<br>F. JEFFREY BELL,<br>EDWIN WATERHOUSE, } *Auditors.*

| Expenditure. | £ s. d. | £ s. d. | £ s. d. |
|---|---|---|---|
| By Salaries and Wages— | | | |
| Director | | 200 0 0 | |
| ,, ,, allowance for Assistant | | 80 0 0 | |
| ,, Naturalist, Mr. J. T. Cunningham | | 250 0 0 | |
| ,, ,, Mr. E. W. L. Holt | | 100 0 0 | |
| ,, Wages | | 335 10 2 | |
| | | | 965 10 2 |
| ,, Stationery, Office Printing, Postages, &c. | | | 159 19 10 |
| ,, Printing Journal | | 91 16 0 | |
| ,, Illustrating ,, | | 2 14 1 | |
| | | | 94 10 1 |
| ,, Sundry Expenses— | | | |
| Gas, Water, Coal, Oil, &c. | | 106 19 7 | |
| Stocking Tanks, Feeding, &c. | | 84 16 6 | |
| Glass, Chemicals, Apparatus, &c. | £133 19 5 | | |
| *Less* Sales to Table Renters | 8 0 2 | | |
| | | 125 19 3 | |
| Maintenance, and Renewal of Building, Boats, and Nets | | 137 11 4 | |
| Rates and Taxes | | 10 7 2 | |
| Boat Hire | | 72 16 0 | |
| Travelling Expenses | | 23 2 0 | |
| Allowance to Naturalist for Expenses of Removal | | 25 0 0 | |
| Expenses of Exhibition of Specimens | | 14 14 7 | |
| Library | | 40 13 5 | |
| North Sea Investigation at Cleethorpes | | 69 12 7 | |
| | | | 711 12 5 |
| ,, Balance forward, being Cash in Bank and in hand (General Fund, and Bait Investigation Fund) | | | 456 12 2 |
| | | | £2388 4 8 |

Investment held 31st May, 1895—

£670 Forth Bridge Railway 4 % guaranteed, at 125......£837 10 0

# OBJECTS

OF THE

# Marine Biological Association of the United Kingdom.

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THE ASSOCIATION was founded at a Meeting called for the purpose in March, 1884, and held in the Rooms of the Royal Society of London.

The late Professor HUXLEY, at that time President of the Royal Society, took the chair, and amongst the speakers in support of the project were the Duke of ARGYLL, Sir LYON PLAYFAIR, Sir JOHN LUBBOCK, Sir JOSEPH HOOKER, the late Dr. CARPENTER, Dr. GÜNTHER, the late Lord DALHOUSIE, the late Professor MOSELEY, the late Mr. ROMANES, and Professor LANKESTER.

The Association owes its existence and its present satisfactory condition to a combination of scientific naturalists, and of gentlemen who, from philanthropic or practical reasons, are specially interested in the great sea fisheries of the United Kingdom. It is universally admitted that our knowledge of the habits and conditions of life of sea fishes is very small, and insufficient to enable either the practical fisherman or the Legislature to take measures calculated to ensure to the country the greatest return from the "harvest of the sea." Naturalists are, on the other hand, anxious to push further our knowledge of marine life and its conditions. Hence, the Association has erected at Plymouth a thoroughly efficient laboratory, where naturalists may study the history of marine animals and plants in general, and where, in particular, researches on food fishes and molluscs may be carried out with the best appliances.

The Laboratory and its fittings were completed in June, 1888, at a cost of some £12,000. Since that time investigations, practical and scientific, have been constantly pursued at Plymouth. Practical investigations upon matters connected with sea-fishing are carried on under the direction of the Council; in addition, naturalists from England and from abroad have come to the Laboratory, to carry on their own independent researches, and have made valuable additions to zoological and botanical science, at the expense of a small rent, for the use of a working table in the Laboratory and other appliances. The number of naturalists who can be employed by the Association in special investigations on fishery questions, and definitely retained for the purpose of carrying on those researches throughout the year, must depend on the funds subscribed by private individuals and public bodies for the purpose. The first charges on the revenue of the Association are the working of the sea-water circulation in the tanks, stocking the tanks with fish and feeding the latter, the payment of servants and fishermen, the hire and maintenance of fishing boats, and the salary of the Resident Director and Staff. At the commencement of this number will be found the names of the gentlemen on the staff. In no case does any one salary exceed £250.

The Association has received some £25,000, of which £11,000 has been granted by the Treasury. The annual revenue which can be at present counted on is about £1,820, of which £1,000 a year is granted by the Treasury, the remainder being principally made up in Subscriptions.

The admirable Marine Biological Laboratory at Naples, founded and directed by Dr. Dohrn, has cost about £20,000, including steam launches, &c., whilst it has an annual budget of £7,000.

The ASSOCIATION IS AT PRESENT UNABLE TO AFFORD THE PURCHASE AND MAINTENANCE OF A SEA-GOING STEAM VESSEL, by means of which fishery investigations can be extended to other parts of the coast than the immediate neighbourhood of Plymouth. Funds are urgently needed in order that this section of the work may be carried out with efficiency. The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

# CONTENTS OF NEW SERIES, Vol. IV., No. 1.



## NOTICE.



## TERMS OF MEMBERSHIP.

| | | £ | s. | d. |
|---|---|---|---|---|
| Annual Members | . per annum. | 1 | 1 | 0 |
| Life Members | Composition Fee. | 15 | 15 | 0 |
| Founders | . . . | 100 | 0 | 0 |
| Governors | . . . | 500 | 0 | 0 |

Members of the Association have the following rights and privileges: they elect annually the Officers and Council; they receive the Journal of the Association free by post; they are admitted to view the Laboratory at Plymouth, and may introduce friends with them; they have the first claim to rent a place in the Laboratory for research, with use of tanks, boats, &c., and have access to the books in the Library at Plymouth.

All correspondence should be addressed to the Director, The Laboratory, Plymouth.