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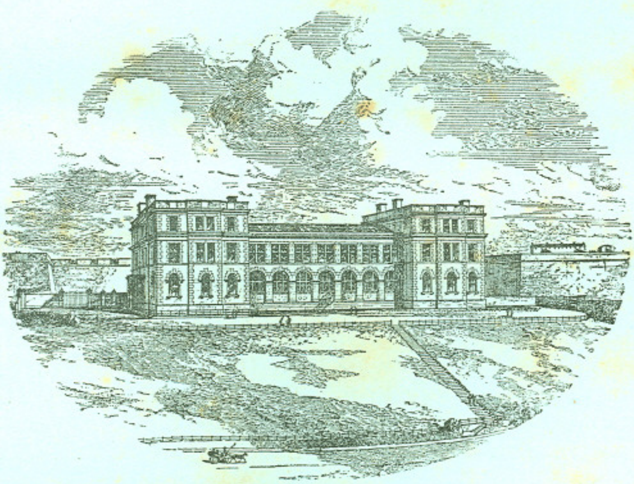
Journal

OF THE

MARINE BIOLOGICAL ASSOCIATION

OF

THE UNITED KINGDOM.



THE PLYMOUTH LABORATORY.

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W. GARSTANG, Esq., M.A.

Marine Biological Association of the United Kingdom.

Report of the Council, 1891-92.

The Council.

Since the last Annual Meeting the Council has met ten times for the conduct of the business of the Association.

The vacancies caused by the retirement of E. W. H. Holdsworth, Esq., and of G. J. Romanes, Esq., F.R.S., were filled in July by the election of Sir Albert Rollit, M.P., and of S. J. Hickson, Esq., D.Sc. No changes have occurred during the year among the Officers.

The Council has to acknowledge the courtesy of the Royal Society in granting the use of its rooms for the several meetings of the Association.

The Laboratory.

The buildings and machinery at Plymouth have been maintained in a satisfactory condition. No serious repairs have been found necessary.

Boats.

The Council is unfortunately unable to report satisfactorily of the condition of the Association's boats. The cost of constant repair to the old steam-launch "Firefly" has become so large, and her working is so uncertain, that it has become an imperative necessity to replace her. The cost of the annual maintenance of such a steamboat as the Association needs is at present beyond its power, namely, a boat in which longer expeditions may be made than has hitherto been practicable.

The Library.

No important bequest has accrued to the Library this year such as was chronicled in the last Report. It is, however, increasing gradually, chiefly in the direction of periodicals. To those naturalists who have presented separate copies of their works the Council renders the thanks of the Association.

The Staff.

At the last Annual Meeting it was announced that Mr. J. P. Thomasson had generously offered £250 for the expenses to be incurred in carrying out observations in the North Sea bearing on the proposed closure of certain fishing grounds by International convention. The Council was fortunate enough to secure for the investigation the services of Mr. E. W. L. Holt, who commenced work in January last.

Mr. W. Garstang, formerly Assistant to the Director, has been appointed a Naturalist on the Staff, and entered on his office on May 30th. His chief duties will be to superintend the collection and supply of material to workers both in the Laboratory and elsewhere.

Mr. F. Hughes, who was appointed temporarily to carry out investigations on the question of artificial bait, has concluded his year of office.

Scientific Investigations.

Mr. Cunningham has been chiefly occupied during the past year in continuing his valuable observations and experiments on young food-fish with reference to their habitat, rate of growth, and attainment of sexual maturity. His results will be found in detail in the last two numbers of the Journal, and it will suffice to mention here that some of the flat-fish which he has reared from about a half-inch in length are now nine inches long, and have reached sexual maturity. Direct observation of this kind is of the utmost value, as supplementing the information derived from fish under natural conditions.

The daily meteorological observations have been continued by Mr. Dickson.

Mr. Holt has only been at work for six months, but his results promise to be of extreme interest. Their scope may be gathered from his notes and from the Director's Report in the last number of the Journal. The Marine Fisheries Society of Grimsby has generously placed its aquarium at Cleethorpes at his disposal, and the Council has undertaken in return to pay half of the caretaker's salary. The Council begs to tender the thanks of the Association to the Society for its assistance in this matter.

It was announced in the last Annual Report that a special drift net was being constructed for the purpose of ascertaining whether anchovies could be procured on the south coast in sufficient numbers to make an anchovy fishery a commercial success. The weather last autumn was most unfavourable for the enterprise: the fish taken by our nets, on the few occasions when they could be used, were very large, and but few in number, although in some places at the same time the herring boats struck large shoals of anchovies. Enough, however, was achieved to justify the repetition of the experiments this year with a reasonable hope of success.

The usual experiments on hatching and rearing fish have been continued.

Eleven naturalists have occupied tables in the Laboratory during the past year for the prosecution of their special researches:

Miss F. Buchanan, B.Sc., University College, London (Anatomy of *Polychæta*).

Mr. F. W. Gamble, B.Sc., Owens College, Manchester (Eyes of *Mollusca*).

Mr. W. Garstang, M.A., Owens College, Manchester (*Tunicata*).

Mr. E. de Hamel, Birmingham (General Zoology).

Mr. S. J. Hickson, M.A., D.Sc., Downing College, Cambridge (*Alcyonium*).

Mr. W. J. Hughes, Birmingham (General Zoology).

Miss M. Robinson, University College, London (Nauplius eye of *Palæmon*).

Mr. T. H. Riches, M.A., Caius College, Cambridge (*Hormiphora* and *Paguridæ*).

Mr. A. H. Stewart, B.A., New College, Oxford (*Holothuroidea*).

Prof. W. F. R. Weldon, M.A., F.R.S., University College, London (Development of *Crangon*).

Mr. A. Willey, B.Sc., University College, London (Development of *Tunicata*).

It is satisfactory to note that, in addition to those which have appeared in the Journal, seventeen original papers have been published elsewhere in the course of the last two years, on work done in the Laboratory.

Finance.

The receipts of the past year include the annual grants from H.M. Treasury (£1,000) and the Fishmongers' Company (£200); the annual subscriptions and composition fees have realised £219, the interest on investments £35, the rent of tables £50, the sale of specimens £87, the charge for admission to the aquarium £84.

The statement of receipts and payments for the year is annexed.

The List of the Officers and Council proposed by the Council for the year 1892–93 is as follows:

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Dr. *Statement of Receipts and Payments for the Year ending 31st May, 1892.* Cr.

Receipts.	£	s.	d.	£	s.	d.
To Balance from last year, made up as follows:						
Special Fund, Bait Investigation	387	9	9			
„ Steam Launch...............	90	4	0			
	477	13	9			
Less Deficit on General Account	267	17	0			
	209	16	9			
Add old outstanding written off	58	19	0			
				268	15	9
To H. M. Treasury				1000	0	0
„ Fishmongers' Company				200	0	0
„ Donation, J. P. Thomasson, Esq., for North Sea Investigation				250	0	0
„ Annual Subscriptions				154	7	0
„ Composition Fees and Donations				65	10	6
„ Rent of Tables £50 6 0						
„ Sale of Specimens 87 17 3						
„ Sale of Journal.................... 12 0 3						
	150	3	6			
„ Sale of Monograph on the Sole	17	5	0			
„ Admission to Tank Room	84	6	4			
„ Interest on Investment	35	2	0			
				286	16	10
				£2225	10	1

Examined and found correct.

Stephen E. Spring Rice,
Edwin Waterhouse,
W. F. R. Weldon,
F. Jeffery Bell,
} *Auditors.*

16*th June*, 1892.

Payments.	£	s.	d.	£	s.	d.
By Salaries and Wages:						
Director	200	0	0			
„ Allowance for Assistant.........	60	0	0			
Mr. J. T. Cunningham	250	0	0			
Mr. E. W. L. Holt, North Sea Investigation	100	0	0			
Mr. F. Hughes, Bait Investigation	90	0	0			
Wages, Salaries of Assistants, &c.	336	2	3			
				1036	2	3
By Stationery, Office Printing, Postage, &c. ...				154	4	9
„ Printing and Illustrating Journal...........				157	7	6
„ Gas, Water, Coal, Oil, &c.	134	18	7			
„ Stocking Tanks, Feeding, &c.	84	8	3			
„ Glass, Chemicals, Apparatus, &c. £147 10 0						
Less Sales 16 12 1						
	130	17	11			
„ Printing and Sale of Monograph on the Sole	1	3	0			
„ Maintenance and General Repairs of Buildings and Boats, including £62 10*s.* purchase of special Anchovy Nets...........	201	17	4			
„ Rates and Taxes	31	6	5			
„ Boat Hire	90	17	0			
„ Travelling...	43	16	9			
„ Library	25	2	8			
„ North Sea Investigation........................	26	11	2			
				770	19	1
„ Balance forward, being Cash in hand, 31st May, 1892, less outstandings, as follows:						
Special Fund, Bait Investigation	297	9	9			
„ Steam Launch, carried to credit of "General Account" by consent of Subscribers	0	0	0			
	297	9	9			
Less Deficit on General Account	190	13	3			
				106	16	6
				£2225	10	1

Investment held 31st May, 1892:
£900 Forth Bridge Railway 4% Debenture Stock at 125...£1125 0 0

Director's Report.

1892

The past summer has been a busy one at Plymouth, and the steady continuance of magnificent weather has made shore-collecting, as well as dredging and tow-netting from the boats, possible at all points in the neighbourhood. The fine weather, as compared to the weather of last summer, seems, moreover, to have had a distinct influence on the pelagic fauna of the Channel. There has been towards the end of the summer a continuance of unusually interesting surface forms, and at the same time almost a total absence of some of the creatures usually found in abundance. For instance, Aurelia has for some unaccountable reason not been found in the Sound this summer, although I have heard of its occurrence in usual numbers in the Solent. Last summer brought innumerable millions of Noctiluca, so that the sea for miles showed orange-red tracks through the dense crowding of these infusorians. This summer has produced practically none.

I particularly note the absence of Aurelia, since it is a form used as a type in teaching, and therefore often ordered from us. It will be impossible to supply Aurelia through the coming winter.

The most important animals captured during the summer are mentioned by one or other of the Staff in the form of special notes, and need, therefore, not be enlarged upon here.

Several gentlemen have taken advantage of the Laboratory to carry on research.

T. H. Riches, Esq., as a Founder of the Association, has continued his studies in Nemertines.

The British Association for the Advancement of Science nominated three gentlemen, viz.—

Edgar Allen, Esq., from the Zoological Laboratory of University College, London, for six weeks.

Gregg Wilson, Esq., Zoological Laboratory, University of Edinburgh, for one month.

F. W. Gamble, Esq., Berkeley Fellow, Owens College, Manchester, for two months.

Mr. Allen worked at the development of Palæmonetes, the fresh-water shrimp.

Mr. Wilson experimented upon the senses of fish, very largely going over the ground covered by Bateson.

Mr. Gamble made a systematic collection and examination of the Turbellaria of the district.

In addition to these gentlemen there were—

R. T. Günther, Esq., from the Anatomical Department, Oxford, working at pigmentation in Cephalopods; and

E. J. Bles, Esq., of Owens College, Manchester, working at a systematic investigation of the "Plankton" of the western portion of the English Channel.

Two alterations have taken place in the Staff of the Laboratory. *Mr. Dickson,* formerly my assistant, who also acted as Physicist, has resigned; and *Mr. Garstang,* previously connected with the Laboratory, has commenced his work:—his appointment having been mentioned in my last Report. I have given into his charge the specimen trade and control of the movements of the steam launch. The arrangement, I find, works well. It is necessary, if the prompt output of well-preserved specimens is to be kept up, that some one person should devote special attention to this branch; and it is hoped, as stated in a previous Report, that the specimen preservation may become more and more perfect under this new *régime.*

With Mr. Dickson's departure the meteorological work has been suspended.

With regard to the Laboratory buildings, little need be said. Slight alterations become necessary from time to time, either for the purpose of improving the general efficiency, or in order that some special investigation may be accomplished with greater ease; the water or gas supply may be rearranged, extra storage room required, or some special apparatus constructed: for instance, five young Mississippi alligators were purchased from a naturalist-sailor home from Florida, and a special hot-water circulation had to be fitted for their benefit. It was thought possible to run the gas engines used in pumping and circulating the sea water with a less consumption of gas, and experiments were tried as to the balancing of speed and power. The result is that now much less gas is consumed, although the circulation is quite efficient.

From the varied nature of the work carried on, such arrangements are expected, but concerning large and important alterations I have nothing to report. A constant watch is kept on all parts of the building, and the establishment maintained in good order, rather than allowed to decline till extensive repairs become necessary. With a comparatively new building this is a matter of no great difficulty;

with the launch, on the other hand, the task is a most disheartening one, being a literal example of the putting of a new piece of cloth on an old garment so that the rent is made worse.

A decided step must shortly be taken to obviate the very great inconvenience caused by the unworthiness and utter collapse of both the engines and hull.

The launch has now served for three years, and was a decidedly old boat when purchased. It is true that she has always been inexpensive in her consumption of coal and water, but of late her extremely inconvenient habit of breaking down has developed itself rapidly, so that the bills for her repair are becoming alarming. It is with a feeling of humility I say it, but she has sometimes broken down as often as three times in one week. It is necessary to work her at a still further reduction of pressure, and she is, moreover, a source of decided danger to those on board. But for the favour of the elements we could have done little sea work during the past summer. There is a certain sum of money—inadequate, no doubt, but still a nucleus—forming what is termed the Boat Fund. In the hope that through the circulation of the Journal, members and others may care to read this report, I venture to write plainly with regard to this our most urgent necessity. Whether or not the Association buys a large sailing trawler for fishery investigations, a new launch with which to procure specimens in this locality is imperative.

The Library continues to increase. An exchange of periodicals has just been arranged with the Director of the new German Station on Heligoland, and by the kindness of many authors a constant influx of papers occurs from all parts of the civilised world.

Constant additions are also being made to the aquarium. At present the tanks show, in addition to ordinary examples of the cod family, dog-fishes, crabs, and flounders, a fine collection of wrasses, some extremely large congers, a red mullet, schools of bass, pipe-fishes, turbots, soles, and other flat-fishes, and a large variety of anemones. The attendance of visitors keeps up, and when some special animals are on view, and an advertisement has been inserted in the local papers, the money taken at the door often becomes considerable. The aquarium is now becoming recognised as one of the sights of Plymouth.

Mr. Cunningham has lately been devoting most of his time to a study of the coloration of fishes' skins, and to a continuation of his work on the rate of growth of food-fishes.

As an addition to the range of his work in connection with the latter subject, a large amount of material has been supplied to him by Mr. Holt from fishes collected at Grimsby and in the deeper parts of the North Sea. In this number will be found a paper by Mr. Cunningham dealing with this material, as compared with the specimens collected at Plymouth. The study of pigmentation in fishes is the outcome of the interesting experiments instituted two years ago, and still in progress—I refer to the cultivation of pigment on the under side of flat-fishes by the action of reflected light.

In my last Report I gave a sketch of the work in the North Sea at present being carried on by Mr. Holt. Much valuable information has been collected as to the sizes at which the various food-fishes spawn for the first time; and it is found that just as the fish of the North Sea are, as a rule, larger than those caught on the south coast, so the spawning periods occur when the fish are of larger size. If legislation as to trawling in the North Sea is to be contemplated, and a restriction put upon fishermen as to the sizes below which it is illegal to capture or sell fish—this legislation being international in character,—then the only rational point of view from which to regard the question is surely the biological one. If we follow the example of a maritime power on the other side of the North Sea, and make the restrictive sizes so small that the fish have never had a chance to spawn before they are captured, then, it appears to me, we do good only to a very limited extent. We do not help in any way to maintain the upkeep of the breeding stock, and therefore do not in the slightest degree touch the question of increased food supply. We only aid the fisherman to some slight extent by keeping very small fish out of the market. We make him sell his small immature sole for a shilling instead of his minute sole for a sixpence. We do not in any way prevent this improvident person, who is, of course, working for a living against keen competition, from drawing upon his stock in trade until he has no more to sell; and since the fisherman represents the manufacturer, so far as the consumer is concerned, the process sooner or later works itself out till the fisherman disappears, and the consumer finds that he can no longer buy his sole.

A very serious difficulty which presents itself in connection with the North Sea trawling industry is, that to prevent the capture of fish till after they have spawned once, would mean the temporary elimination from the markets of a very considerable quantity of certain species, and a corresponding reduction in the incomes of the fishermen or fishing companies, who can already ill afford to submit to such a process.

Mr. Holt, in his "Remedial Measures" at the end of his paper on *The Destruction of Immature Fish in the North Sea*, deals with this important question, and I would call the attention of those interested in the North Sea investigations to this section.

Taking up the advisability of preventing the sale or having possession of flat-fish under a certain size, he advocates the adoption of the biological standard (that of sexual maturity) for turbot, brill, and sole; but is able from a careful study of the eastern grounds on which the small fishes are mostly found, and the sizes above which the fishes in those localities do not appear to be captured, to suggest a way of escape from the difficulty which has ever been present since it was found that, in the North Sea, plaice were of good marketable size before they spawned.

Speaking of the Fishery Conference of last February, he says that if the "limit of eleven inches for plaice were enforced, there would still be enough saleable fish left to make the grounds worth visiting; whereas if it were raised to fifteen or even fourteen inches, the grounds would assuredly be left alone."

To prevent the capture of plaice under eighteen inches (the size at which this species is found to spawn in the North Sea) would mean the practical prohibition of the fishery. This proposition of Mr. Holt's seems to me, therefore, to be of very decided value, since, while sticking to the same system, it compromises the one great practical difficulty.

The Sea Fishery District Committee of Cornwall, like the Committee for Lancashire, has recently been considering a measure for the limitation of the sizes under which fish may be taken in their territorial waters. It is a fortunate circumstance that in this case, and on the south-west coast generally, flat-fishes when spawning for the first time are of a very much smaller size than is the case in the North Sea, because the average sizes of the fish taken are very much less. The whole rate of growth appears to be slower.

At the British Association meetings held this year in Edinburgh, a discussion on the Application of Biological Science to Fisheries was arranged for. Mr. Holt, being the member of the staff engaged in our most important fishery investigation, was sent to take part in the proceedings.

In the course of the discussion the possibility of concentrating scientific power from various important points of the United Kingdom, and the great benefit which would be derived from one central and controlling department of the Government, was commented upon. England especially is in want of some organising body, by which the scientific knowledge already acquired concerning her fisheries may be applied for the protection and improvement of the industry. The fisheries of England are surely not less important than those of Scotland or Ireland, and should not be left to take care of themselves. The outcry on every side that our fisheries are being depleted ought to make us investigate the cause and apply the remedy. Unofficial bodies, who have to rely on private support or Government subsidy, should not be expected to make fishery investigations of national importance on the chance that the legislative machinery of the Government can be brought into action. England has her Worshipful Company of Fishmongers, her National Sea Fisheries Protection Association, and the investigating body for which I have the honour to act as Director. Fishery Conferences are held and resolutions passed; but the misfortune is that these resolutions are not passed by a body with power to legislate, nor can they be placed before a body whose special function it is to investigate their importance on behalf of the Government.

Yet we must continue our investigations and acquire more and more knowledge, so that if at some future period the suggestion thrown out at the British Association meetings be realised, we may be found ready at once to supply the scientific data necessary for the production of thoroughly sound fishery legislation.

W. L. CALDERWOOD.

A Contribution to our Knowledge of the Ovary and Intra-ovarian Egg in Teleosteans.

By

W. L. Calderwood,
Director of the Laboratory of the Marine Biological Association.

With Plates XI and XII.

THE reproductive organs of Teleosteans have been studied by many writers. All observations, however, appear to be either on the organ as seen at only one season of the year, or on the early maturation of the ovum and development of the embryo. I do not in this paper concern myself with the primitive development of the ovary, or the subsequent growth of the permanent ova from the primitive ova or sexual cells of the embryo (1). My attention is rather centred on the adult and mature organ in its various conditions of sexual activity or repose.

I have preserved and sectioned a series of ripening ovaries, and have also turned my attention to the spent organ, and the manner in which it again reaches the condition of what is sometimes known as sexual inactivity; in this way completing what I may call the adult ovarian cycle.

I have examined the ovaries of the following species:—*Pleuronectes limanda, Trigla lyra, Trigla limanda, Labrax lupus, Lophius piscatorius, Clupea finta, Ammodytes tobianes, Gadus æglifinus, Solea vulgaris, Conger vulgaris,* and *Merluccius vulgaris.*

My most complete series of sections are of the ovaries of the common dab (*Pleuronectes limanda*) and hake (*Merluccius vulgaris*), forms readily procurable at Plymouth. The main results of this paper are, therefore, drawn from the examination of these species, sections from the ovaries of the others being used for comparison.

Since the ovary is modified to suit the requirements of the ova, and affected according as the principal ova are ripe or unripe, it will be convenient to consider the ova first.

THE OVA.—*General.*

All writers on the intra-ovarian condition observe large and small eggs in ovaries of fishes which are in any way approaching ripeness.

Scharff (**2**) treats in one chapter on the small ova, in another on the large.

My observations incline me to consider that three conditions must be noticed for fishes, as has been done in the case of batrachians, since it seems more than probable that, in all ripening ovaries, ova for three consecutive spawning periods are present. I therefore propose to treat of the ova under the names of great, small, and minute.

The condition is very well seen in sections from the unripe ovary of a haddock, where the *small* ova are about the size of the nuclei of the *great*, and the *minute* are gathered together in clusters, and are individually by no means so large as the nuclei of the small ova.

So far as I can ascertain, the organ in its flaccid or spent condition has not been previously investigated. Very considerable difficulty has been experienced in obtaining good preservations of spent ovaries, the semi-fluid contents and general disintegration of parts rendering very great care necessary. By removing the organ *in situ* into the fixing reagents it has, however, been possible to obtain sections showing what I believe to be accurate representations of the organ in this condition.

Scharff, in his paper already referred to (**2**), described the smallest ova in the haddock (*Gadus æglifinus*), and what he terms the next stage in the gurnard (*Trigla gurnardus*). These two stages, so far as I can determine, are not stages in the development of one season's eggs, but represent ova which will be extruded at two distinct spawning periods. The larger eggs of his second stage represent, in fact, the formation of great ova at the completion of a spawning season.

The material collected for his excellent paper was preserved in the summer, the only time when this condition can be seen.

I am also led to this conclusion by his description of the eggs themselves.

They show a circular division of the protoplasm into two distinct zones, the inner of the two surrounding the nucleus being more granular, and in section much more darkly stained than the outer; while the nucleus has its membrane, chromatic substance, and nucleoli. When the ova are in this condition the ovary is in process of being reconstructed. With the process of spawning the lamellæ have been ruptured and the stroma scattered. With the inward growth of the supporting tissue which will be treated of later, the eggs which are at a future period to follow those which have already been extruded are being collected into new lamellæ. The flaccid and utterly empty condition of the ovary, as seen in the sections of the spent organ, has to be overcome. By means of a fairly complete series of slides I have been able to follow through this stage, and conclude that this condition of protoplasmic separation in the ovum has a significance not so much connected with the development of the ovum itself as with the building up of the trabeculæ of the ovary.

A circular separation of the protoplasm in the egg of fishes has been noticed by Eimer (**3**) as far back as 1872, and a similar arrangement has been commented upon in reptiles, molluscs, and insects by other authors. To account for it various suggestions have been made. The dark ring must either take its peculiar property from some outside tissue, or stain darkly because it has received matter from the nucleus. Will, in treating of Orthoptera, (**4**) describes the disappearance of the nuclear membrane and the migration of nucleoli to the surface of the ovum, forming in this way a follicular epithelium. Scharff also (loc. cit.) notices the presence of a few nucleoli outside the nuclear membrane of *Gadus virens*, and assigns the peculiar property of this darkly stained layer to the presence of nuclear substance.

The clear protoplasmic portion seems to have attracted less attention, and to be generally considered as the normal unchanged protoplasm of the egg. So far as I know, the ultimate history of the clear and dark layers has not been traced to its issue.

In sections treated in the usual way the dark portion often becomes rather opaque for good observation, the staining having a distinct resemblance to that seen in the colouring of nucleoli. Nevertheless at this particular stage I have not, in the common dab, been able to detect the presence of nucleoli outside the nuclear membrane, although those bodies have been sufficiently apparent in this position at other stages. Scharff says that he saw these nucleoli occasionally in the dark layer, but never, except in the case of *Hippoglossoides,* at the surface of the egg. The explanation may probably be that in different species the nucleoli are given off at different times, and that in the case of the common dab this process takes place previous to the differentiation of the areas. I find that the light protoplasm soon splits off from the dark.

Fig. 1 shows this process. The egg seems to increase rapidly in circumference, owing to the extension of the light protoplasm alone, while the dark protoplasm and nucleus remain as before. A condition is presently reached where this extension causes the light to separate from the dark, so that a cavity is formed around the dark centre with its contained nucleus, *i. e.* around what must now be considered as a complete ovum in itself. The light protoplasm then appears to diminish in extent until only a margin is left inside of what was the old investing membrane.

The cast-off membranes of neighbouring eggs coming in contact with each other, and the light protoplasm being almost completely absorbed, the appearance becomes that of trabeculæ. The contained spaces are occupied by the ova, and the interstices become filled up by fresh ova of a small size, formed from epithelial cells in a manner to be described at a later stage.

I. *The Great Ova, or those which are to be extruded at the first spawning period.*

In the ovary of a common dab which is approaching ripeness (fig. 2) the large ova are well marked. The zona radiata has thickened, and the protoplasm of the egg shows a distinctly reticulated structure. The nuclear membrane has disappeared, the nucleus now appearing as a clear area, either surrounded by or scattered over with the numerous nucleoli, occupying an eccentric position in the ovum.

The nucleoli are much more circular in shape than is the case in eggs of an earlier stage, and when they are arranged round the periphery of the clear area there are numerous very minute bodies of exactly the same appearance to be found in the area itself. These minute bodies must also be considered as nucleoli, for from an examination with a very high power I find that they are budded off from the large nucleoli at the margin of the clear area, and then travel inwards towards the centre. Fig. 3 is drawn from an ovum in the same section as is represented by fig. 2, and sufficiently represents the appearance indicated. These small bodies, by enlarging, form another condition of the nucleus seen at this stage. The parent nucleoli seem to give off many buds in this way, until, having lost much of their old constitution, they stain feebly, and are difficult to distinguish from the coarser granules of surrounding protoplasm.

There is, therefore, among Teleosteans a more or less distinct congregation of nucleoli in the centre of the degenerating nucleus, similar to that described by Iwakawa (5) in the egg of *Triton* at a different stage. This author concludes that the nucleoli, or, as he terms them, the "germinal dots," move to the centre and divide up.

I am inclined to think that in the case of Teleosteans the greatest amount of division takes place at the surface of the nucleus, and that many of the parent nucleoli afterwards become absorbed in the encroaching protoplasm. In this case the darkly stained protoplasmic ring spoken of above is in part explained.

The vacuolated condition present in the nucleoli of *Triton* during their division, and also described by O. Hertwig (**6**) in the egg of *Hæmopsis* and *Rana,* and by V. la Valette St. George (**7**) in the egg of *Libellula,* is not present; nor is there any concentration of these division products into a mass in the centre of the nucleus. A vesicular condition, however, which might be mistaken for vacuolation, appears, and is described below in the case of the conger.

The surrounding protoplasm continues to encroach on the space of the former nucleus, and the central nucleoli appear to be ultimately enveloped in this condition. They then correspond to the permanent nucleus of the ripe ovum as described by Hertwig in *Toxopneustes.*

In the ovary which is quite unripe, in distinguishing the three generations of eggs, many intermediate stages leading from the one to the other are at the same time noticeable. The largest of the eggs in the common dab of this stage do not measure more than four fifths of a millimetre. The nucleus of these eggs has a distinct membrane, and the nucleoli are arranged in contact with its inner surface, so that in section they appear in a ring inside the membrane—the usual appearance of nucleoli in fish eggs. The ova at this stage do not present so marked a contrast as they do later, the proportions between the sizes being less.

The ovary of the common dab may be found in this unripe condition all through the autumn and winter months; it is, therefore, the condition which has been often noticed. About two months before spawning takes place the great ova, which will be ripe for the first spawning season, show signs of rapid enlargement, and in a comparatively short time assume the appearance seen in fig. 2, already described.

I have made no direct observations on the origin of the micropyle, and will pass over the egg in the ripe extruded condition. It has been noticed (**8**) on more than one occasion along with the ova of other Pleuronectids (**9**).

I shall rather take up the consideration of the ovary after the act of spawning. Great ova are then still present in limited numbers. I have counted the number visible in several transverse sections, and find that there are from ten to fifteen seen in each section. It is well known that in many Teleosteans all the eggs are not shed at once, but are rather got rid of a few at a time, brief intervals occurring between each extrusion. In sections of spent ovaries the first thing which strikes one is that the remaining great ova are in many cases provided with a complete nucleus with its surrounding membrane, and nucleoli arranged round the periphery, just as is seen in the egg before it is ripe.*

The majority of the ova, however, either show the after condition in which the nuclear membrane has vanished and the nucleoli are collected towards the centre, or they are in the condition of having no nuclei at all, and are advanced in the process of disintegration. When in this last condition they present a vacuoled and atrophied appearance, seen in fig. 4, where an ovum with nucleoli still present, although the outer protoplasm of the egg is beginning to show signs of decay, is also seen. The eggs still presenting the nucleated appearance are a few which, in my estimation, have never become quite ripe; and, from the appearance of the ovary before spawning takes place, I am inclined to think that a few must be extruded in this condition. One does, in fact, generally notice that when fertilizing by artificial means a quantity of spawn, there are some which seem impervious to the action of the spermatozoa.

The eggs left in the spent ovary become opaque, and can readily be noticed in the fresh organ on this account. They are present for a considerable time after spawning is over.

The small nucleoli, budded off in the manner already mentioned, eventually appear to become free in the loose débris of the spent organ by the total disintegration of the protoplasm around them. The progressive history of the *nucleoli* can be seen very well in the conger, because these bodies are of specially large size. In studying this form the usual appearance is seen to be granular, but in some instances the granules are arranged in the form of a circle placed eccentrically, as seen in fig. 5. As the egg approaches ripeness, however, I find some interesting appearances. While the nucleus has yet a distinct membrane, and the nucleoli are oval in outline—the long axis being placed in a radial manner—a clear highly refracting band appears across the short axis. This band becomes spherical, and increases in size till the granular substance of the nucleoli is collected only at the two poles. I notice, however, that the inner pole has always more granular matter than the outer. These vesicular bodies have a distinct double contour, and are of a somewhat smoky colour even in stained sections. Their growth is towards the nuclear membrane, and eventually, when this

* In one instance I observed that a large nucleolus was about to give off four small circular nucleoli, showing that the progressive development had not yet ceased.

membrane begins to disappear, they burst through, forcing in each case a small amount of nucleolar substance in front of them—the outer pole of the nucleolus. They then take up a position amongst the surrounding yolk-spheres. The nucleolar portion which is thrown off does not assume any definite shape, but rather becomes loosely interspersed amongst the yolk-spheres. It still stains readily. Unfortunately, up to the present date no observer has been able to obtain the ripe egg of the conger. I am on this account unable to make any definite statement as to what becomes of the vesicles just described. I can only throw out the suggestion that there is probably some connection between these vesicles and the oil-globules. The supposition is based simply on the striking resemblance which the vesicles have to oil-globules, and on the absence of any theory which accounts for the existence of the globules in any other way.

Scharff (loc. cit.) mentions clear vesicles with granular nucleolar contents as being budded off in *Trigla*, but supposes that the vesicles are formed in the nuclear substance itself. The ovum of *Trigla* has a large oil-globule, or it may be two or three small ones (the last case being rare). Should the vesicles described by Scharff prove to be analogous to those I have just described, a still greater probability will be given to my suggestion. Personally I am inclined to think that the vesicles are analogous, although not noticed by Scharff as coming from the nucleoli. I have not met with any other products of the nucleoli, such as the tubular prolongations described by Balbiani (**10**) in *Geophilus*. When the nuclear membrane has disappeared the nucleoli have given off so many of these spheres, and have themselves taken up a position so far back from where the nuclear membrane originally was—partly, no doubt, on account of their outer poles having been carried away—that the space of the nucleus has become small and irregular. Since, as I have already said, it is extremely difficult to procure a ripe conger, I have not in this species been able to follow through the so-called disappearance of the nucleus.

II. *The Small Ova.*

In fig. 4, which has already been referred to, the three classes of ova are distinctly seen.

To study the small ova from their very commencement, one should begin at the point where the *small* ova are for the first time distinguishable from the *minute, i. e.* when the ovary is in a quite unripe condition, a year and a half probably before the small ova will be extruded; but since the small ova show no change till the time when the great ova have to be discharged, the early period may be passed over.

My account of the small ova, therefore, simply becomes one of their transformation into great ova at the time when the latter are extruded.

In the spent ovary, then, where a few great ova still remain, the small ova of the past year are seen to present two distinct appearances ; one that of fig. 4, the normal, and another a much-vacuoled condition, seen in fig. 7. In both I find signs that the ova do at this stage divide. I have chosen figs. 7 and 8 to represent this, both being taken from the same section. There is a considerable amount of variation in the sizes of the eggs of each condition, but from a series of careful measurements I do not distinguish any difference between the average sizes of sufficient importance to be worthy of mention as of significance. It will be noticed from the figures that the non-vacuoled ova have the nucleus with its nucleoli present in the ordinary position, whereas in the vacuoled eggs the nuclear membrane has no nucleoli in connection with its inner surface. I have examined a large number of slides showing ova in this condition, but only on one occasion have I found a slight trace of nucleoli. They appear in the normal position, but are extremely small in size, and have apparently atrophied. In a few eggs, which show what I may perhaps describe as an inclination to become vacuoled, the nuclei are already considerably reduced. I further notice that for the most part the vacuoled eggs lie at the surface of the ovary, the normal or fully nucleated eggs being towards the centre in the vicinity of the germinal epithelium. I am convinced that the vacuoled eggs break up simultaneously with the few remaining great ova. There is probably a double significance of this curious condition. The fact that a limited number of great, and very many small eggs should break up at the same time may go to show that the old eggs are not present in the spent ovary, simply because they could not be extruded, but because they may be useful as pabulum, and that there are a superabundance of small eggs formed from the epithelium at an early stage. It is somewhat difficult to estimate with any degree of accuracy the number of eggs present in an unripe section, although in the case of the riper organ there may be less difficulty. Numbers no doubt vary in different individuals ; but it seems probable that even with the great enlargement of the organ and the filling up of the central cavity in ripening ovaries there is not room enough, after the great eggs are gone, for a sufficient number of new developing minute ova. At this stage, at any rate, the débris of the organ is added to by the breaking up of a certain number of the ova under consideration, and I take it that the products must either be used for the nourishment of the coming stroma, or are gradually got rid of by extrusion. In the normal eggs of this stage the nucleoli are few in number but large in size. Whenever the nucleoli atrophy and disappear there is no prospect of the egg ever coming to maturity. Without nucleoli it cannot even form its dark ring of protoplasm. It seems to me that under these circumstances I cannot agree with Scharff and Will, who unite in attaching no morphological significance to the nucleoli.

It is true, as the former says, that they are sometimes present and sometimes entirely absent, but I have never found any evidence to show that without nucleoli ova of Teleosts can ripen. I am, in fact, inclined to regard the nucleoli as of the highest importance, the fountain-head of the entire system.

III. *The Minute Ova.*

The only point of interest in studying the minute ova is their origin, since their average condition is one of inactivity.

After spawning, the enveloping membrane of the ovary sends out fibrous prolongations in an irregular manner towards the centre of the organ. These form leading lines of support in the loose arrangement of the ova. As offshoots from these the supports of the lamellæ are formed. In different species the lamellæ run in different ways, *e. g.* longitudinally in Pleuronectids, transversely in Gadidæ, and obliquely in the mackerel. With few exceptions (Murænidæ and Salmonidæ) the inner boundary line of the lamellæ is composed of germinal epithelium.

It has been stated by Brock (11) and Kolessnikov (12) that each forming ovum is produced from one single epithelial cell. In addition to this the appearances presented in my sections lead me to believe that, in the case of the common dab at any rate, ova are also formed in another manner. I find small nests of cells, collected at intervals, inside the germinal epithelium, and from watching them am satisfied that while perhaps in the majority of instances ova are formed from single cells only, they are also formed from these nests of, it may be, ten or twelve cells. Fig. 9 shows a growing lamella at this stage, where a few of the nests are seen (*n*). They are quite separate from all other epithelial cells, and shortly begin to show a disposition to coalesce. The outlines of the individual cells disappear, and the mass, beginning to stain deeply, assumes a very dense appearance.

A collection of deeply stained bodies, very similar to the nuclei of the cells or the amalgamated nuclei, then make their appearance, and take up the position of nucleoli in what must now be called the ovum. Meanwhile there are other epithelial cells collecting in all the spaces of the ovary—often showing division. These grow round the forming ova, and ultimately form the follicle. I find no sign of a central cell in the nest, enlarging at the expense of the others, becoming itself the ovum while the rest form the follicle. These nests of epithelial cells which become ova have a singular resemblance to the nests described by Balfour (loc. cit.) for Elasmobranchs. In his description of the formation of the permanent ova several primitive ova coalesce to form nests, masses, or syncytii. These nests enlarge in size as development proceeds—explained by the probable division of nuclei without a corresponding division of the protoplasmic matrix, so that nuclei become very numerous. Some of the nuclei unite and become the nuclei of permanent ova, and are budded off with their surrounding protoplasm, which is of small amount; others again break up, and are used as pabulum for the young ova. "In many cases normal nuclei of the germinal epithelium may be observed within the ovum." The ova then become surrounded by germinal epithelium, from which the follicle is formed. If in the common dab we call the epithelial cells primitive ova, the analogy is practically complete.

My study of the *egg membranes* themselves is of course confined strictly to those of intra-ovarian ova. I may preface the few statements I have to make by explaining that I accept the term "zona radiata" as used by Balfour and some others in describing the constant and most important membrane, and find it convenient to treat of other membranes as *inside* or *outside*, according to their position with regard to that membrane. What I shall call the zona radiata is, therefore, the vitelline membrane of Waldeyer, Kölliker, and others; the egg capsule of His and Müller; and the zona pellucida of Eimer.

Cunningham (**13**) describes the almost ripe ovum in the sole when the radial striæ are very distinct. The vitelline membrane (zona radiata) described by him is considered to be the only membrane present. My examination of soles' ova inclines me to the conclusion that there is a membrane inside the zona radiata, as well as the follicular layer outside. The membrane is seen to best advantage in eggs in which some slight shrinkage of the protoplasm has taken place, and fig. 10 represents the appearance as seen in an egg of this description. Scharff figures an exactly similar condition in the egg of *Trigla*, and other authors have also described it. Kupffer, when treating on the herring, compared this structure to the true vitelline membrane. Ransom calls it the inner yolk-sac—his outer yolk-sac being the zona radiata of Balfour. On the other hand, His, Waldeyer, and Brock deny its existence.

The membrane may be the product of the vitellus, or it may be derived from the zona radiata, and it is also possible that the zona may be derived from it. The ready way in which it seems, by clinging to the yolk mass, to separate from the zona radiata, appears to favour the idea that it has no immediate relation with the latter. In this case it may be possible that, in those species in which the membrane is present, no pabulum can be supplied to the ovum from the follicular layer through the supposed radial pores. I cannot prove the origin of this structure, and therefore hesitate to give it the name of vitelline membrane. It has a very distinct double contour, and appears to be proof against stain.

What becomes of it when the ovum is shed and comes in contact with the water I am, unfortunately, unable to say. Its relation to the perivitelline space would be a point of some interest; and further, if this space contains albumen, as stated some time ago by Raffaele, and not water which has gained access through the micropyle or radial canals, a somewhat important function might be found for it.

In none of my sections do I find a membrane outside of the zona radiata. The follicular layer is often irregular in its composition, and sometimes cloudy in appearance, and a distinction between it and any outer layer of the zona radiata, therefore, would be difficult. I am inclined to think, however, that an outside membrane of this kind must occur in very few species (**14**). Brook (**15**) describes a vitelline membrane outside of the zone radiata in *Trachinus vipera*, and Balfour (**16**) notes one in the herring and describes an imperfect one in the perch, but so far as I know these are the only instances.

IV. *The Ovary.*

In treating of the whole organ I do not intend that my remarks should apply to the ovaries which, according to Jules MacLeod (**17**), constitute "la première forme"—the ovaries of Salmonidæ and Murænidæ, where the ova are dropped into the abdominal cavity, and find their way to the exterior by abdominal pores. In the case of these fishes the arrangement of the ovary is, to a certain extent, reversed, the germinal epithelium being free, and not enclosed, so as to form a tube, by a surrounding membrane.

Although I have described the nucleoli of the conger's egg, I shall therefore not touch on its ovary, but must refer the reader to the account given by Cunningham (**18**). I shall confine my remarks to the ovaries of those fishes in which the epithelium is enclosed by a surrounding membrane, and the eggs, becoming free in the centre of the organ, are extruded through an oviduct.

The ovary is usually described as a tubular structure, and in the unripe condition it is so; but as development of the ova proceeds, the lumen becomes more and more closed by the extension of the lamellæ towards the centre of the organ.

At the time when a section shows an appearance similar to that shown in fig. 2 the lumen disappears, and the lamellæ become indistinguishable on account of their closely packed and fused condition. Ultimately, by the thinning out and rupture of the epithelium, the almost ripe ova lie free in the organ, ready for extrusion.

The outer wall consists of fibrous tissue, which assumes different appearances according to the sexual condition of the ova. The fibres run, for the most part, in a longitudinal direction, and are therefore seen best in longitudinal sections. The outer fasciuli, however, frequently bend until they lie transversely. From the main membrane, offshoots spring towards the interior of the organ. These pass off in a curved manner, similar to the spokes of an iris diaphragm, although by no means so regularly.

The offshoots form the leading divisions of the internal arrangement, and on their branching afford support to the lamellæ in much the same way as veins do in the leaves of plants.

In what we may describe as the resting stage in the common dab—for I certainly believe that a condition of this sort obtains —when after spawning the ovary has been made up with quite unripe eggs, the outer wall has a thickness of about ·9 mm.

In following the various conditions of the ovary we find that the condition of its outer wall fluctuates in a rather singular manner, that in the cycle from one resting stage to another it thickens twice, and thins again twice. From the ·9 mm. thickness it gradually grows until, when the ova are what has been described as half ripe (fig. 2), (when the lumen of the ovary disappears) it reaches the thickness of from ·19 to ·20 mm. This is its maximum thickness in the purely laminated fibrous condition. The organ now increases rapidly in size, and as it does so the outer wall decreases in thickness, the fibrous composition being less and less evident as this goes on. When the ova are ripe the thickness is only from ·2 to ·3 mm. in the common dab.

Whenever the process of spawning releases the pressure, the wall rapidly thickens again, and when spawning is completed and the organ is in its flaccid condition, a distinct division into an outer and an inner layer is noticeable. The outer is still the normal fibrous envelope, but the inner coat becomes highly modified. Numerous nuclei make their appearance (fig. 11), and increasing by a process of division, first of all form thickened masses, and then by the bursting of the inner membrane are poured out, and form irregular masses amongst the vacuoled eggs at the periphery of the ovary.

It is to be noticed, however, that the thickened masses occur round the inner surface of the membrane only at intervals, and that the modified inner portion becomes decidedly thin at the other parts. One of the thickened masses is seen in fig. 12, the total thickness in this case being ·25 mm. Following the progress of the masses, we find that the cells thus added to the stroma continue for some time to keep together, and that those on the inner margin continue to divide rapidly, extending inwards amongst the loosely arranged ova. They often give off chains of cells which follow separate directions, twine round ova, and extend until they eventually reach the germinal epithelium. We find, in short, that the whole supporting structure of the ovary has been laid down.

These chains of cells then begin to flatten, they stain more and more deeply, the nuclei become less distinct, and the appearance becomes once more that of ordinary fibrous connective tissue.

The spaces between the fasciculi of fibrous tissue are generally considered to contain albuminous matter, and therefore with the rupture of these cells from the ovarian membrane an albuminous substance would at the same time be given to the ovary. Such a substance has been described as being present in the ovaries of Teleosts, its function being considered to be that of a lubricant, useful in allowing the eggs to be readily extruded at the spawning period. The origin of this substance may be explained in this way.

In treating on the great ova in the common dab I have stated that the quite unripe condition persists all through the autumn and winter months, that the ovary is then in a resting or inactive condition.

I am not prepared to consider this statement as applicable to all Teleosts, because in some cases, if a resting period does occur, it must be a short one. I am not even prepared to say that all Pleuronectids have a distinct resting period, because the reproductive organs of this genus, as of others, show a considerable diversity of arrangement, and the spawning periods are often widely apart. Still the condition seems also to obtain in round fishes, since I find it in the hake. A circumstance which may affect the condition very decidedly is the extent of time taken by any one species in getting rid of all its spawn. If the intervals between the expulsion of successive batches of ova are prolonged, then it follows that the anterior part of the ovary is very much later in getting into its resting condition, and that by the time it has done so a progressive change may have already set in at the periphery of the posterior or early part of the organ.

The Plaice, for instance, has a spawning period which extends over a very considerable length of time, and it also sheds a large number of eggs in each batch—an interesting provision, by which a fish possessing somewhat bulky eggs can nevertheless extrude an unusually large number, since when all the eggs of the various batches have escaped, many more have swelled to maturity than could possibly have been contained in the ovary if all had to be shed at once, or the batches soon after one another. It seems to me, therefore, that with this condition a resting period must of necessity be at any rate much shorter than in the condition where batches of ova are rapidly extruded one after the other, until all are gone.

I should, therefore, expect that in all Salmonidæ, and fish which get rid of all their eggs at once, a long resting period was invariable. The common dab certainly does not get rid of all its eggs at once, yet has a long resting period; and if similar conditions bring about similar results in other groups, I can have no hesitation in saying that I believe a resting period is usual in Teleosts.

It may appear that I lay too much stress on this point, but with the diversity of systems of extruding the eggs, the long period during which spawning goes on, and the presence of eggs of more than one generation in the ovary, a resting period has appeared to some to be improbable.

Whenever the ova escape and the pressure on the ovary is relieved, the fibrous walls contract rapidly; and as the organ becomes empty, so it is drawn together from every point. The majority of fibres were seen to run longitudinally; the significance of this now appears, since the greatest reduction in size takes place in the long axis of the organ.

From the very greatest distension the ovary is speedily reduced to a size *almost* as small as that seen in the immature condition, the walls being then at their very thickest.

It was my original intention, in treating of the ovary, to compare the immature organ of the young fish with the resting or inactive condition in the adult; being of opinion that a decided difference could be demonstrated—a point of very decided importance. I have, however, decided against taking the matter up in this paper, since, if the subject is treated from a practical fishery point of view, the results can be more forcibly applied to that branch of work, on which it has the most important bearing.

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Plate XI.

Fig. 1.

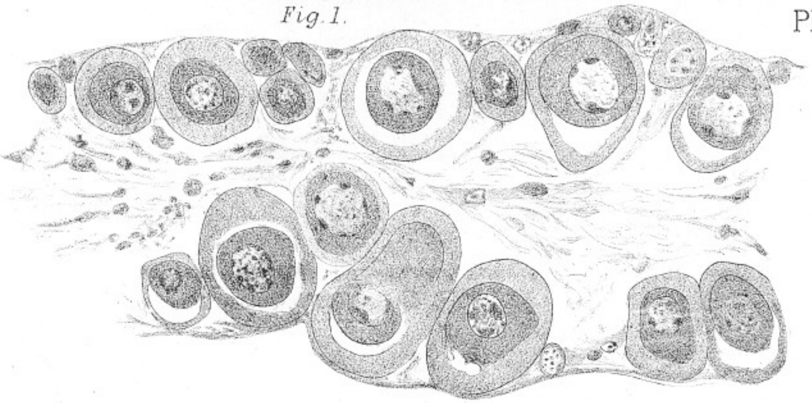


Fig. 2.

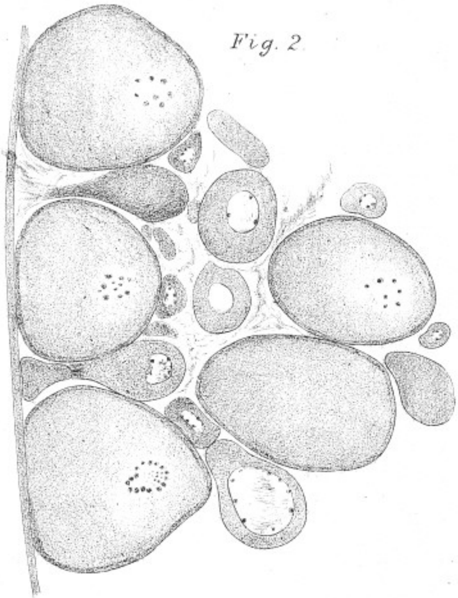


Fig. 3.

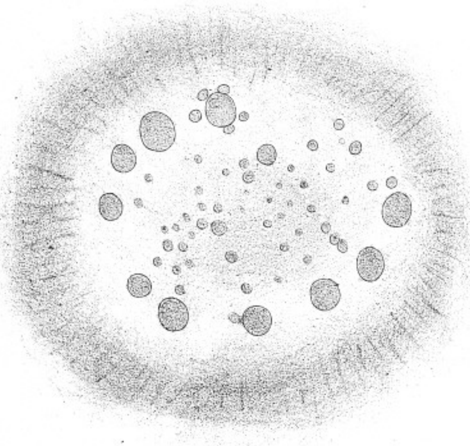


Fig. 4.

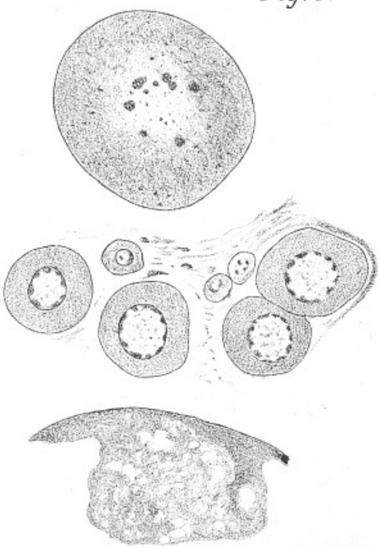
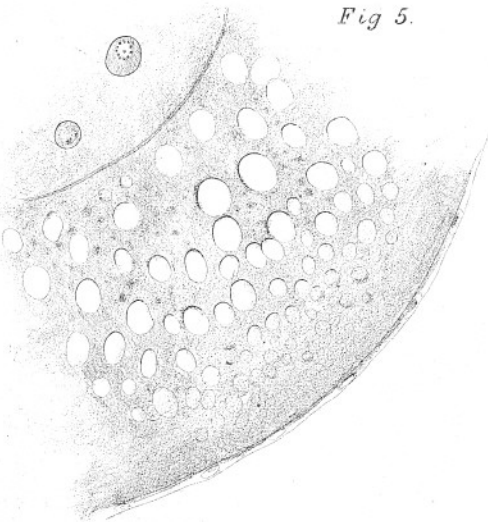


Fig 5.



W. T. C. DEL AD NAT.

J.E.W.

Plate XII.

Fig. 6.

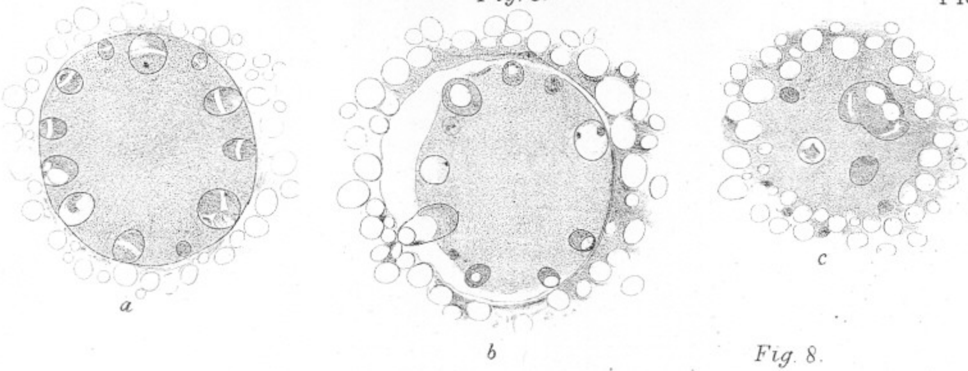


Fig. 7.

Fig. 8.

Fig. 9.

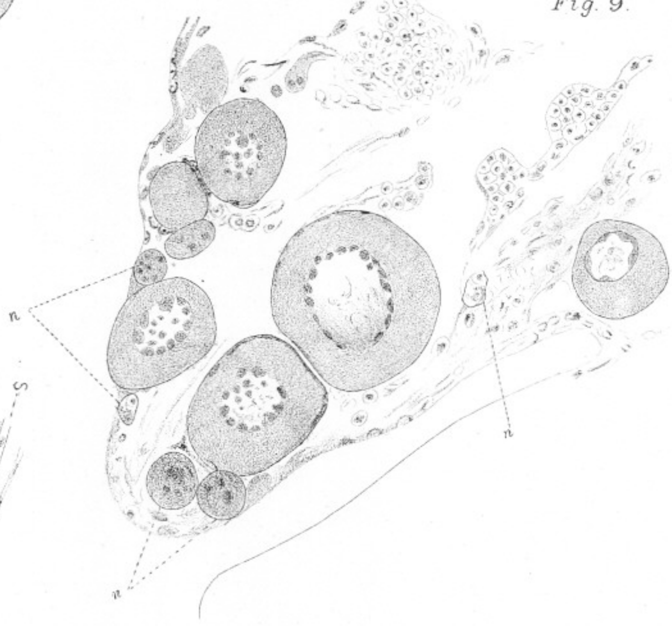


Fig. 10.

Fig. 11.

Fig. 12.

W. T. C. DEL AD NAT. J.E.W.

DESCRIPTION OF PLATES XI AND XII.

Illustrating Mr. Calderwood's paper on "A Contribution to our Knowledge of the Ovary and Intra-ovarian Egg in Teleosteans."

PLATE XI.

FIG. 1.—Forming lamella of common dab, showing the ova separated into darkly stained and light zones, and the subsequent splitting of the light zone from the dark. Young ova developing from epithelial cells are seen filling up the remaining spaces of the lamella. Zeiss D, oc. 2.

FIG. 2.—Transverse section of ovary of common dab becoming ripe, showing the three sizes of ova, the great having no nuclear membrane, and the rapidly thinning ovarian wall. Zeiss CC, oc. 2.

FIG. 3.—Highly magnified nucleus of egg taken from same section as Fig. 2, showing absence of nuclear membrane and budding nucleoli. Zeiss F cor., oc. 4.

FIG. 4.—Portion of section from spent ovary of common dab, showing the three sizes of ova, large egg still with nucleoli although zona radiata disappeared; also portion of egg in advanced state of disintegration.

FIG. 5.—Transverse section of intra-ovarian ovum of conger becoming ripe. Nucleoli with circular arrangement of granules.

PLATE XII.

FIG. 6, *a*, *b*, *c*.—Three successive stages in the development of nucleus in ripening conger. *a*. Nuclear membrane distinct; nucleoli arranged regularly, numerous, showing clear bands across short axis. *b*. Showing ultimate development of clear bands into vesicles, which are expelled from the nucleoli, and merge with the yolk-spherules. *c*. Nuclear membrane gone; protoplasm encroaching on former space of nucleus; nucleoli few; vesicles still forming; nucleolar matter seen outside area. Zeiss F cor., oc. 2.

FIG. 7.—Vacuoled small ova without nucleoli dividing, taken from margin of longitudinal section of spent ovary of common dab. Zeiss F cor., oc. 2.

FIG. 8.—From same section as Fig. 7. Ovum from centre of spent ovary of common dab. Nucleoli present; ovum showing signs of division. Zeiss F cor., oc. 2.

FIG. 9.—A longitudinal section of lamella of ovary from common dab in process of being built up after spawning. It is a later condition than that seen in Fig. 4. The germinal epithelium is rapidly forming minute ova, and the follicular layer of the larger eggs is also appearing. The small masses of epithelial cells also forming minute ova are seen in various stages of development at *n*.

FIG. 10.—Section showing the egg-membranes in the almost ripe ovum of the sole. S = follicular layer. Z = zona radiata. X = the inner membrane described by Kupffer as the vitelline membrane.

FIG. 11.—Inner surface of fibrous envelope of spent ovary, showing the first appearance of the connective-tissue cells. Zeiss F cor., oc. 2.

FIG. 12.—Later stage in the development of connective-tissue cells on the inner surface of ovarian envelope, showing a collection of the cells into a mass previous to their separation from the fibrous portion of the wall. Zeiss D, oc. 2.

Note on a Large Squid (Ommastrephes pteropus, Stp.).

By

E. S. Goodrich, F.L.S.,

Assistant to the Linacre Professor of Human and Comparative Anatomy, Oxford.

On the 6th of January, 1892, Dr. Elliot of Kingsbridge most generously presented to the Marine Biological Association a large and interesting Cephalopod which was captured off Salcombe.

Dr. Elliot brought the squid to the Plymouth Laboratory, and it was subsequently purchased for the Oxford Museum by Prof. Ray Lankester, who requested me to identify it, giving me much kind help, for which I wish to express my sincere thanks.

The specimen in question, which I find to be a female *Ommastrephes pteropus*, Stp. (*Sthenoteuthis pteropus*, Verr.), is in very fair condition, having been preserved in chromic acid and in alcohol. The left eye is unfortunately missing, and the lateral membranes of the arms and lining of the siphon pit are somewhat torn. The principal measurements, which can only be approximate owing to the shrinking during preservation, are as follows :—Length from the extremity of the body to the edge of the mantle, dorsally, 51 cm.; length from the extremity of the body to the edge of the mantle, along the postero-ventral surface, 50 cm.; length from the extremity of the body to the level of the mouth, 66 cm. The edge of the mantle is nearly straight along its postero-ventral border, and is produced to a slight point dorsally at the end of the nuchal cartilage, as figured by Steenstrup (**3**, p. 146, fig. 3). The large "caudal fins" are transversely rhomboidal, as described and figured by Verrill (**5**, p. 229, and Pl. LIV, fig. 2 *a*). The breadth across the two is 40 cm.; they each measure 27 cm. along the posterior free edge, and 23 cm. along the dorsal line of attachment. The dorsal or first pair of sessile arms is 23 cm. long, and trapezoidal in section. The second pair is 28 cm. long, with a keel and a small lateral membrane, whose maximum width is about 1·5 cm., on the ventral border. The third or lateral pair of arms (Fig. 1) is 28·5 cm. in length; on the outer surface is a large keel, broadest

FIG. 1.

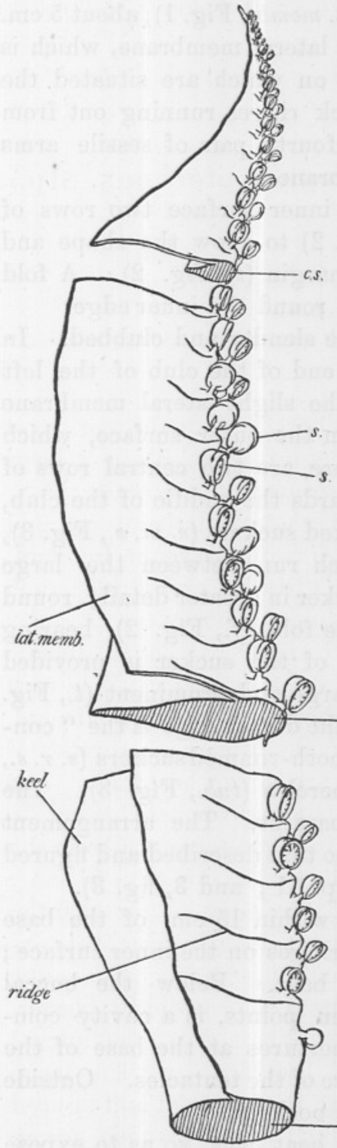


FIG. 2.

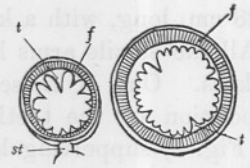


FIG. 3.

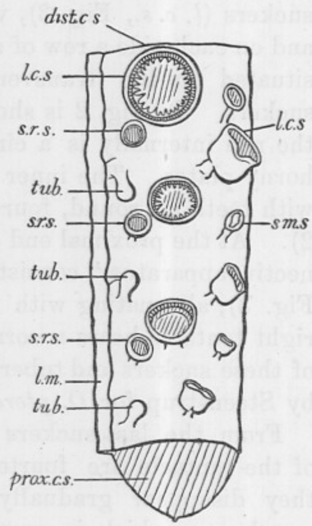


FIG. 1.—Posterior view of the third (left) arm. *Lat. memb.*, lateral membrane; *s.*, sucker; *c. s.*, cut surface. The arm is drawn diagrammatically, as if cut into three pieces.

FIG. 2.—On the left, figure of one of the suckers of the sessile arms. On the right, figure of one of the large suckers of the club of the left tentacle. *st.*, stalk or peduncle; *f.*, circular fold bearing horny plates; *t.*, teeth of horny margin.

FIG. 3.—View of the proximal part of the left tentacular club, diagrammatically drawn as if cut off. *Dist.c.s.*, distal cut surface; *prox.c.s.*, proximal cut surface; *l.c.s.*, large central sucker; *sm.s.*, small sucker; *s.r.s.*, smooth-rimmed sucker; *tub.*, tubercle; *l.m.*, lateral membrane.

below the middle of the arm. Along the postero-ventral edge of this arm extends a broad membrane (*Lat. memb.*, Fig. 1), about 5 cm. wide near the middle of the arm. This lateral membrane, which is formed by the extension of the platform on which are situated the suckers of the arm, is supported by thick ridges running out from between the suckers. The ventral or fourth pair of sessile arms is 28 cm. long, with a keel but no membrane.

All the sessile arms have along their inner surface two rows of suckers. One of these is figured (Fig. 2) to show the shape and disposition of the teeth of the horny margin (*t*, Fig. 2). A fold (*f*, Fig. 2) supporting horny plates runs round the inner edge.

The tentacular arms, 64 cm. long, are slender and clubbed. In Fig. 3 I have represented the proximal end of the club of the left tentacle as if cut off, in order to show the slight lateral membrane on the dorsal edge, and the small keel on the outer surface, which is more prominent towards the tip. There are two central rows of suckers (*l. c. s.*, Fig. 3), very large towards the middle of the club, and on each side a row of small long-stalked suckers (*s. m. s.*, Fig. 3), situated on the transverse ridges which run between the large suckers. In Fig. 2 is shown a large sucker in greater detail; round the rim internally is a circular shelf-like fold (*f.*, Fig. 2), bearing horny plates. The inner horny margin of the sucker is provided with teeth all round, four of which are large and prominent (*t.*, Fig. 2). At the proximal end of the club on the dorsal edge is the "connective apparatus," consisting of three smooth-rimmed suckers (*s. r. s.*, Fig. 3), alternating with three large tubercles (*tub.*, Fig. 3). The right tentacle bears a corresponding apparatus. The arrangement of these suckers and tubercles is similar to that described and figured by Steenstrup for *O. pteropus* (**2**, fig. 2, p. 81; and **3**, fig. 3).

From the last suckers on the club to within 15 cm. of the base of the tentacle are fourteen transverse ridges on the inner surface; they disappear gradually towards the base. Below the buccal membrane, which is provided with seven points, is a cavity communicating with the exterior by two apertures at the base of the dorsal arms, and two apertures at the base of the tentacles. Outside the base of the tentacles are two pits, or pockets.

The funnel is represented in Fig. 4 as bent back, so as to expose the pit in which it lies. It is retained by four bridles, two towards the middle line (*in. br.*, Fig. 4), and a thicker bridle on each side (*out. br.*, Fig. 4). Within the bases of attachment of the inner bridles are seen two apertures (*d. ap.*, Fig. 4), communicating with the cavity of the siphon above the valve.* Inside the external bridle is an aperture, perhaps artificial, communicating from the siphon pit

* I have observed these apertures in *Thysanoteuthis rhombus*.

to the cavity outside the bridle, which opens by the "ouverture anale" of D'Orbigny (1, p. 342). At the top of the siphon pit are seen folds which correspond pretty closely, but not exactly, to those figured for this species by Steenstrup (2, p. 79, fig. 1). There are

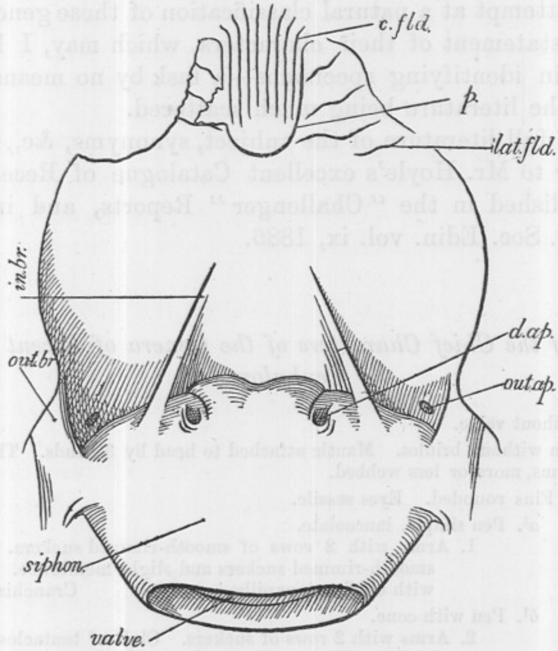


FIG. 4.—View of siphon pit, the siphon being bent down so as to expose it. *out. br.*, outer bridle; *in. br.*, inner bridle; *out. ap.*, outer aperture; *d. ap.*, aperture in dorsal or inner wall of siphon; *c. fld.*, central fold; *lat. fld.*, lateral fold; *p.*, shallow pocket or velum.

eight grooves within the central space, bounded by a U-shaped fold or velum, and four folds on either side outside it. Steenstrup figures only twelve folds in all.

The specimen before us, then, agrees with Prof. Steenstrup's species, *O. pteropus*, in size, in having very well-developed lateral membranes to the arms, a nearly straight mantle edge, numerous folds in the siphon pit, and in possessing a particular arrangement of the connective apparatus. This species, which inhabits the Atlantic, has rarely been recorded from our shores. Mr. E. A. Smith, of the British Museum, has kindly given me the following information concerning two specimens now in the Natural History Museum. One is an incomplete specimen obtained on November 19th, 1883, at Scarborough: it was 52 inches long (arms included), 25 inches in girth, and 22 inches across the fins. The second specimen is a perfect one, captured in the North Sea, February 27th,

1884. It measures from the mouth to the end of the body 39 inches; in girth 22 inches; across the fins 23 inches. The tentacles are 36 inches in length.

I have added to this note a table of the chief diagnostic characters of the well-established genera of living Oigopsid Cephalopods. It is not an attempt at a natural classification of these genera, but only a tabular statement of their characters, which may, I hope, be of some use in identifying specimens—a task by no means easy now, owing to the literature being much scattered.

For the full literature of the subject, synonyms, &c., I must refer the reader to Mr. Hoyle's excellent Catalogue of Recent Cephalopoda, published in the "Challenger" Reports, and in the Proc. Roy. Phys. Soc. Edin. vol. ix, 1886.

Table of the Chief Characters of the Genera of Recent Oigopsid Cephalopods.

A. Siphon without valve.

A. Siphon without bridles. Mantle attached to head by 3 bands. Three dorsal pairs of arms, more or less webbed.

a. Fins rounded. Eyes sessile.

a^1. Pen simple, lanceolate.

1. Arms with 2 rows of smooth-rimmed suckers. Tentacles with smooth-rimmed suckers and slight membrane. Mantle covered with chitinous papillæ. Cranchia (Leach, 1817).

b^1. Pen with cone.

2. Arms with 2 rows of suckers. Club of tentacles with 4 rows of blunt-toothed suckers, and group of suckers and tubercles forming connective apparatus. Prominent eyes. Seven lobes to buccal membrane. Taonius (Stp., 1861).
3. Arms short, with 2 rows of suckers. Tentacles absent in adult. Eyes prominent. Two rows of cartilaginous papillæ on mantle. Leachia (Les., 1821).

b. Pen lanceolate. Fins more or less angular. Eyes pedunculate.

4. Arms with 2 rows of stalked suckers. Tentacles with 2 rows of suckers along the stem and 4 on the club. Suckers all smooth. Eyes pedunculate (sessile in type species?). Fins terminal. Loligopsis (Lam., 1812). [Zygœnopsis, de Roche., 1884.]
5. Arms with 2 rows of sessile suckers. Tentacles long, with tubercles along stem. Fins triangular and subterminal. Pyrgopsis (de Roche., 1884).

B. Siphon with 2 bridles.

6. Arms with 2 rows of toothed suckers. Club of tentacle with 4 rows of toothed suckers. Siphon pit with velum. Pen with cone. Seven lobes to buccal membrane. Eye with sinus. Fins rounded. Steenstrupiola (Pfeffer, 1884).

B. Siphon with a valve.

A. Siphon without bridles.

7. Arms with 4 rows of smooth suckers. Club of tentacle with many rows of minute suckers. Small sinus. Pen feather-shaped. Suckers on the 7 lobes of buccal membrane. Fins subterminal, rounded. Bathyteuthis (Hoyle, 1885).

B. Siphon with 1 bridle (probably 2 fused).

8. Three dorsal pairs of arms, webbed. Socket I-shaped. Pen feather-shaped. Fins rounded. Histiopsis (Hoyle, 1885).

C. Siphon with 2 bridles.

a. Ear-shaped socket of mantle.

*a*¹. No sinus. Fins subterminal and rounded. Ventral arms large and with lateral membrane.

9. Arms very unequal, 2 rows of toothed suckers to first 3, and 1 row to ventral arms (?). Club of tentacle with sessile suckers and membrane, 4 rows down the stem. Spoon-shaped olfactory organ. Pen with hollow cone. Doratopsis (de Roche., 1884).

10. Arms with 2 rows of toothed suckers. Tentacles extremely long, suckers along stem, large club with long curved toothed suckers and spoon-shaped extremity. Buccal membrane with 7 lobes. Six buccal aquiferous openings. Spoon-shaped olfactory organ. Pen lanceolate. Cheiroteuthis (d'Orb., 1839).

*b*¹. Small sinus. Lateral membrane of arms very small.

11. Arms with 2 rows of nearly smooth suckers. Tentacles long and lash-like, numerous minute toothed suckers at end. Six lobes to buccal membrane. Pen narrow, with cone. Fins rhomboidal. Socket without pronounced tooth.
Mastigoteuthis (Verrill, 1881).

b. l-shaped socket (except Ancistrocheirus?)

*a*¹. Without sinus.

*a*². Fins of separate filaments.

12. First 3 pairs of arms with 4 rows of smooth suckers. Ventral arms with 2 rows, and lateral membrane. Club of tentacles with many rows of smooth suckers. Fins of muscular filaments joined only at base. (Small sinus?).
Chtenopteryx (Appelöf, 1888).

*b*². Fins rhomboidal. Pen lanceolate.

13. Arms with 2 rows of toothed suckers. Tentacles long and slender, with suckers along whole length; club with lateral membrane and numerous small suckers. Lobes of buccal membrane indistinct.
Brachioteuthis (Verrill, 1881).

*c*². Fins rounded.

*a*³. Pen with cone.

14. Arms with 2 rows of suckers, smooth proximally and toothed distally. Club of tentacle with 4 rows of smooth suckers and group with tubercles (conn. app.). Buccal membrane with 7 lobes. Pen broad, hollow, bent at tip, and with small cone. Calliteuthis (Verrill, 1880).

*b*³. Pen lanceolate.

15. Arms with 2 rows of suckers, the 3 dorsal pairs of arms joined by a web, and the ventral joined by a web. Tentacle with 6 rows of toothed suckers on club, and conn. app. extending down the stem, cluster of smooth suckers at tip. Four buccal and 2 brachial aquiferous openings. Buccal membrane with 6 lobes.
Histioteuthis (d'Orb., 1839).

*b*¹. With sinus.

*a*². Without hooks.

*a*³. Pen with cone. Nuchal crests small or absent.

16. Arms with 2 rows of toothed suckers and slight web. Club of tentacle with 4 rows of toothed suckers distally and 10 rows of smooth suckers proximally. Buccal membrane with 7 lobes. Fins rounded.
Tracheloteuthis (Stp., 1881).

17. Arms with 2 rows of toothed suckers. Club of tentacles with 4 rows of toothed suckers and lateral membrane. Conn. app. extending along the stem, cluster of smooth suckers at tip. Fins forming an arrow-head.
Architeuthis (Stp., 1856).

*b*³. Pen lanceolate. Nuchal crests.

18. Arms with 2 rows of smooth suckers. Tentacles mere stumps. Chaunoteuthis (Appelöf, 1890).

b^2. With hooks. Fins rhomboidal. Conn. app. at base of club, and generally group of suckers at tip.

a^3. Pen lanceolate.

a^4. Fins terminal. Suckers to tentacles.

19. Arms with 2 rows of hooks. Tentacles short, suckers few. Pen slender, cartilaginous. Fins somewhat rounded, terminal. Verania (Krohn, 1847).

b^4. Fins subterminal generally. Hooks to tentacles.

a^5. Hooks to arms and tentacles. Very large fins.

20. Arms with 2 rows of hooks. Tentacles with hooks on club. Fins large, along nearly whole length of mantle, subterminal. Socket ear-shaped (?). Ancistrocheirus (Gray, 1849).

b^5. Hooks and suckers to arms and tentacles.

21. Arms with 2 rows of hooks and a few suckers. Club of tentacles with hooks. Buccal membrane with 8 lobes. Fins slightly rounded. Enoploteuthis (d'Orb., 1839).

22. Arms with 1 row of hooks near base and 2 rows of suckers near tip. Club of tentacles with alternate hooks and suckers. Abralia (Gray, 1849).

b^3. Pen with cone.

a^4 Only suckers on arms in 2 rows. Hooks and suckers on tentacles. Buccal membrane with 7 lobes.

23. Arms with two rows of smooth suckers, and lateral membrane. Club of tentacle with 2 rows of hooks. Two brachial and 6 buccal aquiferous sacs. Solid cone to pen. Onychoteuthis (Licht., 1818).

24. Arms with two rows of suckers. Club of tentacles with 2 inner rows of hooks, and 2 outer of toothed suckers. Cone of pen solid at apex. Teleoteuthis (Verrill, 1882).

25. Arms with 2 rows of smooth suckers. Club of tentacles with 2 rows of hooks. Cone of pen hollow. Ancistroteuthis (Gray, 1849).

b^4. Hooks and suckers on arms in 4 rows.

26. Ventral arms with 4 rows of suckers, the other arms with 2 rows of hooks within and 2 rows of suckers without. Hooks on tentacles. Buccal membrane rounded. Pen with hollow cone. Fins reach beyond tip of body. Gonatus (Gray, 1849).

c. Socket with large tooth or process.

27. Arms with 2 rows of toothed suckers and lateral membrane. Club with 4 rows of toothed suckers and conn. app. extending along the stem. Sinus. Two apertures at back of siphon. Pen lanceolate. Long fins along whole length of the mantle. Thysanoteuthis* (Troschel, 1857).

D. Siphon with 4 bridles, and 2 apertures at back. ⊥-shaped socket. 2 brachial, 2 anal, and 4 buccal aquiferous openings. Buccal membrane with 7 lobes. Three longitudinal nuchal crests. Eye with sinus. Pen with hollow cone. Arms with 2 rows of toothed suckers.

a. Folds in siphon pit absent, or only within the velum.

28. Smooth siphon pit. Little or no lateral membrane to arms. Teeth absent or blunt on large suckers of club. Illex (Stp., 1880).

29. Folds in siphon pit within the velum. Lateral membrane of arms small. Alternate sharp and blunt teeth on one half the circumference of large suckers of club. Todarodes (Stp., 1880).

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* A small specimen of Thysanoteuthis rhombus, Trosch., presented to the Oxford Museum by Prof. Ray Lankester, appears to possess 4 bridles; this may perhaps be due to the artificial splitting of a single pair.

b. Folds in siphon pit within and without the velum. Lateral membrane of arms large. Large suckers of club with 4 large teeth, and small teeth all round.

30. Suckers of arms moderate in size and number.
Ommastrephes (d'Orb., 1835).

31. Suckers of arms long-stalked and crowded.
Dosidicus (Stp., 1857).

List of Works referred to.

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3. STEENSTRUP, *Notæ Teuthologicæ,* Oversigt Kong. Danske Vid. Sels., 1887.

4. VERRILL, *Ceph. N. E. America,* Trans. Connect. Acad., vol. i, part 1, 1880.

Notes on Centrina Salviani.

By

W. L. Calderwood,
Director of the Laboratory.

With Plate XIII.

Two specimens of this Elasmobranch have recently been landed at Plymouth, the one on the 21st of June, and the other on the 8th of July. They were both captured by steam trawlers working off Vigo Bay on the north-west coast of Spain. The specimens cannot, therefore, be claimed as English; but since only one example appears to have been previously landed in this country, having been taken off the coast of Cornwall in 1877; and since the fish is, therefore, not at all well known, a few notes on the two specimens brought to the Laboratory may be of interest.

In looking up the literature on this fish I do not find a drawing which gives a satisfactory idea of its appearance. I have, therefore, attempted to represent one of the specimens in question by an accompanying figure.

The following measurements will also help to give a comprehensive idea of the proportions:

Extreme length	31	inches.
Extreme breadth of flat ventral surface . .	$5\frac{1}{2}$	,,
Breadth of mouth	$1\frac{1}{8}$	,,
Breadth between grooves on each side of mouth	2	,,
Length from centre of spiracle to end of snout .	3	,,
Longitudinal measurement of eye . . .	$1\frac{1}{8}$	,,
,, ,, spiracle . .	$\frac{3}{4}$	inch.
,, ,, gill-slits . .	$\frac{3}{8}$	,,
Length of abdominal cavity	17	inches.
Breadth ,, ...	$4\frac{1}{2}$	,,

The other specimen measured 35 inches in length.

Günther's description of the genus, of which *Salviani* forms the only species, is as follows:

"Two dorsal fins, each with a strong spine; no anal fin. Trunk rather elevated, trihedral, with a fold of the skin running along each side of the belly. Mouth narrow, with a deep groove on each side. Teeth of the lower jaw erect, triangular, firmly serrated; those of the upper slender, conical, forming a group in front of the jaw. No membrana nictitans. Spiracles wide, behind the eye. Gill-openings narrow.

"Mediterranean and neighbouring parts of the Atlantic."

The ventral aspect is perfectly flat, suggesting the idea that the habit of the fish is to frequent the bottom, and to lie in one position for long periods. The mouth also is extremely oblique in its opening, and provided with deep grooves resembling the appearance found in the skate. The eye, in proportion to the size of the head, is large, and the heavy lids can easily be drawn so as to cover the eyeball completely. The pupil has a somewhat singular appearance. It is elliptical in outline, the long axis being vertical.

The skin is a remarkable feature, its extreme roughness being at once apparent to the eye and rasping to the touch.

Each scale or dermoid denticle is irregularly pyramidal, presenting, a sharp apex. The scales are so arranged as to form a close covering of a diamond pattern, so hard as to be almost impenetrable to steel. I have not seen any Elasmobranch which, in proportion to its size, is so completely enveloped in "kosmin." A large *Læmargus* will show the placoid scales of equal height, but not with the same sharpness of point or closeness of base.

One specimen when received had already had the abdominal viscera removed. The other was a female. The ovaries were filled with eggs, and extended the entire length of the abdominal cavity. The eggs were in some cases of great size, the largest being two inches in diameter. The oviducts had enlarged uterine dilatations, the inner surfaces of which were covered with a dense mass of vascular villi, the muscular layer being thrown into longitudinal folds. A shell gland of a somewhat rudimentary character was present on the anterior portion of each oviduct. Two large abdominal pores were present in the posterior part of the cloaca. Both oviducts opened internally by a single wide aperture situated at the anterior end of the abdominal cavity.

The intestine had no convolution, but was divisible into an extremely short small intestine and the usual spiral colon.

The liver was composed of two large lateral lobes, reaching to the posterior end of the abdominal cavity, and a small middle lobe.

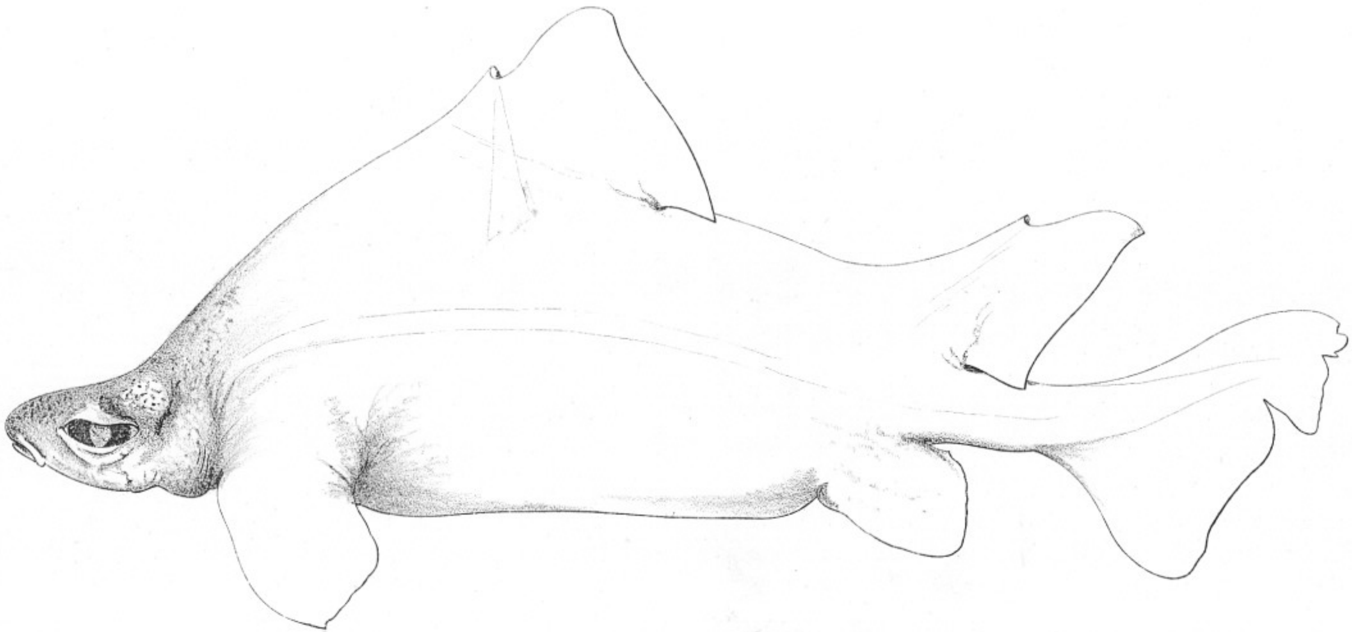
Stomach empty. Spleen in two portions, one in front of the stomach and one in the mesentery of the large intestine. Pancreas and rectal gland present.

As in other Elasmobranchs destitute of a nictitating membrane, the cartilaginous skeleton shows a more or less primitive arrangement. The notochord is not continuous through the centra of the vertebral column, but the column itself is entirely cartilaginous, the centra corresponding with the neural arches. The interneural pieces exactly resemble the neurapophyses inverted, and are interposed between them like wedges, the apices reaching the centre as in *Acanthias*. No pleurapophyses are present.

The conspicuous spines which support each dorsal fin also mark a certain resemblance to *Acanthias*. There is, however, a distinct difference in that the spines of the spur-dog pass off from the neural arch of the vertebral column in exactly the same direction as, and are parallel to, the anterior margins of their dorsal fins ; whereas in *Centrina* the spines run in opposite directions, the anterior one pointing forwards, the posterior one backwards.

In both cases they correspond, in position and arrangement, to modified neural spines, but in the fleshy fin of *Centrina* there is no arrangement of supporting cartilaginous plates as seen in the fin of *Acanthias*.

The position of each spine is suggested in the figure.



W. L. C. DEL. AD NAT.

CENTRINA SALVIANI

J.E.W. SC

Ichthyological Contributions.

By

J. T. Cunningham, M.A.

With Plate XIV.

1. Zeugopterus norvegicus (Günther).

In my paper in the preceding number of this Journal I erroneously described several specimens of this species as *Zeugopterus punctatus*, not having carefully examined or compared them. Since then, having seen specimens of *Zeugopterus norvegicus*, and re-examined my own, I find that my specimens belong to this species. The record of their capture in the neighbourhood of Plymouth is—

July 9th, 1891, between Eddystone and Rame Head, 25 fms., four specimens, 3 ♀, 6·2, 6·5, 9·5 cm.; 1 ♂ 8·2 cm. in length.

March 21st, 1892, six miles from Plymouth Breakwater, about 27 fathoms, one specimen ♀, 8·4 cm. long. The last specimen was a ripe female, yielding ripe ova ·9 mm. in diameter, with a single oil-globule ·15 mm. in diameter.

In Günther's British Museum Catalogue, 1862, this species was only stated to occur on the west coast of Norway. In 1864 Couch recorded the capture of a specimen in the Bristol Channel in 1863. In a paper published in 1888 Günther recorded that he had obtained a specimen 2 inches long in 1868 from a depth of 90 fathoms off Shetland, and that three specimens taken in the Firth of Clyde, at depths of 6 to 45 fathoms, occurred among fishes captured by Mr. John Murray on the west coast of Scotland in 1887 and 1888. Two of the Clyde specimens were 3½ inches (8·9 cm.) long, the third somewhat smaller. Lastly, Mr. Holt obtained a specimen during the survey of the fishing-grounds on the west coast of Ireland in the s.s. Harlequin in 1891. This specimen was obtained at 30 fathoms in Donegal Bay in May, 1891, and is recorded in Mr. Holt's report on the survey, published in the Report of the

Council of the Royal Dublin Society for 1891, and also in the Proceedings of that Society, vol. vii, pt. 4.

It was the inspection of this Irish specimen which led me to identify my own, and I have to thank Mr. Holt for kindly supplying me with references to the literature of the subject. I have now given all the recorded occurrences of this species on British coasts, and it will be seen that it appears to be occasionally fairly common in the Firth of Clyde and off Plymouth Sound, while only single specimens have been taken in the Bristol Channel, Donegal Bay, and off the Shetland Isles.

The species was originally described by Scandinavian zoologists, but first correctly distinguished by Günther. Couch's description and figure are fairly good, but not so satisfactory as those given by Günther in his report on Mr. Murray's collection from the west of Scotland. Day unfortunately failed to recognise the validity of Couch's description of this species, and placed the name used by that author as a synonym of *Zeugopterus unimaculatus;* and as I generally use Day's work, this was the reason that I at first confused the species with *Z. punctatus.* I prefer to use the generic name *Zeugopterus* for this form, rather than *Rhombus,* with which Günther unites it, on account of its evident affinities with *Z. punctatus,* and the difference between these forms and the turbot or brill. One important character, which unites the so-called topknots, namely, *unimaculatus, punctatus,* and the present species, is that the dorsal and post-anal fins are prolonged posteriorly on to the lower side at the base of the tail, towards the middle line of that side. The following is a list of the passages relating to *Zeugopterus norvegicus* cited in the preceding remarks :

J. Couch, Fishes of British Islands, 1864, vol. iii, p. 175, pl. clxvii.

Albert Günther, Brit. Mus. Catalogue, vol. iv, p. 412.

Idem, *Report on Fishes obtained by Mr. J. Murray, &c.,* Proc. Roy. Soc. Edinburgh, No. 127, Session 1887–8, p. 217, pl. iv.

E. W. L. Holt, *Report on the Results of Fishing Operations, Survey of Fishing-grounds of West Coast of Ireland,* Proc. Roy. Dubl. Soc., vol. vii, pt. 4.

Idem, *Preliminary Note on the Fish obtained during the Cruise of the s.s. "Harlequin,"* 1891, Proc. Roy. Dubl. Soc., vol. vii, pt. 3, p. 218.

Zeugopterus punctatus is by no means uncommon in the neighbourhood of Plymouth. It is frequently taken by shrimp trawlers in the Sound, and brought in alive to our aquarium. I have four specimens, 11·4 to 15 cm. ($4\frac{1}{2}$ to $5\frac{7}{8}$ inches) in length; and also a young specimen 5 cm. long, taken in the Sound on October 21st, 1889.

This specimen was probably only six or seven months old, having been hatched in the preceding spring.

Zeugopterus unimaculatus, Risso, must be extremely rare on this coast. I have never yet met with a specimen. The collection made by Mr. Murray in 1887 and 1889 included only one specimen, taken in the Firth of Clyde off Ardrossan.

2. On a Stage in the Metamorphosis of Solea.*

Plate XIV, fig. 2.

The larva represented in fig. 2 was obtained by Mr. F. W. Gamble on August 9th, when working with a hand-net among the fronds of Laminaria on the inner side of Plymouth Breakwater. It evidently belongs to the genus *Solea* from the shape of the snout, mouth, and head generally. The larva was 11 mm. long. The dorsal fin-rays are eighty-six in number, the post-anal sixty-eight, so that it is certainly either *Solea vulgaris* or *lascaris*. I have not been able to discover any indication of the enlarged nostril on the lower side which distinguishes *lascaris*, and am therefore inclined to believe that the specimen belongs to the common sole. The chief difficulty in thus regarding it is the date of its occurrence. I have taken completely metamorphosed young soles in Mevagissey Harbour on May 15th, but they have not been seen there later. However, I know that a few soles are spawning in May, although a great many are then spent. But the larva here in question could not be much more than a month or five weeks old, and must, therefore, have been spawned late in June or early in July. It is possible that some soles spawn as late as this, although I have not observed any ripe specimens in these months. The specimen when alive was very transparent, as shown in the figure. The drawing was made with the camera lucida, so that its proportions are accurately correct to scale; but the exact number of the fin-rays has not been reproduced in the figure.

There are several points of interest and importance in this larva. It shows in the first place that in *Solea*, as in the genus *Pleuronectes*—the plaice and flounder, for example—the eye of the lower side passes round the edge of the head to reach the upper side, and not

* While these pages were in the press I noticed, on referring to Raffaele's paper (*Mitt. Zool. Stat. Neapel*, Bd. viii, tav. iii, figs. 8, 9), that a similar stage of Solea is there described and figured. Thus the fact that the left eye reaches the right side in Solea by passing in front of the dorsal fin was already known, but as Raffaele's description and figures scarcely do full justice to this intermediate stage, the description and figure I have given are by no means superfluous.

through the tissues of the base of the anterior part of the dorsal fin. It is well known that Steenstrup in 1863 described transition stages of Pleuronectids, obtained from the North Atlantic, in which the eyes, after metamorphosis, were on the left side, and the right eye passed through the head to reach that side. He considered these stages to belong to the genus *Plagusia*. Agassiz in 1878 (Proc. Amer. Acad. Arts and Sci., vol. xiv) described transition stages, quite similar to those of Steenstrup, captured at the mouth of Newport Harbour, and ascribed them likewise to the genus *Plagusia*. Emery, the Italian ichthyologist, has pointed out that these specimens of Steenstrup and Agassiz certainly do not belong to the genus *Plagusia*, because in the latter the dorsal and post-anal fins are continuous with the caudal, and in these specimens they are quite distinct and separate. Without discussing the question at length, or carefully examining the evidence, Emery suggests that the North Atlantic specimens belong to the genus *Rhomboidichthys*. Emery, in the same paper, describes another larval form in which the longitudinal fins are continuous with the caudal, and the right eye passes through the base of the dorsal fin to the left side of the head. He did not succeed in identifying this larva with any known adult species. The larvæ in which this process of perforation has been hitherto described are sinistral, the eyes are on the left side; but nevertheless, considering the great anterior prolongation of the dorsal fin in the adult sole, it seemed not impossible that the migration of the lower eye should take place in that species also by perforation. The larva now described proves that this is not the case, its dorsal fin being still behind the left eye. The left eye has not quite reached the edge of the head; it is still on the left side, but it is very near the edge; and when the larva is examined on a slide, lying flat on its left side, the cornea of the left eye is seen to project slightly beyond the edge of the head, as seen in the figure.

The next important feature in this larva is the presence of an air-bladder of considerable size. Hitherto, so far as I am aware, an air-bladder in larval Pleuronectidæ has only been observed in the turbot and brill. I have never seen a trace of it in species of *Pleuronectes*. In that stage of the flounder which corresponds to the stage of *Solea* here described, and which I have frequently examined, no trace of an air-bladder is visible (compare the pl. xvii, fig. 5, of my *Treatise on the Sole*). No air-bladder is present in the adult sole; and in the stage just after the completion of the metamorphosis, when the little sole is 12 to 15 mm. long, the organ has already disappeared (see pl. xvi, fig. 5, op. cit.).

It is interesting to notice that in this larval stage some of the specific characters are already developed. I refer especially to the shape of the snout and the position and structure of the mouth. The edge of the upper lip on the right side is curved, as in the adult sole; teeth are absent from the jaws on the right side, present in the lower jaw on the left. The intestine, however, does not reach its adult condition till a much later period. In this stage it has only one coil, and the posterior part does not extend backwards behind the median body-cavity. The coloration is not reproduced in the figure: it consisted of black and orange specks (chromatophores) and more diffuse patches of lemon-yellow. The pigment was not arranged in the markings which characterise the adult, and which are already visible in the early post-larval stage figured in my treatise. On the body and head the specks were pretty uniformly distributed, but on the dorsal fin there were three pigmented regions, one at the anterior end, one in the middle, and one near the posterior end. On the post-anal fin there was only one pigmented area of considerable extent, opposite the posterior area of the dorsal fin.

In my *Treatise on the Sole* I was only able to figure the newly hatched larvæ and the earliest post-larval stage. Three other larval stages were figured and described in vol. ii, No. 1 of this Journal (pl. iii). The stage here described is intermediate between the latter and the first post-larval stage, and fills up an important gap in the series, although additional intermediate stages are still required. My use of the terms larval and post-larval differs from that adopted by Professor McIntosh and some of his pupils, who restrict the former term to the stages prior to the absorption of the yolk, and call subsequent stages post-larval. I cannot see any justification for this application of the terms. A fish is a larva until the most important organ-systems of the adult, such as the permanent skeleton and fins, are developed.

3. A Larval Stage of the Mackerel.

Plate XIV, fig. 1.

In the first number of the current volume of this Journal (vol. ii, No. 1, p. 71, pl. iv, fig. 7) I described and figured the newly hatched mackerel larva. Last year I made further experiments in hatching and rearing the larvæ of this species from artificially fertilized eggs, using a hatching box of Captain Dannevig's pattern. I succeeded in keeping some of the larvæ alive four days after hatching, and the condition then reached is shown in fig. 1.

In this stage the yolk is almost entirely absorbed, but a remnant remains containing the oil-globule, which is still conspicuous. The mouth is developed and open, and indications of the gill arches are seen behind the head. The intestine has increased so much in length that it makes a single coil in the neighbourhood of the stomach. The pectoral fin is rather large. The choroid of the eye is deeply pigmented. With regard to the pigmentation of the skin, only the position of the chromatophores is represented in the figure. The black were arranged in a series along the dorsal and ventral edges of the body, and in a group about the oil-globule. There was no pigment at all in the larval median fin-fold. The iris of the eye appeared bright blue, and there was a large irregular patch of light yellow close behind the eye on the side of the head. In my figure of the newly hatched larva I represented the pigment as black and green, the green colour being present not only behind the eye, but round the oil-globule and at three other points. The explanation of the difference is that the green colour is due to the mixture of black and yellow pigments, as in the adult mackerel. In the larva at present described the yellow pigment is not mixed with the black, and its appearance is therefore not altered. I do not suppose that the distribution of pigment in the larva now described is absolutely constant in all larvæ at this stage—on the contrary, I believe it is subject to considerable individual variation; but the absence of chromatophores from the median fin-fold appears to be constant and characteristic of the mackerel.

DESCRIPTION OF PLATE XIV.

FIG. 1.—Larva of *Scomber scomber*, the mackerel, drawn June 15th, 1891, hatched June 11th. Zeiss A_3, oc. 3, camera. Actual length 4·3 mm.

FIG. 2.—Larva of *Solea vulgaris* (or *S. lascaris*), caught August 9th, 1892. Drawn from life with camera lucida. Actual length 11 mm. *a, b.* Air-bladder.

4. Growth of Young Herring in the Thames Estuary.

I am indebted to Mr. E. W. H. Holdsworth, author of the well-known work on *Deep Sea Fishing and Fishing Boats,* for some references to passages bearing on this subject which had not come under my notice when I wrote my paper on the *Rate of Growth of Sea Fishes* for the previous number of this Journal. In that paper (see last number, pp. 240, 241) I stated that I had been unable to find any record of observations on the spawning of herring at the mouth of the Thames in spring. Mr. Holdsworth has directed my

Plate XIV.

Fig. 1.

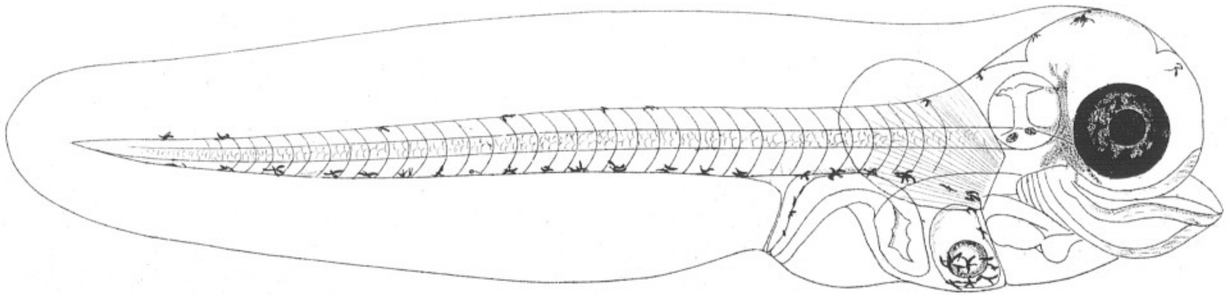
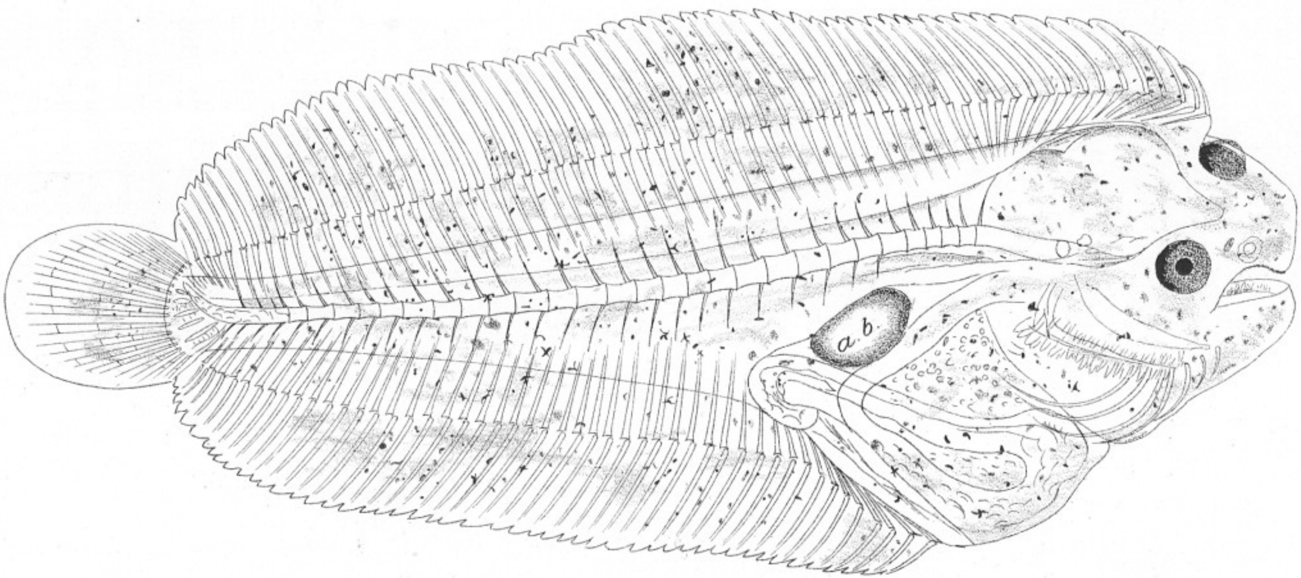


Fig. 2.



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attention to such a record in Yarrell's *British Fishes*. In that work, first edition, 1836, vol. ii, p. 117, is an account of what the author believes to be a distinct species of herring, which he calls Leach's herring, *Clupea Leachii*. Yarrell says that he found herring of this sort among the fish taken at the mouth of the Thames during winter by the sprat fishermen. He points out that the common herring deposits its spawn towards the end of October, and says that numbers of the young of these herring are taken with the sprats. These are yearling herring, have the elongated form of the common herring, and although reaching 7 inches in length are without roe. The herring of the new species is found heavy with roe at the end of January, and does not deposit its spawn till the middle of February. Its length is not more than 7½ inches, and its depth near 2 inches. The characters by which Yarrell distinguishes this species from the common or autumn herring are not very salient, but it is quite possible that they correspond to those in which, according to Heincke, the spring race of herrings differs from the autumn race. The principal are the greater depth of the body and the more anterior position of the dorsal fin. However, whether these herrings are structurally distinct or not, the important fact is that Yarrell found them spawning in the middle of February. I inferred in my previous paper, from the occurrence of the larval herrings in Thames whitebait, that the parents of the latter spawned in March, April, and May; and it is not improbable, considering that Yarrell did not fully determine the limits of their spawning period, but only states that they did not spawn until the middle of February, that he only noticed the commencement of the spawning, which may have continued till the middle of May. Mr. Holdsworth, in his book on Deep Sea Fishing, p. 249, refers to Yarrell's account of Leach's herring in the Thames, stating that a more extensive examination has resulted in ranking it only as one of the numerous races of the common herring. He states also that this "small variety" of herring appears in the Wash in December, and spawns in February and March, and that it is there the object of a regular but not very extensive fishery.

Mr. Holdsworth further points out in his letter to me that he states in his book that the herring fishery takes place at Ramsgate in October and November, not the spawning, as in the citation given in my paper. With regard to the spawning, the statement in his book is that the herring are full at the eastern end of the Channel in November, and his impression is that the end of that month would be the general spawning-time in that locality. I am glad to correct this slight inaccuracy in my quotation of Mr. Holdsworth's observations. I assumed that some ripe, spawning herring were taken at Ramsgate in the first part of the fishing season, in October; and although Mr. Holdsworth doubts the validity of this assumption, it agrees with Yarrell's statement, already quoted, that the common or autumn herring deposits its spawn towards the end of October, supposing that this statement is intended to refer to the mouth of the Thames, which is probable, but not quite certain from the context.

Notes on the Marine Invertebrate Fauna of Plymouth for 1892.

By

Walter Garstang, M.A.,

Naturalist in Charge of the Dredging Operations, M.B.A.

The following faunistic notes are offered as an indication of the chief results which have characterised our collecting operations during the present year. It is hoped that, short as they are, they may prove serviceable to British naturalists desiring to pursue special researches in marine zoology, but undecided as to the locality most likely to meet their needs. The notes are incomplete, owing to my absence from Plymouth during the earlier part of the year; but they are sufficient for the formation of an inference, since the results here described were obtained for the most part during only a fragment of the year—from June to September.

I have not discussed the peculiarities which have characterised the floating fauna, since Mr. Bles, who has been specially pursuing planktological researches, is publishing a note upon his observations in the same number of this Journal.

In future numbers I hope to give a systematic account of the fauna characterising the different bays and natural areas which are within the reach of the routine dredging and collecting operations of the Laboratory. Such an account will, I trust, be useful to naturalists visiting the Laboratory, and will also be so arranged as to form a contribution towards the general subject of marine bionomics.

The dredging, tow-netting, and trawling work of the Laboratory is, however, carried on at present under difficulties* which can hardly be adequately realised. The frequent breakdowns of the small and antiquated launch belonging to the Association seriously interfere with the continuity of our work, and needlessly limit the scope of our operations. A new and seaworthy steamboat has become an absolute necessity.

Porifera.—A specimen of *Leucosolenia lacunosa* (Bwk.), a rare and

* These difficulties, I learn, are, happily, nearly at an end (October 17th).

beautiful calcareous sponge, was dredged* in 25 fms. on September 14th, attached by its slender stalk to an old egg-case of *Scyllium canicula*, which was itself adhering to the stem of a *Gorgonia*.

HYDROZOA.—A colony of Norman's *Tubiclava* (*Merona*) *cornucopiæ*, consisting of from 90 to 100 polyps, was dredged in 15 fms. water on June 10th. The colony covers almost the whole of the upper side of the shell of an *Aporrhaïs*, tenanted by a *Phascolion strombi*. Several interesting points, in which I have been able to supplement Dr. Norman's original description, will be found described in a paper contributed by me to the Transactions of the Devonshire Association for the present year. The original specimens of *T. cornucopiæ* were dredged thirty years ago among the Shetlands, in from 80 to 100 fathoms of water.

Several additional colonies of *Haloikema Lankesterii* (G. C. Bourne) have been dredged, but the description of these is for the present deferred.

SCYPHOZOA.—In a little creek beyond the breakwater *Haliclystus octoradiatus* (= *Lucernaria auricula*) has been discovered in hundreds, attached to *Ceramium* and *Enteromorpha*, between tide-marks. The early part of the spring would be the time at which the development of this form could be followed out.

ANTHOZOA.—The Actinians of Plymouth present a valuable field for special investigation. On June 28th a specimen of one of the varieties of *Eloactis Mazeli* (Jourd.) was trawled by us a few miles off the Mewstone, and furnishes an interesting addition to the British fauna. It has been fully described in my paper read to the Devonshire Association last July.

Actinia equina, *Anemonia sulcata*, *Cereus pedunculatus* (*S. bellis*), *Thoë sphyrodeta*, *Cylista undata* (*S. troglodytes*), *Urticina felina* (*T. crassicornis*), and *Corynactis viridis* are all common at Plymouth. *Cylista viduata* is rare within the Sound, although common enough in the neighbourhood. *Bunodes coronata* and *Ballii* both occur, the former in Whitsand Bay, the latter on the breakwater. Of *Bunodes Ballii*, the typical pink-spotted variety, which is very common on the shores of the Isle of Wight, is rare here, and is replaced by the varieties *dealbata* and *livida* of Gosse. In addition to the above, several interesting forms that appear to be undescribed are quite common in certain localities.

TURBELLARIA.—Mr. Gamble's researches during the present summer have revealed the existence of a Rhabdocœle fauna unparalleled in the number of its species, and upon which we may expect a special report in an early number of the Journal.

NEMERTEA.—For a similar reason there is no need that anything

* Two additional specimens have since been taken.

should here be stated concerning the Nemertines of Plymouth, since they are being specially investigated by Mr. Riches.

ANNELIDA.—This large group will require considerable time before it can be adequately treated from a faunistic point of view. The dredge is constantly bringing to light the existence of species whose presence has been hitherto unsuspected. The permanent haunts of *Gattiola spectabilis* have been discovered. *Myxicola* has been added to our lists. *Staurocephalus rubrovittatus* (Grube), a remarkable little Eunicid which has hitherto been found* exclusively, I believe, in the Mediterranean, has been taken on several occasions. Where the bottom is muddy, a species of *Chætozone* has been taken in quantity, and *Polydora ciliata* builds its mud tubes in thousands upon the stones and shells brought up in the dredge.

The Gephyrea are represented by a small species of *Phascolosoma*, which is abundant in the crevices of shaly rocks between tide-marks, *Phascolion strombi*, and *Thalassema Neptuni*.

Phoronis, whose occurrence at Plymouth I recorded some time since, proves to be quite plentiful in certain parts of the Sound, and its beautiful larva has been a feature of the autumn tow-nettings.

POLYZOA.—The localities for the different members of this large group are being gradually established. Beyond the fact of the common occurrence of *Pedicellina*, however, there is nothing that calls for special notice, unless it is that *Crisia denticulata*, which Mr. Harmer, in his paper on the British species of *Crisia*, mentions as having been seldom found at Plymouth, proves to be abundant in the deeper waters a few miles outside the breakwater.

ECHINODERMATA.—*Antedon rosacea* remains a constant element in the fauna, and its Pentacrinoid larva has been taken in some numbers during the autumn.

Solaster papposus has been the most plentiful starfish this year; and, among Ophiuroids, *Amphiura elegans*, *Ophiothrix pentaphyllum*, and *Ophiocoma nigra*.

Holothuria nigra and *Ocnus brunneus* have been taken in quantity.

MOLLUSCA.—Numbers of minute specimens of *Solen* were fished during June, and showed the early development of the gill-plates in a beautiful manner through their perfectly transparent shells.

The principal additions to the Gastropod fauna have been in the Opisthobranchiate section, but it may be mentioned that two favourite Prosobranchs, *Emarginula reticulata* and *Phasianella pullus*, have been found in quantity, the former inhabiting shell-banks in about seven fathoms of water, the latter feeding upon filamentous red-brown algæ in various parts of the Sound.

* Grube, I find, records a specimen in his St. Mâlo list, so that the species is probably not uncommon in the Channel waters.

Philine punctata, of which only a single specimen was recorded in my list of 1890, I find to be plentiful in twenty fathoms among shells and stones covered with *Bugula.*

Cylichna truncata has been met with several times, but its real locality is yet to be discovered.

Young specimens of *Oscanius membranaceus* were dredged repeatedly in the Sound during September, and on the night of the 21st were found actively swimming in some numbers at the surface of the sea.

Six additional specimens of *Lomanotus* were dredged within the Sound during June and September, but as yet no large individuals have been met with.

Cratena amœna and *olivacea* have been obtained rather often, and the same remark applies to *Jorunna Johnstoni* and *Lamellidoris aspera. Calma glaucoides* was dredged on June 18th, and a beautiful specimen of *Idalina elegans,* grotesquely embedded within a small *Cynthia* upon which it had been feeding, on July 30th. Mr. Gamble twice brought me specimens of a little Æolid, which proved upon examination to be the *Embletonia pulchra* of Alder and Hancock, although much paler in coloration than the type of that species. *Amphorina cœrulea,* a species which has not been met with on the English coasts since the time of Montagu, was dredged on September 12th. The individual captured was 3 mm. in length, and the whole of the body with the head and tentacles was of a semi-transparent pale greenish colour. The gorgeous cerata are the chief peculiarities of this little creature. The colour of these is partly due to the cæca shining through, and to the superficial markings of the skin. The cæca in this case were deep sage-green, granulated, nearly filling the cerata. The upper half of each ceras was marked by conspicuous bands of colour—a rather broad band of glistening dots of cerulean blue, bounded above and below by a ring of bright yellow pigment-cells, branched and reticulating. There was no trace of orange. The rhinophores were rather short and conical, not filiform, as Vayssière found to be the case at Marseilles ('Ann. Mus. Hist. Nat. Marseille,' t. iii, mem. 4, pl. i, fig. 5), nor nearly so long as represented in his figure, perhaps because they were incompletely extended. They were held vertically upwards, parallel with each other; while the oral tentacles, slightly dilated towards their extremities, were held horizontally, and curved outwards on each side. There were seven rows of stout clavate cerata (2×2, 3, 4, 3, 2, 2, 1). The first three rows were close together, forming a cluster as in *Cratena;* this was separated from the fourth row, and the posterior rows from one another, by a considerable interval.

In August two specimens of *Antiopa hyalina* were dredged, one of them 5·5 mm., the other 9·5 mm. in length. This rare species furnishes another valuable addition to our fauna.

Perhaps the most interesting addition of all, however, has been the rediscovery of D'Orbigny's *Stiliger bellula*, the *Calliopæa bellula* of that author's beautiful memoir on new species and genera of Nudibranchs observed on the coast of France. Ten individuals were dredged in Cawsand Bay on the 3rd of August, but I have hardly a remark to add to the admirable description of the external form, colour, and habits of the species which the talented French naturalist gave sixty years ago. The bearings of the anatomy of this primitive form upon the epipodial theory of the cerata must be important, since it occupies a position intermediate between *Hermæa* and the Æolids, which have been shown by Prof. Herdman to possess a ceratal innervation constructed upon two distinct types.

Among Cephalopoda, *Eledone cirrhosa* and *Sepiola atlantica* are plentiful; *Rossia macrosoma* has been taken twice this autumn. The smallness and unseaworthiness of our present steamboat unfortunately prevent us from visiting the proper localities for the larger species of cuttle-fish, and we are therefore unable to obtain good specimens of forms like *Loligo Forbesii* except on rare occasions.

CRUSTACEA.—An Amphipod, which Dr. Norman has kindly identified for me as *Unciola crenatipalma*, Bate (sp.), is plentiful among shells and stones on a muddy bottom at a depth of twenty fathoms. The two sexes were described by Spence Bate under the names *Dryope crenatipalma* (♀) and *D. irrorata* (♂), and wrongly removed by him from the genus *Unciola*, to which Gosse had rightly referred the latter "species," owing to his inability to discover the secondary appendage of the first antennæ. A minute one-jointed appendage, however, is constantly present, as Stebbing has already stated. The species is readily recognised, when alive, by its form and colour, the latter being yellowish, much speckled with white. It appears to be very locally distributed, for it is not included in Mr. David Robertson's recent catalogue, in Mr. A. O. Walker's lists of the L. M. B. C. Amphipoda, or in Carus's Prodromus Faunæ Mediterraneæ.

Corophium grossipes (*longicorne*) and *C. crassicorne* (*Bonellii*) inhabit their special localities in thousands.

Among Isopoda, *Apseudes talpa* has been taken in some numbers, while species of *Anceus*, *Munna*, and *Jæra* are abundant. On June 19th I found a male *Anthura gracilis*, 4 mm. long, provided with an antennal flagellum of nine joints, each of which was encircled by a dense ring of long slender hairs. Another specimen, dredged on September 16th, was 5 mm. long; the antennæ were as long as the head and first two segments of the pereion, and each of the twelve joints of the flagella was encircled with hairs, as in the preceding specimen. The discovery of these specimens confirms in an interesting manner the prediction of Norman and Stebbing concerning the secondary sexual characters of the adult male of this species (Trans. Zool. Soc., xii, p. 123).

A specimen of *Idotea parallela* (B. and W.) was dredged on June 8th in Cawsand Bay. It presented a curious appearance when alive, for it was inhabiting a piece of the stem of a dead *Zostera* plant, which it carried about with it like a caddis-worm in its tube. The thick, soft, white antennæ of this species are very characteristic, and were at first much more suggestive to me of the tentacles of a Polychæte than of Crustacean appendages.

Two species of *Arcturus* have been frequently taken among the filamentous Algæ to which they cling. Their peculiar form, colour, and habits of fixation render them excellent examples of protective adaptation.

The Cumacea are still under examination. *Pseudocuma cercaria* is abundant; and *Iphinoë trispinosa,* a species of *Diastylis,* and other forms, are plentiful in their respective localities.

Of the Schizopoda, *Macromysis flexuosa* (*chamæleon* of authors) has been very abundant this summer. Each time that I visited the estuary of the Yealm during July and August I found it at low tide swimming in countless myriads close to the water's edge. It is interesting to watch the behaviour of this Mysis when placed in a tank containing some of its piscine enemies. It is a good match for the sharp-sighted but too eager wrasses, and, when pursued, generally manages to escape from them by darting swiftly away in an irregular zigzag manner; but the John Dory catches the Mysis easily by moving stealthily towards them by means of its almost invisible fins, and, when within reach, suddenly projecting its huge protrusible jaws, and sucking in the unsuspicious shrimps. The middle of July marked the height of the breeding season of this species.

The same may be said of *Schistomysis spiritus,* which was taken in considerable numbers in Whitsand Bay on July 15th, at which date all the individuals were of large size, and the marsupial pouches of the females were full of embryos. By August 3rd almost all the large individuals had disappeared, and the bottom net brought up thousands of small Schizopods, consisting chiefly of the young of this species. Along with them, however, were adult specimens of *Gastrosaccus sanctus,* and of a small robust species of *Schistomysis,* allied to *S. arenosa,* which seems to be new to science.

On the night of September 21st the Mysidæ *Gastrosaccus Normani* and *Siriella jaltensis* (*S. crassipes,* G. O. Sars) were taken in the surface-net in about equal numbers (principally males). The former species was taken by the "Porcupine" in 1869, and by

Norman off the south-west coast of Ireland in the following year, since which date it appears not to have been observed upon our coasts.

Our museum already contains a considerable collection of Decapoda, named by Prof. Weldon and Dr. Norman, which is all but representative of the fauna. The year's additions to this type collection consist of the species *Xantho floridus, rivulosus,* and *tuberculatus, Hyas araneus, Achæus Cranchii* (a valuable addition made by my assistant, Mr. Walker, in the spring), and *Eupagurus Forbesii,* which was added by Mr. Riches. The reserve stores of other interesting forms, *e. g. Portunus arcuatus, Polybius Henslowii, Ebalia, Diogenes varians, Crangon Allmanni,* have been considerably increased.

Notes on the Plankton observed at Plymouth during June, July, August and September, 1892.

By
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Hon. Research Fellow in the Owens College.

THE absence of systematic records showing the variations of the floating fauna and flora, or plankton, of the Plymouth waters is much to be regretted. My observations on the amount of animal and plant life suspended in the sea from the surface to the bottom would show that in comparison with similar observations made elsewhere, the quantity of plankton in this locality was during the past summer surprisingly small. The absence of data upon which comparisons could be based between the state of the water in this season and that obtaining in former years is all the more to be deplored because the present season has in many respects been a remarkable one. In the first place, the Plymouth mackerel fishery has so far been a complete failure; it has further been found that dog-fishes (both *Scyllium* and *Acanthias*) were not obtainable during June and July; and lastly, *Aurelia aurita,* which in summer is usually common, was extremely scarce in the Sound and tidal waters of Plymouth. If my surmise that the amount of plankton was for the locality exceptionally small proves correct, then these three salient instances of scarcity of animals which are directly or indirectly dependent on the plankton for their food will suffice to show the importance of a series of more or less continuous observations on the physical and biological condition of the inshore and Channel waters. Were accurate information on these points available, it would in all probability enable us to explain, and we might even in time be able to foresee, the occurrence of so important an event as the exceptionally sporadic appearance of the mackerel in 1892.

The quantitative and faunistic observations I have made with the aid of a Royal Society grant are made with this object in view, but it will be some time before the results are ready for publication, and it may now be of interest to record some extracts from my diary.

June 17*th.*—**Hormiphora plumosa**, the Ctenophore common at

Plymouth, was not seen in the adult condition after this date, but at the middle of September minute young Hormiphora made their appearance and ova were found, but the adult was absent from hauls which otherwise were in excellent condition.

The Hydroid medusa, **Obelia lucifera**, was very plentiful throughout June. It was interesting to note the effect of killing the medusæ in the dark. On adding a saturated solution of corrosive sublimate to the sea water the stimulus caused the animals to become phosphorescent, and the position of each medusa was indicated by a small clear ring of blue light round the margin of the umbrella. The light did not fade until after about a minute.

June 21st.—From this day onwards **Porcellana zoœa** have occurred almost constantly. On *June 28th* **Appendicularia** were first observed, and on *July 4th* they became very common, chiefly belonging to the species Oikopleura cophocerca. Of this form young specimens abounded.

Rhizoselenia obtusa and R. setigera, two diatoms with immensely elongated frustules, began to occur in large numbers on July 4th. On this day, moreover, **Evadne** appeared, together with the other marine Cladoceran **Podon** which hitherto had been the only representative of the group. Evadne gradually increased in numbers, while Podon gradually became scarcer, disappearing near the middle of September. Evadne constantly produced swarms of ephippial young, and is still bearing ova and larvæ (1st October), but about the middle of September they commenced to produce their large winter eggs, one egg in each individual. Another feature of the haul on July 4th was the great increase in the quantity of **Dinoflagellates**, Ceratium tripos, C. fusus, and Peridinium sp. Both the Dinoflagellates and Rhizoselenia are known to be more abundant towards the south-west and near the ocean, and on June 25th I found Evadne in large numbers off the French coast, sixty to seventy miles south of Plymouth.

The sudden appearance on July 4th of these various forms from the south and south-west may perhaps be explained. On June 28th the wind in the western part of the channel was light and variable, but from then until July 3rd—4th it blew from a westerly quarter (S.W. and W.S.W.), freshening on July 3rd. These facts seem to indicate that the wind has a very marked influence on the distribution of plankton. This conclusion is strongly supported by the fact that oceanic **Radiolaria** belonging to Haeckel's Acantharia also occur in the same haul of July 4th. Mr. Bourne, in his Report of a Cruise in H.M.S. "Research" off the South-west Coast of Ireland, remarks, "The absence of pelagic Radiolaria at Plymouth has often engaged my attention,"* and records the

* This Journal, vol. i, p. 321.

occurrence off the Irish Coast of several species in "tolerable abundance" amongst them an Acanthometron, which may be identical with mine. On no other occasion have I seen Radiolaria at Plymouth, and this sudden appearance, together with that of the other organisms mentioned, very probably indicates that the surface-layers of the sea with their plankton are displaced through considerable distances by the prolonged or powerful action of the wind in one direction.* It is desirable that this observation should be extended and confirmed, as it has obviously an important bearing on the distribution of the food of migratory fishes like the herring and mackerel.

July 23rd.—**Saphenia mirabilis**, *Haeckel*, was taken at the bottom in 9 fathoms off Penlee Point. The specimens were of the same size as those recorded by Mr. J. T. Cunningham in this Journal, vol. ii, page 194. The haul also contained a number of ~~**Irene viridula**~~, ~~*Eschsch.*~~, a medusa which was almost invariably present in the bottom tow-nettings from June to August. Once only did they appear in a surface netting, and that was one taken soon after midnight on July 21st in Start Bay.

August 26th.—The Siphonophore **Muggiæa atlantica**, *Cunningham*, made its appearance. The eudoxomes were at this time immature, and were not observed to be detached until September 2nd, when they bore ripe sexual products in the manubrium of the genital nectocalyx. Later on (23rd September) I found the young Calyconula larva corresponding to a figure by Chun in the Ann. and Mag. Nat. Hist., ser. 5, vol. xi, pl. v, fig. 6. This was at a time when the adult occurred in very large numbers, and just before it began to become scarce.

September 5th.—The pelagic larva of the interesting Polychæte, **Magelona papillicornis**, *Fr. Müll.*, was plentiful for a fortnight after this date, and then began to diminish in numbers; at the end of the month only stray specimens were found.

September 10th.—Young **Amphioxus** larvæ were taken just outside the Breakwater. A few more at a slightly later stage were taken on 13th and 17th September, with sixteen to seventeen primary gill-slits.

September 23rd.—**Müller's larva** (Polyclad) was first noticed and was frequently found during the ensuing week. In August and September the surface tow-nettings often contained a young Polyclad, probably **Leptoplana**, from 1½ to 2 mm. in length.

September 24th.—The absence of **Noctiluca** is a very extraordinary feature of the year, for 1891 was remarkable for the immense pro-

* Dr. John Murray informed me that Radiolarians had not been taken in the Clyde area until I found them, after the prolonged south-westerly gales of 24th to 26th August, in a tow-netting taken from the yacht "Medusa," off Rothesay, Bute.

fusion of this infusorian, which in the months of June and July was present in such numbers that it discoloured large stretches of sea. This year it has been almost entirely absent, and a few individuals which I found at the end of September were the only signs of its existence. There were no great displays of phosphorescence this summer, either in the Sound or in the Channel, on the occasion of my nocturnal excursions.

September 30th.—Two species of Copepods which, according to Bourne (this Journal, vol. i, pp. 150 and 151) have only been taken here from February to May, I found outside the Breakwater in September. They are **Euterpe gracilis** and **Corycæus anglicus**, the former being fairly plentiful. During the whole summer **Cetochilus septentrionalis** has been present, but never in large numbers, each tow-netting generally containing a few.

In the last days of September a marked increase in the number of **Dinoflagellates** took place, and among them a form appeared which seems to be intermediate between Dinophysis and Ornithocercus, but which I have not yet identified.

I have collected a number of interesting Annelid and Mollusc larvæ, which I have not mentioned above, as I hope to report on them in detail elsewhere.

I have found that it is easy to rear Annelid and other larvæ by the following method :—The whole of a tow-netting in a large confectionery jar full of pure sea-water may be placed up to its neck in a tank through which water circulates. If the tow-netting is rich in species but poor in individuals, a large number of larvæ will live and continue to develope. Such a tow-netting I obtained on September 5th, and in seven to ten days later, after keeping the bottle at a constant low temperature in the way described above, I found on the sides of the bottle young Serpulids in tubes, a few two- three- aud four-celled colonies of Membranipora and young bivalve molluscs in the prodissoconch stage. I also found four specimens of *Protodrilus leuckartii, Hatschek,* a most interesting Archiannelid which has until now, I believe, not been recorded from any other locality but the Mediterranean and Black Sea.

Report on the Probable Ages of Young Fish collected by Mr. Holt in the North Sea.

By

J. T. Cunningham, M.A.

During the past summer Mr. Holt has sent me from time to time young specimens of fish which he has collected, in order that I might report upon the evidence which they afforded as to the rate of growth of the various species in the North Sea. He has also supplied me with a complete list containing the names and the measurements of all the specimens he has collected, including many others besides those sent to me. I have simply studied the specimens and the list, and endeavoured to estimate the probable ages of the specimens. The necessary information as to the limits and duration of the spawning period in the case of each species has also been supplied to me by Mr. Holt. I have registered below the observed specimens of each species separately in the chronological order of their capture. All have been collected in the course of the current year.

The principal sources whence these specimens were obtained were the shrimp nets worked on the sands at Cleethorpes, the shrimp-trawls in the Humber, Grimsby Market, and the deep sea trawling grounds. The shrimp-nets are of two kinds—the shove-net worked by hand, the fisherman wading in the water ; and the cart-trawl,* which is drawn by a horse. The shove-net is ten feet wide at the lower end, the cart-trawl is larger. In Mr. Holt's list there are records of fish taken in these nets at the end of April, in May, in June, in July, and in September. The fish obtained from them were most numerous at the end of April, when they consisted of hundreds of small plaice, with a few flounders, dabs, soles, turbots, brill, and smelt. With these were numerous valueless fish, such as gobies and dragonets, which need not here be considered. The majority of the small plaice were 1½ to 3 inches long, and I think there is little doubt that they were derived from the same year's spawning, which commenced in January. None of the other

* Locally termed a "shrimp-seine" (*vide* p. 387).

valuable fish from these nets in April were so young, all being in their second year at least. In May the same kinds of fish were obtained, but the plaice were not so numerous; in addition to those mentioned, two whiting occurred, about eleven months old, 4 and 5½ inches long. In June also plaice of the year occurred in large numbers, over 200 on the 3rd in the cart-trawl. A few soles, flounders, plaice, turbot, brill, one year old, continued to be taken. In July the year's plaice are in much smaller numbers, 25 on one occasion, 13 on another. Soles and brill 3 to 7 inches long still occurred. On September 10th plaice of the year were still present, but in small numbers, only 40 under 3 inches being taken; on this date one whiting 3¾ inches long, and hatched the preceding spring, was taken.

If we turn next to the fish taken by the fish- and shrimp-trawls in the Humber at a depth of 1 to 2 fathoms, we find in March plaice 5 to 9 inches long the most numerous; the majority of these are one year old, some may be two years; there are also a few year-old dabs, 1¼ to 3¼ inches; a year-old sole, 5¾ inches, and five specimens of year-old whiting, 4¾ to 6 inches. In May a considerable number of soles 7 to 10 inches long were taken, some of these are only one year old, but many of the larger are probably two years. There are also a large number of flounders 5 to 10 inches, and some larger, and plaice of the same sizes. Most of the flounders are two years old and upwards, and many of them adult and mature. The greater number of the plaice are 7 to 8 inches long, and these are probably only one year old. In June a large number of soles occur, of various sizes, from 7 to 12 inches; the smaller of these may be only one year old, the majority are two years, and some are probably adult. In July there occur only a few soles on one occasion, 5 to 7 inches long, one year old. In August there are no observations. September is remarkable for the appearance of large numbers of whiting 2½ to 5 inches long, and evidently derived from eggs shed in the preceding spring; 254 were taken on the 9th; cod of similar size occur, but in much smaller numbers. On the 9th half a dozen of the year's plaice were also taken.

These observations give a distinct and accurate idea of the destruction of young fish by shrimp fishing at the mouth of the Humber. The young fry of the year are largely taken in the case of two species only, the plaice and the whiting, the former at the very edge of the water by the shove-net and cart-trawl, the latter by the shrimp-trawl. These results, of course, only hold good for the months mentioned, the observations not extending beyond September. A considerable number of year-old, and therefore immature specimens, are taken of the sole, plaice, turbot, and brill by the shove-nets, and they are also taken mixed with older specimens, some of which are mature, by the shrimp-trawls. Mr. Holt writes to me that spent soles begin to appear in the Humber about the beginning of July, and become numerous afterwards; that before July there are none but immature soles, with the occasional exception of a large fish which has not yet spawned. It must be remembered that, according to my observations in the flounder, only a minority of fish are mature at two years old. It is especially noteworthy that not a single lemon sole (*Pleuronectes microcephalus*) was taken in the shrimp-nets in the Humber.

The specimens in the list, which were obtained on the deep-sea trawling ground, are few in number. The most interesting are small cod, whiting, and haddock taken in July and August. These are from 2 to 5 inches long, and evidently derived from the year's spawning. The haddock were taken at thirty fathoms on the Great Fisher Bank, and also fifty to sixty miles to the eastward of Spurn Light-vessel at twenty fathoms, but most abundantly on the latter ground where eight occurred on one occasion, thirty-one on another. The young cod were most numerous on the Great Fisher Bank, where whiting did not occur at all; eight of the latter occurred in the other region mentioned. This shows that the whiting fry of the year are not confined to inshore waters, while the haddock fry seem to be absent from the latter entirely.

Of the fish obtained in Grimsby Market the smallest sole was 8 inches long, many were only 9 or 10 inches, but the majority were over 10 inches. Those about 8 inches long may have been only one year old, but the rest were probably two years or more. Plaice from the market were examined in May and June, and large numbers were obtained between 6 and 12 inches in length, those between 8 and 10 inches being most numerous. According to Mr. Holt all these were immature, but a male plaice was observed once to be ripe at 6¼ inches. Some plaice may reach 12 inches in one year, but probably only a small proportion, so that these small plaice from the market may be considered as mixed, some one year and some two years old. The only other fish in the list taken from the market were 140 turbot 11 to 15 inches long. Most of these were probably two years old or more, though some turbot may reach 12 inches in a year.

Pleuronectes platessa, the Plaice.

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
Jan. 29	7	4·5—5·4	$1\frac{3}{4}$—$2\frac{1}{8}$	8 or 9 months	Humberstone Sands, near Cleethorpes; sprat stake-nets.
	7	9·5—19·1	$3\frac{3}{4}$—$7\frac{1}{2}$	9 to 12 ,,	
Feb. 20	1	15·9	$6\frac{1}{4}$	2 years (ripe male)	35 miles E. of Flamborough Head, 33 fathoms; deep-sea trawler.
March 30	1	8·9	$3\frac{1}{2}$	12 to 14 months	Humber, North Channel, 1 to 2 fathoms.
	6	10·2—12·1	4—$4\frac{3}{4}$	,,	
	11	12·7—14·6	5—$5\frac{3}{4}$	,,	
	12	15·2—17·2	6—$6\frac{3}{4}$	,,	
	16	17·8—19·7	7—$7\frac{3}{4}$	,,	
	17	20·3—22·2	8—$8\frac{3}{4}$	,,	
	7	22·8—24·7	9—$9\frac{3}{4}$	2 years	
	1	25·3	10	,,	
	2	27·9	11	,,	
April 25	5	3·8	$1\frac{1}{2}$	2 to 3 months	Cleethorpes to Humberstone Sands, spring tides; shrimp shove-net.
	149	4·4	$1\frac{3}{4}$	,,	
	240	5·1	2	,,	
	176	5·7	$2\frac{1}{4}$	3 to 4 months	
	72	6·3	$2\frac{1}{2}$	,,	
	27	7·0	$2\frac{3}{4}$	,,	
	13	7·6	3	,,	
	4	8·3	$3\frac{1}{4}$	About 1 year	
	3	8·9	$3\frac{1}{2}$	,,	
	3	9·5	$3\frac{3}{4}$	,,	
	4	10·2	4	,,	
	204	4·4—10·8	$1\frac{3}{4}$—$4\frac{1}{4}$	Smaller 2—4 months	
	1	11·5	$4\frac{1}{2}$	1 year	
	3	12·7—15·2	5—6	,,	
	1	18·4	$7\frac{1}{4}$	,,	
	Many	22·9 circâ	9 circâ	1 year or 2	
April 28	172	4·1—7·9	$1\frac{5}{8}$—$3\frac{1}{8}$	2 to 4 months	Cleethorpes Sands; shrimp shove-net.
	16	8·6—10·8	$3\frac{3}{8}$—$4\frac{1}{4}$	About 1 year	
	1	12·0	$4\frac{3}{4}$	,,	
	4	15·2—20·3	6—8	,,	
May 10–11	1	4·6	$1\frac{13}{16}$	2 to 3 months	Cleethorpes Sands; shrimp shove-net, at night.
	2	5·0	2	,,	
	3	5·4	$2\frac{1}{8}$	,,	
	22	5·7—7·0	$2\frac{1}{4}$—$2\frac{3}{4}$	,,	
	10	7·6	3	3 to 4 months	
	4	8·2	$3\frac{1}{4}$	,,	
	6	8·9	$3\frac{1}{2}$	,,	
	7	9·5—12·0	$3\frac{3}{4}$—$4\frac{3}{4}$	About 1 year	
	8	12·7—15·2	5—6	,,	
May 16	9	21·5	$8\frac{1}{2}$	1 year 4 months	Grimsby Market, from Arlberg, Denmark; 84 males and 114 females, all immature, contents of one box; fish much the same size in all boxes.
	37	22·8	9	,,	
	51	24·1	$9\frac{1}{2}$	,,	
	43	25·3	10	,,	
	18	26·6	$10\frac{1}{2}$	,,	
	11	27·9	11	,,	
	6	29·2	$11\frac{1}{2}$	,,	
	11	30·5	12	,,	
	7	31·7	$12\frac{1}{2}$	,,	

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
May 20	7	15·2	6	13 to 16 months	Tetney, mouth of the Humber; shrimp trawler.
	44	16·5	$6\frac{1}{2}$	,,	
	92	17·8	7	,,	
	81	19·0	$7\frac{1}{2}$	,,	
	92	20·3	8	,,	
	52	21·6	$8\frac{1}{2}$	,,	
	34	22·8	9	,,	
	15	24·1	$9\frac{1}{2}$	,,	
	8	25·3—27·9	10—11	,,	
May 24	2	12·7—15·2	5—6	13 to 16 months	Humber; shrimp trawler.
	27	17·8	7	,,	
	90	20·3	8	,,	
	67	22·8	9	,,	
	42	25·3	10	,,	
	6	27·9	11	,,	
May 28	2	12·7—13·9	5, $5\frac{1}{2}$	13 to 16 months	Cleethorpes Sands; shove-net.
	3	15·2—22·8	6—9	,,	
	1	24·1	$9\frac{1}{2}$	,,	
June 1	10	4·7—7·0	$1\frac{7}{8}$—$2\frac{3}{4}$	3 months	Cleethorpes; cart-trawl.
	1	16·2	$6\frac{3}{8}$	14 ,,	
June 1	1	15·2	6	14 to 18 months	Grimsby Market, from Schiermonnikoog; contents of one box, 154 males and 154 females, all immature except 2 males.
	8	17·8	7	,,	
	71	20·3	8	,,	
	120	22·8	9	,,	
	76	25·3	10	,,	
	5	27·9	11	Perhaps over 2 years	
	4	30·5	12	,,	
	1	33·0	13	,,	
June 3	235	4·1—7·9	$1\frac{5}{8}$—$3\frac{1}{8}$	3 or 4 months	Cleethorpes to Humberstone; cart-trawl.
	3	8·9—10·5	$3\frac{1}{2}$—$4\frac{1}{8}$	6 months	
	2	10·2	4	,,	
	15	12·7	5	,,	
	35	15·2	6	Over 1 year	
	17	17·8	7	,,	
	8	20·3	8	,,	
	1	23·2	$9\frac{1}{8}$	,,	
July 19	25	2·1—4·4	$1\frac{1}{16}$—$1\frac{3}{4}$	3 months	Cleethorpes Sands; shove-net.
July 22	13	2·5—3·3	1—$1\frac{5}{16}$	,,	
Sept. 9	5	3·9—4·6	$1\frac{9}{16}$—$1\frac{13}{16}$	5 months	Off Humberstone; shrimp-trawl.
Sept. 10	38	3·6—4·9	$1\frac{7}{16}$—$1\frac{15}{16}$	5 or 6 months	Cleethorpes to Humberstone; shrimp shove-net; low tide just after springs.
	3	5·5—7·0	$2\frac{3}{16}$—$2\frac{3}{4}$	7 months	
	1	12·7	5	8 ,,	

It will be seen from the above record that there was a great outburst, so to speak, of small plaice at the end of April. On April 25th several hudhred were taken in the shove-net, on the 28th nearly 200. The greatest number of these were 2 inches in length, their range in length was from $1\frac{1}{2}$ to 3 inches; the specimens exceeding 3 inches were comparatively few in number. In May only a few specimens of this size were taken. They appear only on one day (or night), May 10th—11th, the number is less than fifty; the average size of these is a little larger, the greatest number being from $2\frac{1}{4}$ to $2\frac{3}{4}$. At the beginning of June another outburst appears; on the 1st only a few are taken, but on the 3rd 235 are taken in the cart-trawl. In July, in the middle of the month a few still smaller specimens are taken, only about $1\frac{1}{2}$ inches long, and as late as the beginning of September we find thirty-eight specimens under 2 inches long in the shove-net. Mr. Holt finds that plaice spawn in the North Sea chiefly from the middle of January to the end of March, though a few may spawn earlier or later. I think it is evident that the large number of specimens 2 inches in length taken at the end of April are derived from the eggs shed in January, and are therefore three months old. Those which are larger may be a week or two older or may have grown faster. I have shown in previous papers how variable the rate of growth is. Those which are smaller than 2 inches, may in like manner be younger, or may have grown more slowly. It is difficult to fix the maximum size of specimens derived from the immediately preceding spawning season. I have fixed it at 3 inches, referring specimens above this length to the spawning of the previous year. I do not understand why comparatively few of these young plaice were taken in May. The large number taken at the beginning of June include chiefly those hatched in February and March. Those taken in July and September are few in number, and represent those whose growth has been slow, who have been behindhand in the competition for food, or which are the progeny of the last spawners of the season, of parents which spawned in April or even in May. All these young plaice of the year are taken on the flat sandy shores near Grimsby in shrimp nets, either in the shove-net, which is worked by hand, and has a spread of 10 feet, or by the cart trawl which is towed by a horse. I have shown previously (this Journal, vol. ii, No. 2, p. 99), that plaice of the year occur in June on similar sandy shores near Plymouth. It is evident that the destruction or, at any rate, the capture of plaice fry by shrimpers at the mouth of the Humber must be enormous.

I have considered the seven specimens taken in sprat stake-nets on January 29th to be remnants of the previous year's brood. Possibly some plaice may spawn in December, but even then the young fish produced could not reach a length of two inches in less than two months. These small fish must, therefore, be derived from the spawning of the previous year, and be eight or nine months old *at least*. The consideration of such specimens as these shows conclusively that fish may live in the sea for months, with scarcely any increase in size, just as some of the flounders out of a number kept by me in captivity. Some of my captive flounders were only about 2 inches in length when one year old; these plaice taken at Humberstone in January were of the same length, and must have been at least eight months old, while they may have been more.

It is not easy to infer from the data given in the table, the average size or the limits of growth of the plaice in their second year. In the entry for May 20th we have a large number of specimens certainly over a year old, and the greater number of these are $6\frac{1}{2}$ to $8\frac{1}{2}$ inches long. The flounders I reared in captivity were mostly from 4 to 6 inches long at one year of age, and as the plaice in the North Sea is a much larger fish, and these were taken some months after the principal spawning season, these specimens may all have been in their second year only. But on the other hand, it is certain that some fish at two years old are not bigger than others at one year, so that it is impossible to say whether some fish in their third year may not be present in this lot.

The maximum growth for a plaice of fourteen to sixteen months old is difficult to fix with the evidence at present available. The maximum observed by me in the flounder at one year was $7\frac{1}{2}$ inches, and as the plaice in the North Sea reaches 28 inches in length, while the flounder's maximum length is 16 or 17 inches, individual plaice might reach $12\frac{1}{2}$ inches in sixteen months. I have accordingly estimated the age of the specimens of May 16th from the Denmark coast at twelve to sixteen months; a conclusion supported by the fact that they were all immature. But some of these specimens may be in their third year.

It will be seen from the entry of March 30th, of fish taken in the Humber by a shrimp trawler, that many plaice occur, only 4, 5, or 6 inches long, which are certainly a year old.

Pleuronectes flesus, the Flounder.

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
April 25	3	6·3—8·4	$2\frac{1}{2}$—$3\frac{5}{16}$	1 year	Cleethorpes to Humberstone Sands; shrimp shove-net.
	3	11·4—12·4	$4\frac{1}{2}$—$4\frac{7}{8}$	,,	
	1	23·5	$9\frac{1}{4}$	2 or 3 years	
	Several	About 22·8	About 9	,,	
April 28	4	5·9—9·1	$2\frac{5}{16}$—$3\frac{5}{8}$	1 year	Cleethorpes Sands; shove-net.
	2	10·8, 15·9	$4\frac{1}{4}$, $6\frac{1}{4}$	,,	
May 14	2	9·5, 12·5	$3\frac{3}{4}$, $4\frac{7}{8}$	1 year	Humberstone Sands; cart-trawl.

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
May 20	1	12·7	5	1 year	Tetney, mouth of Humber; shrimp trawler.
	2	19·0	7½	,,	
	9	20·3	8	2 years	
	8	22·9	9	,,	
	3	24·1	9½	,,	
	3	25·4	10	,,	
	1	28·0	11	3 years	
	1	33·0	13	,,	
May 24	1	16·5	6½	1 year	Humber; shrimp trawler.
	1	19·0	7½	,,	
	1	20·3	8	2 years	
	2	22·9	9	,,	
	1	24·8	9¾	,,	
	2	25·4	10	,,	
	1	30·5	12	3 years	
June 1	1	7·0	2¾	1 year	Cleethorpes Sands; cart-trawl.
June 3	2	8·9, 12·0	3½, 7½	,,	

It will be seen from the table, that Mr. Holt has not obtained the young flounders of the year. The flounder spawns in the North Sea from February to the end of May, probably in March and April chiefly; there is thus no difference between the periods at Grimsby and at Plymouth, except that at Plymouth it begins and ends a few weeks earlier. The newly metamorphosed flounders appear at Mevagissey in the beginning of May or end of April, and are then only about ½ inch long.

I should think that the shove-net is as well adapted to catch small flounders as small plaice, and there must be plenty of flounders of the year's brood somewhere in the neighbourhood of Grimsby in June and July. Probably the reason that they are absent from these collections is that they ascend the rivers, and are, therefore, not to be found at the mouth of the estuary with the plaice.

Pleuronectes limanda, the Dab.

Date of collection.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
Feb. 20	1	12·1	4¾	1 year, ♀ immature	35 miles E. of Flamborough Head, 33 fathoms.
	6	12·3—15·6	5¼—6⅛	2 years, ripe	
	5	16·8—20·3	6⅝—8	,,	
March 3	3	16·5—17·1	6½—6¾	2 years	45 miles E.N.E. of Spurn Light-vessel, 33 fathoms.
	26	17·8—20·3	7—8	,,	
	6	20·6—21·3	8⅛—8⅜	3 years	
	1	20·4	10	,,	

Date of collection.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
March 30	1	2·0	$\frac{3}{4}$	6 weeks	North Channel, Humber, 1 to 2 fathoms.
	2	3·2	$1\frac{1}{4}$	10 months	
	3	3·8—5·1	$1\frac{1}{2}$—2	,,	
	1	8·2	$3\frac{1}{4}$	1 year	
April 2	4	13·3—14·6	$5\frac{1}{4}$—$5\frac{3}{4}$	2 years	S.W. edge of Dogger, $12\frac{1}{2}$ to 33 fathoms.
	4	15·9—17·2	$6\frac{1}{4}$—$6\frac{3}{4}$	,,	
	4	20·6—22·9	$8\frac{1}{8}$—9	3 years	
April 6	2	7·0—7·6	$2\frac{3}{4}$—3	1 year	W. edge of Dogger, 27 to 30 fathoms.
	1	14·0	$5\frac{1}{2}$	,,	
	11	15·3—17·2	6—$6\frac{3}{4}$	2 years	
	20	17·8—19·7	7—$7\frac{3}{4}$	,,	
	15	20·3—22·2	8—$8\frac{3}{4}$	3 years	
	1	24·1	$9\frac{1}{2}$	,,	
April 25	3	3·3—4·4	$1\frac{1}{4}$—$1\frac{3}{4}$	1 year	Cleethorpes to Humberstone Sands; shrimp shove-net.
April 28	2	4·1—4·7	$1\frac{5}{8}$—$1\frac{7}{8}$	,,	Cleethorpes Sands; shove-net.
May 10	5	4·1—5·0	$1\frac{5}{8}$—2	,,	Ditto, by night.
	5	5·2—8·9	$2\frac{1}{16}$—$3\frac{1}{8}$	,,	
May 14	2	4·8	$1\frac{7}{8}$	,,	Humberstone Sands; cart-trawl.
July 12	7	5·7—9·5	$2\frac{1}{4}$—$2\frac{3}{4}$	1 year 3 months	Inner shoal water of Great Fisher Bank, 30 fathoms trawl amongst *Flustra foliacea.*
	1	33·0	13	4 years	

Mr. Holt tells me that the dab began to spawn at Grimsby in the middle of February, and continued till the end of May; March and April being the principal months. Taking this into consideration, I find that among all the specimens registered above only one could possibly be derived from the spawning of 1892, namely the specimen $\frac{3}{4}$ inch long, taken on March 30th. I do not think that a specimen, hatched towards the end of February, could reach a length of $1\frac{1}{4}$ inches by the end of March, and have, therefore, attributed the specimens of that size to the spawning of the previous year. The young dabs from the same year's spawning were not taken in the shore-nets in June and July together with the plaice. I have estimated the probable age of the larger specimens in accordance with the considerations discussed in a former paper (this Journal, vol. ii, No. 2, p. 101). The examination of these specimens confirms the conclusions I formed from those collected at Plymouth.

There is only one specimen of the lemon sole (*Pleuronectes microcephalus*) in the collection; it is $7\frac{1}{2}$ inches (19 cm.) long, taken on the south-west edge of the Dogger Bank in $12\frac{1}{2}$ to 33 fathoms on April 2nd. This specimen may have been one year old, but was more probably two years. Three specimens of the long rough dab (*Hippoglossoides limandoides*) were taken, two on April 4th, $4\frac{1}{16}$, $4\frac{5}{8}$ inches long (10·3, 11·8 cm.) on the west edge of the Dogger, and one on July 12th, on the Great Fisher Bank, $5\frac{1}{2}$ inches long (14 cm.). These three were doubtless year-old fish. The limits of the spawning period were not observed, but some fish of this species were found to be spawning in March.

Solea vulgaris, the Sole.

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
Feb. 9	3	27·3—30·2	$10\frac{3}{4}$—$11\frac{7}{8}$	3rd year	Grimsby Market, smallest procurable, probably from Silver Pits.
	2	30·5—32·0	12—$12\frac{5}{8}$	„	
Feb. 10	8	22·8—29·8	9—$11\frac{3}{4}$	„	
Feb. 11	4	25·1—29·2	$9\frac{7}{8}$—$11\frac{1}{2}$	„	
	3	30·5—31·4	12—$12\frac{3}{8}$	„	
Feb. 20	3	25·4—26·9	10—$10\frac{5}{8}$	„	
	6	28·3—29·5	$11\frac{1}{8}$—$11\frac{5}{8}$	„	
	2	31·1—31·7	$12\frac{1}{4}$—$12\frac{1}{2}$	„	
Feb. ?	7	28·6—31·1	$11\frac{1}{4}$—$12\frac{1}{4}$	„	
March 30	1	14·6	$5\frac{3}{4}$	8 to 10 months	Humber, North Channel, 1 to 2 fathoms.
April 25	4	6·0—8·6	$2\frac{3}{8}$—$3\frac{3}{8}$	9 to 12 months	Cleethorpes; shrimp shove-net.
April 28	1	8·9	$3\frac{1}{2}$	„	
	1	20·3	8	1 year	Grimsby Market, smallest procurable.
	4	22·8—25·4	9—10	2 years	
	2	27·9	11	„	
May 4	2	7·6, 9·5	3, $3\frac{3}{4}$	9 to 12 months	Cleethorpes Sands; shove-net.
May 10	2	6·5, 7·3	$2\frac{1}{2}$, $2\frac{7}{8}$	„	Humberstone Sands; cart-trawl.
May 14	1	11·8	$4\frac{5}{8}$	„	
May 16	9	22·8—24·1	9—$9\frac{1}{2}$	2 years	Grimsby Market, from Dutch coast, smallest procurable; nearly all males.
	29	25·4—26·6	10—$10\frac{1}{2}$	„	
	4	27·9—29·2	11—$11\frac{1}{2}$	„	
	2	20·3, 21·6	8, $8\frac{1}{2}$	„	Humber; shrimp trawler; the whole catch sold, but smaller fish may have been eliminated at sea.
	4	22·8—24·1	9—$9\frac{1}{2}$	„	
	1	38·1	15	3 years	
May 17	1	8·4	$3\frac{1}{4}$	$9\frac{1}{2}$ to $12\frac{1}{2}$ months	Cleethorpes Sands; shove-net.
May 19	2	17·8—19·0	7, $7\frac{1}{2}$	1 year	Humber; shrimp trawler; whole catch as brought to market.
	10	20·3—21·6	8—$8\frac{1}{2}$	2 years	
	16	22·8—24·1	9—$9\frac{1}{2}$	„	
	2	25·4—26·6	10—$10\frac{1}{2}$	„	
May 27	3	20·3	8	„	
	15	21·6	$8\frac{1}{2}$	„	
	9	22·8	9	„	
	6	24·1	$9\frac{1}{2}$	„	
	1	25·4	10	„	
May 31	4	21·6	$8\frac{1}{2}$	„	
	3	22·8	9	„	
	3	24·1	$9\frac{1}{2}$	„	
	2	25·4	10	„	
	1	26·6	$10\frac{1}{2}$	„	

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
June 1	2	9·2—15·2	3⅝, 6	10 to 13 months	Cleethorpes Sands; cart-trawl.
June 3	2	8·3, 8·7	3¼, $3\frac{7}{16}$	"	Cleethorpes to Humberstone; cart-trawl.
June 15	4	21·6	8½	2 years	Humber; shrimp trawler.
	3	22·8	9	"	
	3	24·1	9½	"	
	2	25·4	10	"	
	1	26·6	10½	"	
June 17	2	17·2—17·5	6¾—6⅞	1 year	
	10	18·1—20·3	7⅛—8	"	
	25	20·6—22·9	8⅛—9	2 years	
	10	23·5—24·4	9¼—9⅝	"	
	5	25·4—26·0	10—10¼	"	
	2	28·6—29·9	11¼—11¾	"	
	1	32·0	12⅝	3 years	
June 15	8	6·4—8·9	2½—3½	10½ to 13½ months	Cleethorpes Sands; shove-net.
	1	22·9	9	2 years	Humberstone Sands; shove-net.
June 23	2	7·8, 11·3	$3\frac{1}{16}$, $4\frac{7}{16}$	11 to 14 months	New Clee; shove-net.
July 2	2	10·2, 19·1	4, 7½	"	
July 14	3	12·7—15·2	5—6	1 year	Mouth of Humber, Tetney ground; shrimp trawler's whole catch for night; no fish returned to sea.
	9	16·5	6½	"	
	5	17·8	7	"	
July 15	2	16·8, 17·2	6⅝, 6¾	11½ to 14½ months	Tetney Sands; shove-net.
July 20	1	9·8	3⅞	"	Cleethorpes Sands; shove-net.

The most interesting feature of this collection is the absence of soles small enough to be referred to the spawning season of the same year. Mr. Holt finds that in the North Sea the spawning period of the sole coincides with that of the brill, but that it is not quite over till the beginning of August. Therefore, it begins at the end of April, goes on chiefly in May and June, and rare individuals are found spawning in July. The smallest specimens obtained are 2⅜ to 2½ inches, 6·0 to 6·4 cm. long, and were taken in the shove-net on Cleethorpes sands in April, May, and June. These could not be less than nine or ten months old, and may have been more, so that some soles grow as slowly under natural conditions as some of the flounders which I have reared in captivity. These soles of the previous year's brood were taken chiefly in the shove-net or the cart-trawl quite close to the shore, very few appearing in the produce of the shrimp trawlers. The sole is somewhat larger than the flounder, and we may reasonably suppose that 8 inches is about the maximum length attained in one year's growth. The total number of specimens obtained which were less than 8 inches long is sixty-two, of which thirty-five were taken in the shrimp trawl at some distance from shore, and twenty-seven in the shove-net in less than one fathom of water. But the smallest taken in the shrimp trawl is 5 inches long, and some of the specimens between 5 and 8 inches may be in their third year. We can scarcely suppose that these small numbers represent more than a small portion of the previous year's produce, so that one-year-old soles would seem to be by no means exclusively found in shallow waters near shore.

The young soles derived from the year's spawning might be expected to appear from June onwards, and to be at first from ½ inch to 1½ inches in length, later reaching 2 inches. But although plaice of about this size were taken in June, July, and September, no such soles appear. At Mevagissey I have found soles less than 1 inch long in May in small numbers in tide pools, so that it is certain they do occasionally come to the shore. Provisionally I infer from these facts that the soles of the year are widely distributed over the North Sea, and do not, like the plaice, collect together in the shallow waters near the shore.

There is no definite gap or interval between the series of sizes of the soles caught by the shrimp trawl in the Humber, and the series of those caught by the deep-sea trawl, and procured in Grimsby Market. The minimum size of the deep-sea specimens is larger, namely 8 inches, but soles of 8 to 12 inches and upwards are obtained both in the estuary and out at sea, both in the shrimp trawl and the great trawl. I have attempted to indicate the probable age of these specimens, taking 12 inches as about the maximum length, at two years of age; but, as I have before pointed out, the growth of fish is so variable in different individuals, that it is not possible to distinguish by size alone two-year-old specimens from those which are three years old or more.

Rhombus lævis, the Brill.

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
April 25	2	9·1—9·6	$3\frac{5}{8}$—$3\frac{3}{4}$	9 to 11 months	Cleethorpes to Humberstone Sands; shrimp shove-net.
April 28	1	10·4	$4\frac{1}{16}$	,,	Cleethorpes Sands; shrimp shove-net.
May 4	2	7·4—9·6	$2\frac{15}{16}$—3	10 to 12 months	,, ,, ,,
May 14	2	9·8—10·8	$3\frac{7}{8}$—$4\frac{1}{4}$	,,	Humberstone Sands; cart-trawl.
June 15	2	8·9—10·4	$3\frac{1}{2}$—$4\frac{1}{8}$	11 to 13 months	Humberstone Sands; shrimp shove-net.
July 20	1	13·9	$5\frac{1}{2}$	,,	Cleethorpes; shove-net.

Mr. Holt finds that the brill begins to spawn in the latter part of April, and that some ripe fish are found until the end of July, the majority of the fish shedding their eggs in May and the early part of June. It is clear, therefore, that the specimens recorded in the table are all about a year old. In a previous paper (Journ. Marine Biol. Assoc., vol. ii, No. 2) I recorded the growth of young brill reared by me in captivity in 1890—91; some of them reached 2·8 to 3·9 inches in length in six months, others 3·3 to 3·7 inches in twelve months. It is interesting to find that the specimens collected by Mr. Holt from the sea were no larger at the end of their first year than those reared in the Plymouth aquarium. At the same time these year-old brill were taken only in small numbers in the shrimp-nets in the Humber, and cannot be considered as fully representing the young fish derived from the spawning of the previous year. Probably the year-old fish are widely distributed from the shore to deep water, and the average and the maximum sizes for fishes at that age are probably greater than those of the above specimens. The young brill of the year are pelagic in May and June, and could not be taken on the bottom till August and September and following months

Rhombus maximus, the Turbot.

Date of capture.	No. of specimens.	Length of centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
April 25	1	7·9	$3\frac{1}{8}$	8 to 11 months	Cleethorpes to Humberstone Sands; shrimp shove-net.
May 16	1	6·8	$2\frac{11}{16}$	9 to 12 months	Cleethorpes; seine.
May 16	2	7·3, 8·5	$2\frac{7}{8}$, $3\frac{3}{8}$	,,	Humberstone Sands; cart-trawl.
June 3	140	28·0—38·1	11—15	2 years	Grimsby Market; trawler from opposite coast; the whole catch of this species.
June 15	1	10·6	$4\frac{1}{8}$	10 to 13 months	Humberstone Sands; shrimp shove-net.
Taken in surface-net:					
July 1	1	·55	$\frac{3}{16}$	A few weeks	22 miles N.N.E. of Horn Light Vessel.
	12	·6—·9	$\frac{1}{2}$—$\frac{5}{8}$	,,	
July 12	1	·7	$\frac{1}{4}$	,,	Inner shoal of Great Fisher Bank; about 220 miles N.E. by E. of Spurn Light Vessel.
July 28	22	·7—1·3	$\frac{1}{4}$—$\frac{1}{2}$	,,	150 miles E. by N. of Spurn Light Vessel.
Aug. 10	6	·6—1·6	$\frac{1}{4}$—$\frac{5}{8}$	,,	Off the N.W. corner of the Dogger.

The spawning of the turbot in the North Sea, according to Mr. Holt, is general in June and July, but occasional ripe fish occur as early as the end of March and as late as the beginning of September.

In the above estimates of ages I have included, therefore, four spawning months—May, June, July, and August—leaving out April, when probably few turbot spawn. Those taken in shore waters in the shrimp-nets, like the young brill in the previous table, are undoubtedly from the spawning of the previous year, and probably represent only the most backward specimens of that year's brood. I have at present no evidence as to the average or the maximum length of year-old specimens; but as the maximum length of the turbot, according to Dr. Fulton, is 28 inches, I should think that most of those obtained in Grimsby Market on June 3rd, 11 to 15 inches long, were two years old, and some may have been three years.

Some observations on the growth of turbot in captivity were made many years ago in France, and are published in the *Bulletin de la Société Impériale Zoologique d'Acclimatation* for 16th June, 1865. At the aquarium of Concarneau young turbot hatched in June, 1864, had a length of 5 to 6 cm., 2 to $2\frac{3}{8}$ inches, on April 16th, 1865, and a mean weight of 4 grammes. Others, a little older, hatched in April, 1864, had on the same date a length of 14 to 19 cm., $5\frac{1}{2}$ to $7\frac{1}{2}$ inches, and weighed 52 to 126 grammes. Others about two years old measured 20 to 28 cm., $7\frac{7}{8}$ to 11 inches, and weighed 200 to 380 grammes. All these specimens had been taken by the seine on sandy shores, and how far the ages given are accurate I am unable to say. But the sizes given agree closely with my own conclusions. The authors call particular attention to the inequality in the rate of growth, and give the same explanation as I have given for my captive flounders, namely, that the most greedy and boldest individuals seize all the food.

Gadus morrhua, the Cod.

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
July 12	Many	4·7—12·7	$1\frac{3}{4}$—5	3 to 6 months	Inner shoal-water of Great Fisher Bank, 30 fathoms, trawl, among *Flustra foliacea.*
Aug. 14	2	5·0, 6·3	2, $2\frac{1}{2}$	4 or 5 months	54 miles E. of Spurn Light Vessel; trawl, 20 fathoms.
Sept. 7	1	7·3	$2\frac{7}{8}$	5 or 6 months	Shrimp trawl, off Humberstone.
Sept. 9	13	6·0—7·3	$2\frac{3}{8}$—$2\frac{7}{8}$	,,	Shrimp trawl, off Humberstone.
	3	8·0—9·8	$3\frac{1}{8}$—$3\frac{7}{8}$	,,	Shrimp trawl, off Humberstone.

The cod spawns chiefly from the end of January to the end of April, and it is evident that these specimens belong to the year's produce. They seem to be widely distributed, having been taken both on the Fisher Bank in the middle of the North Sea, and in the estuary of the Humber.

Gadus merlangus, the Whiting.

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
Jan. 29	118	10·2—14·9	$4—5\frac{7}{8}$	9 months	} Sprat stake-nets at Humberstone Sands.
	11	15·2—19	$6—7\frac{1}{2}$	11 months	
Feb. 20	2	17·1—21	$6\frac{3}{4}—8\frac{1}{4}$	11 months and 2 years	35 miles E. of Flamborough Head; 33 fathoms.
Mar. 3	1	14·6	$5\frac{3}{4}$	1 year	45 miles E.N.E. of Spurn Light Vessel; 33 fathoms.
Mar. 30	5	12·1—15·2	$4\frac{3}{4}—6$	"	North Channel, Humber; 1 to 2 fathoms.
April 2	2	22·9—25·4	9—10	2 years	S.W. corner of Dogger; 20 to 26 fathoms.
April 2	Number	16·5	$6\frac{1}{2}$ upwards	1 and 2 years	S.W. edge of Dogger; $12\frac{1}{2}$ to 33 fathoms.
April 2	"	20·3	8 upwards	2 years	W. edge of Dogger; 20 to 33 fathoms.
May 10	2	10·2—14	$4, 5\frac{1}{2}$	11 months	Cleethorpe Sands; shrimp shove-net.
Aug. 8	1	8·3	$3\frac{1}{4}$	4 months	54 miles E. of Spurn Light Vessel; 20 fathoms.
Aug. 28	7	7·6—9·2	$3—3\frac{5}{8}$	"	61 miles E. by S. of Spurn Light Vessel; 16 to 20 fathoms.
Sept. 7	44	7·3—11·1	$2\frac{7}{8}—4\frac{3}{8}$	3 to 6 months	} Off Humberstone; shrimp trawl.
Sept. 9	254	6·7—12·6	$2\frac{5}{8}—4\frac{15}{16}$	"	
Sept. 10	1	9·5	$3\frac{3}{4}$	"	Cleethorpes to Humberstone; shove-net.

Mr. Holt finds that the whiting spawns in the North Sea from the beginning of March to the early part of June, chiefly in April. It is evident, therefore, that whiting taken on January 29th could not be less than eight months old. The specimens taken on this date are from 4 to $7\frac{1}{2}$ inches long. The smaller, 4 to $5\frac{7}{8}$ inches, might, I think, easily have reached that length if spawned the preceding April. The others, 6 to $7\frac{1}{2}$ inches long, are more doubtful; the adult whiting does not exceed 16 inches in length, and some flounders, which are of the same size when full grown, reach $7\frac{1}{2}$ inches in a year; I have, therefore, estimated the age of these whiting at eleven months. I do not think, however, that a whiting could reach $8\frac{1}{4}$ inches in less than one year, and have put down the specimen of this size of February 20th as two years old. The whiting of the year appear, like the plaice, in large numbers in inshore waters, but later in the year; this is shown by the abundance of young specimens taken in the Humber at the beginning of September. They are not, however, entirely restricted to littoral zones, some having been taken in August in the middle of the North Sea.

Gadus æglefinus, the Haddock.

Date of capture.	No. of specimens.	Length in centimetres.	Length in inches.	Probable age.	Locality and mode of capture.
Mar. 3	1	20·3	8	1 year	45 miles E.N.E. of Spurn Light Vessel; 33 fathoms.
April 2	Number	20·3 to 50·8	8 to 20	1 and 2 years and upwards	S.W. corner of Dogger; 20 to 26 fathoms.
April 2	Number	17·8 upwards	7 upwards	„	W. edge of Dogger; 20 to 33 fathoms.
May 20	1	16·5	$6\frac{1}{2}$	1 year	Grimsby Market.
	10	17·8—19·1	$7—7\frac{1}{2}$	„	
	17	20·3—21·6	$8—8\frac{1}{2}$	„	
	1	22·8	9	„	
	3	25·4—26·6	$10—10\frac{1}{2}$	2 years	
	2	28·0—29·2	$11—11\frac{1}{2}$	„	
July 12	2	5·7—8·9	$2\frac{1}{4}$, $3\frac{1}{2}$	4 or 5 months	Inner shoal water of Great Fisher Bank; 30 fathoms; trawl; amongst *Flustra foliacea.*
Aug. 14	1	8·1	$3\frac{3}{16}$	4 to 6 months	54 miles E. of Spurn Light Vessel; 20 fathoms; trawl.
	2	8·7, 8·9	$3\frac{7}{16}$, $3\frac{1}{2}$	„	
	2	9·8, 10·0	$3\frac{7}{8}$, $3\frac{15}{16}$	„	
	2	10·6, 10·8	$4\frac{3}{16}$, $4\frac{1}{4}$	„	
	1	12·1	$4\frac{3}{4}$	„	
Aug. 28	2	8·9, 9·1	$3\frac{1}{2}$, $3\frac{9}{16}$	4 to 6 months	61 miles E. by S. of Spurn Light Vessel; 16 to 20 fathoms; trawl.
	19	9·6—10·8	$3\frac{3}{4}—4\frac{1}{4}$	„	
	10	11·1—12·7	$4\frac{3}{8}—5$	„	

The haddock spawns in February, March, and April, especially in March. Young specimens derived from the year's spawning were taken on three occasions, once in July, twice in August. The number taken was not very great, and all were taken in the open sea, on the trawling grounds far from shore; none were taken in the shrimp-net or shrimp-trawls in the Humber.

These results agree with those of Dr. Fulton, published in the eighth Annual Report of the Scottish Fishery Board. I have for convenience fixed the limit between specimens one year old and two years old at 10 inches. It is evident from the entry for May 20th that a large number of year-old immature haddocks are brought to market by the trawlers.

Of *Gadus luscus,* the pout, only one specimen was obtained; it was $3\frac{5}{8}$ inches, 9·2 cm. long, and was taken in the sprat stake-net at Humberstone on January 29th. This specimen was probably hatched in the previous May or June, and was, therefore, about seven months old.

A number of young Motella, apparently *M. tricirrata,* were taken in the surface tow-nets at various positions in the North Sea as follows:

July 8th.—About fifteen miles N. of Horn Reef Light-vessel, Jutland. One specimen $\frac{5}{16}$ of an inch (8 mm.).

9th.—Twenty and twenty-two miles N.N.E. of Horn Reef Light-vessel. Many specimens.

12th.—Inner shoal-water of Great Fisher Bank. Three specimens $\frac{3}{8}$ to $\frac{1}{2}$ an inch (9 to 13 mm.). Two specimens $1\frac{1}{8}$ to $1\frac{7}{16}$ inches (2·8 to 3·7 cm.).

17th.—West Shoal and West Spit of Dogger Bank. Many $\frac{3}{8}$ to $1\frac{5}{8}$ inches (·9 to 4·1 cm.).

23rd.—Two hundred and fifty miles E. of Spurn Light-vessel. One specimen $\frac{7}{16}$ of an inch (1·1 cm.). Many $\frac{9}{16}$ to $1\frac{3}{4}$ inches (1·4 to 4·4 cm.).

27th and 28th.—One hundred and fifty miles E. by N. of Spurn Light-vessel. Several.

August 10th.—West end of Dogger. Three specimens $\frac{7}{16}$ to $\frac{5}{8}$ of an inch (1·1 to 1·6 cm.). Many $\frac{7}{18}$ to $1\frac{13}{16}$ inches (2·2 to 4·2 cm.).

18th.—One hundred and fifty miles E. $\frac{1}{2}$ S. of Spurn Light-vessel. Five specimens $\frac{5}{6}$ to $1\frac{1}{16}$ inches (1·6 to 2·7 cm.).

These were evidently hatched in May and June and were therefore one or two months old.

The two families, Pleuronectidæ and Gadidæ, only are well represented in this collection, and the specimens of these have been considered in the preceding pages. The remaining few specimens belong to various families, and the greater number of them to species of no value in the market.

Clupea harengus (*Herring*).—Two specimens $6\frac{3}{4}$ and $7\frac{3}{8}$ inches (17·2, 19·7 cm.), taken in sprat stake-net, Humberstone sands, January 29th. These were probably a year and four or five months old, assuming that they were derived from spawn shed in autumn, in August or September.

Clupea sprattus (*Sprats*).—Three $3\frac{3}{4}$ inches (9·5 cm.), five $4\frac{1}{4}$ inches (10·8 cm.), one $5\frac{1}{4}$ inches (12·3 cm.), in the same net, same date.

These were all adult or nearly so; the smallest would probably be two years old, the larger three years in the following March or April.

Osmerus eperlanus (*Smelt*).

April 25th.—Five $3\frac{1}{2}$ to $3\frac{7}{8}$ inches (8·9 to 9·8 cm.), Cleethorpes, shove-net.

25th.—One $6\frac{5}{8}$ inches (16·9 cm.), Cleethorpes, shove-net.

July 3rd.—Three $4\frac{1}{2}$ to $4\frac{3}{4}$ inches (11·5 to 12·1), Cleethorpes, cart-trawl.

The smelt spawns about April, and the smaller specimens taken at Cleethorpes were doubtless a year old, the specimen $6\frac{5}{8}$ inches long two years. The three taken in July were about fifteen months old.

Anguilla vulgaris (*Eel*).—A number of young eels, about $2\frac{1}{2}$ to $2\frac{3}{4}$ inches long (6·3 to 7·0 cm.), were taken on March 30th in the Humber, North Channel, at a depth of one to two fathoms by the shrimp trawl. Such young eels, very transparent at this size, are found everywhere in spring, and seem to be derived from spawn shed the previous autumn, so that they are three or four months old.

Scomber scomber (*the Mackerel*).—A few specimens were obtained by Mr. Holt in the tow-net.

July 9th.—Twenty-two miles N.N.E. of Horn Reef Light-vessel. Twelve specimens from 6·0 to 9·0 mm. (about $\frac{1}{4}$ of an inch).

27th and 28th.—One hundred and fifty miles E. by N. of Spurn Light-vessel. Three from 13·5 to 19·25 mm. ($\frac{1}{2}$ to $\frac{3}{4}$ of an inch).

These are the first young mackerel of the year's brood that have yet been obtained and recognised. The largest specimens already showed the specific characters, the smaller were larval. They will be described by Mr. Holt. The mackerel spawns in June and July, and the largest of these specimens were probably one to two months old.

Agonus cataphractus.

April 25th.—One $2\frac{1}{8}$ inches (5·4 cm.), Cleethorpes, shove-net.

28th.—Three $2\frac{1}{8}$ to $2\frac{5}{8}$ inches (5·4 to 6·6 cm.), Cleethorpes, shove-net.

May 10th.—Twenty $2\frac{1}{4}$ to 3 inches (5·7 to 7·6 cm.), two 5 to $5\frac{1}{2}$ inches (12·7 to 14 cm.), Cleethorpes, shove-net.

This species has adhesive ova, which at Plymouth are deposited in February and March, at Grimsby probably a little later. The specimens up to 3 inches I consider to be just over a year old, at 5 inches they may be two or three years, as the maximum length is only $6\frac{1}{2}$ inches.

Cottus bubalis.

May 10th.—Seven $2\frac{1}{2}$ to $2\frac{3}{4}$ inches (6·3 to 7·0 cm.), two 3 inches (7·6 cm.), one $4\frac{3}{4}$ inches (12·1 cm.), Cleethorpes, shove-net.

This species spawns early in the year, from January to March or April. The specimens up to 3 inches were probably in their second year, the last specimen, $4\frac{3}{4}$ inches, two years old at least.

Callionymus lyra (*the Dragonet*).—Twenty-nine specimens of this species, ranging from $1\frac{3}{4}$ to $2\frac{5}{9}$ inches in length, were taken in the shove-nets on April 25th and 28th. The adults spawn between February and May, and these small specimens were doubtless just a year old.

Gobius minutus.—This species lives on sandy shores, and is always taken in shrimp-nets. At Cleethorpes, in the shove-net, April 25th, 261 were taken, ranging from $1\frac{1}{8}$ to $3\frac{7}{8}$ inches in length. These were of all ages, one year upwards, the adult not exceeding $3\frac{1}{2}$ inches. It spawns in spring.

Syngnathus acus (*Common Pipe-fish*).

April 25th.—Two $3\frac{1}{2}$ to $4\frac{3}{4}$ inches (8·9 to 12·2 cm.), at Cleethorpes, shove-net.

June 3rd.—Twenty-four $3\frac{1}{4}$ to $4\frac{7}{8}$ inches (8·3 to 12·4 cm.), at Cleethorpes, cart-trawl.

When adult this species is 12 to 16 inches long, so that these specimens are presumably not more than a year old ; but they are nearly all breeding, the males carrying ova, and many of the females full. These young specimens differ from the large adults in several characters, and appear at first sight to belong to a distant species. The subject is discussed in Günther's Brit. Mus. Catalogue, vol. viii, p. 159.

North Sea Investigations.

(Continued.)

By

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I. On the Relation of Size to Sexual Maturity in Pleuronectids.

Introductory.—I believe that, so far as concerns the more important species, sufficient information has been accumulated to allow of the deduction of a reliable conclusion.

Though it is certain that some local variation exists in the different parts of the North Sea, I have not found it possible to treat the area otherwise than as a single district. This is of the less importance since the variation seems to be very slight, and in any practical application of the results arrived at I do not see how it would be feasible to subdivide the district.

It again becomes my pleasing duty to acknowledge much courtesy and assistance in carrying out my work. Without the permission of owners to examine the larger and more valuable kinds of fish without purchasing them, my records would be indeed meagre. I shall not attempt to enumerate those who have helped me in this way, as the list would comprise almost every smack-owner or fish merchant in Grimsby. The greater part of the work has been carried on, by kind permission of the Marine Fisheries Society of Grimsby, at the Cleethorpes Hatchery.

Scheme of Work.—The scheme upon which my deductions are based requires little explanation, since I have seen no good reason to change the opinion which I have expressed in a report upon the same subject for a different district (Sci. Proc. R. Dubl. S.,* vol. vii,

* Reprinted from the Report of the Council Royal Dubl. Soc. for 1891, Feb., 1892.

pt. 4, 1892, p. 418), that any biological definition of mature and immature fish must depend upon the conditions of the larger sex, or, strictly speaking, upon the sex in which, *as regards dimensions*, maturity is most retarded. This sex is almost invariably the female.

But it must be borne in mind that when a ripe or nearly ripe fish is caught there is, and I think can be, no means of determining whether it is spawning for the first time or has spawned in previous years. Consequently observations made during or shortly before the spawning season yield results that are only entirely reliable for the time of year during which they were made—for this reason, that a fish which by a narrow margin was either too young or too small, or from whatever cause was unfitted to spawn last season, will have very materially increased in length before the present season. In this connection researches on the rate of growth are of the highest importance, and without a greater knowledge on that subject than we already possess, it is impossible to form reliable conclusions. Much, however, may be done by continuing the examination of the reproductive organs throughout the year.

I do not know whether it will ever be practicable to utilise the evidence afforded by such fish in formulating any size limit for practical use. In any case the season is not sufficiently advanced for their consideration, and therefore in the tables which are appended I have only dealt with fish taken during, shortly before, or shortly after the spawning season. I believe that the size limits deduced from these will be quite as high as any that are likely to be acceptable, and that they will be sufficiently efficacious for the upkeep of the species.

The term "immature" is used in this paper to denote that the reproductive organs show no sign of activity, and to the best of my knowledge have not subserved a reproductive function in previous years.

Method of distinguishing the Different Conditions.—I have studied the conditions of the female reproductive organ with much more attention than has been devoted to that of the male, since the larger size and numerical preponderance render the former sex infinitely the more important in the present connection. In the case of the male I have relied chiefly on the external characters of the testis, viz. those of size, contour, and apparent consistency, since these seem to be sufficient for the purpose, except in the case of the sole, which has required more careful attention than the rest.

In the immature female, the ovary, so soon as it is large enough to be easily perceptible, is found to contain a number of minute translucent ova, their size and condition depending neither upon the season of the year nor upon the size of the fish. Thus there is no obvious difference in the ova of two plaice of five and ten inches respectively.

The first approach to maturity is denoted by an enlargement of some of the ova, and by various changes in their internal structure (well known to students of Teleostean embryology), of which we need notice only one. This is the assumption of an *opaque* condition ;* and since it is the character which is most readily apparent, I have utilised it in separating ova which are approaching an individual participation in the reproduction of the species from such as either will or may be absorbed without ever ripening. The former, for the purposes of the present work, may be termed "active," and the latter "inactive" ova, without implying the actual difference denoted by the two words. Even before they are actually visible to the naked eye, the presence of "active" ova may be detected in a germinal epithelium by a change in the coloration and consistency of the latter.†

Mr. Cunningham, in the last number of this journal, p. 227, deplores the absence of any criterion by which one can find out whether a fish has spawned or not ; if the fish be not ripe or ripening when caught "it may be sexually immature, or it may have spawned previously, its sexual organs being merely in an inactive state at that particular time of the year."

To establish such a criterion has, of course, been an essential part of the present research ; as a result, I am satisfied that the features upon which I myself, and I suppose most other observers, have been accustomed to base a diagnosis, are adequate for the purpose, provided a careful examination is possible.

I have met with no single character, nor even combination of several characters, which has a general applicability in this matter for Teleosteans as a whole. The variation in structure and disposition of the reproductive organ is so remarkable that a different treatment may be required even within the limits of a single genus.

As we are here dealing only with the flat-fishes, there is no need to advert to other forms, and I shall therefore confine myself to discussing the conditions in so far as they affect the former alone.

Undoubtedly the most important point is the distinction between immature and spent (and resting) fish.

The most important characters in distinguishing these stages may be enumerated, in the order in which they become apparent, as follows:

* The changes which give rise to the opaque condition are not the same in all species, but they occur at much the same stage of development, and appear to possess the same significance.

† Specimens in which the ovaries exhibit the other characters of immaturity, but in which the largest ova are just passing from the "inactive" to the "active" condition, are included in the tables amongst the immature.

(i) Size and appearance of ovary.
(ii) Topographical relationships of ovary.
(iii) Size and condition of living ova.
(iv) Presence of ripe ova which have failed to be extruded at the time of spawning.

Characters (i) and (ii) are essentially dependent on each other, and their interpretation varies with the species in a manner which I shall attempt to indicate below.

In the next character (iii) we have, I suppose, the clue to the difficulty in distinguishing immature and spent fish, since one may find, in the ovaries of a fish which from its large size might be supposed to have spawned at some previous time, only such "inactive" ova as I have described above. I have, however, never met with such a condition, during the spawning season, in any fish which might not, from its contiguity in size to a series of obviously immature examples, be reasonably supposed to illustrate the variation in the assumption of the mature state.

It is still too early in the season to ascertain whether a period of inactivity is a regular feature in the rhythm of ovarian development in all Pleuronectids, since some are still spawning, and others have only recently ceased to do so.

I have met with no such condition in the plaice, which is the earliest spawner of all (with the doubtful exception of the halibut, about which little is known), though I have made somewhat careful inquiries into the ovarian condition of that species since the end of the spawning season. Dabs, however, which presumably spawned about April, now* exhibit a germinal epithelium entirely destitute of active ova.

It need hardly be said that the last character (iv) is an infallible proof of previous spawning when it is present.

In all species which I have studied a certain number of ripe ova fail to make their escape, and remain to decompose either in the lumen of the ovary itself or in the ovary duct. But their number, and the period during which their presence can be ascertained, appear to vary with the individual and also with the species. Thus I believe that they are most numerous and perceptible for the longest period in the plaice, perhaps because this species has the largest ova; and I have no doubt the lemon sole is the form in which this character gives us the least assistance. I have received a plaice with ovaries enormously distended with ripe, yet dead and slightly decomposed ova, and though outside pressure caused these to be extruded, it was evident that their deposition was beyond the power of the parent.

* In September.

That the ova of an individual female are not shed all at once, but in successive crops, is well known (cf. Fulton, *Comparative Fecundity of Sea Fishes,* Rep. S. F. B., 1891, p. 245), and I think that the different degrees in which the retention of ripe ova obtains in different species must be explained by the difference in the size of and interval between the several crops. In the plaice, and in some other species, a greater number of ova, compared to the capacity of the ovary, ripen together, and the successive crops appear to overlap each other to some extent, so that there never seems to be a time when some ova are not ready for extrusion. Consequently the muscular efforts for extrusion have the co-operation of the constant and rapid increase of the successional crops, so long as any such remain; but when it comes to the turn of the last crop the elasticity of the walls of the ovary and the muscular power of the parent are so insufficient that a comparatively large number fail to make their escape.

In the lemon sole, on the contrary, I have evidence that the crops are individually small (compared to the capacity of the ovary), and separated from each other by intervals which, though imperceptible in the spawning period of the species, must be well marked in individual parents. The fish must therefore possess resources, muscular or otherwise, which render it practically independent of the assistance afforded by the successional crops in extruding the ripe ova (the difficulty being lessened by the comparatively small number of the latter which are simultaneously ready), and thus does not encounter any unusual obstacle in disposing of the last crop.

Before dealing with the topographical features of the ovary in its different conditions we must briefly advert to the modifications exhibited in the disposition of the viscera in the various species.

As is well known, the ripe ovaries in any flat-fish are disposed on either side of the hæmal spines, and extend from a point in the neighbourhood of the bony buttress which forms the centre of the hind wall of the peritoneal cavity to a greater or less distance from the commencement of the caudal peduncle. A single ovary duct, formed by the coalescence of the duct from either ovary, follows the course of the buttress in its anterior curve to the genital orifice.

But while all have this much in common in the ripe condition, the British representatives of the family fall into two groups, based upon the arrangement of the alimentary canal and the shape of the reproductive organ:

(*a*) including the halibut, long rough dab, turbot, brill, megrim (scald-fish and topknots ?), plaice, flounder, and common dab.

In these no portion of the alimentary canal extends to any considerable distance beyond the first hæmal spine. The ovaries are subequal in size, and markedly dilated dorso-ventrally in their anterior region. The kidney is situated in the roof of the peritoneal cavity, in front of the great hæmal spine, and the urocyst between the anterior ends of the ovaries and their ducts.

(*b*) including the lemon sole, the witch or pole dab, the common sole (and probably other members of the genus *Solea*).

In these a loop of the ileum passes back on the *ocular** side of the hæmal spines for a greater or less distance (greatest in the sole, least in the witch). The ocular is consequently much smaller, having less space at its disposal, than the blind ovary, and neither is very markedly dorso-ventrally dilated in its anterior region. The excretory organs are as in group (*a*) in the lemon sole and witch, but in the true sole the urocyst and the hinder part of the kidney pass back on the blind side of the anterior hæmal spines.

In immature fish of group (*a*) on removing the body-walls of the abdominal region on either side the free anterior portions of the ovary are seen to form, with the bony buttress, the hind wall of such part of the body-cavity as lodges the alimentary viscera. The one ovary is a little in front, the other a little behind the buttress, or both may be to some extent united in front of it. They appear as plump cushion-like structures, following the course of the buttress, rounded off near its origin, and tapering into the ovary ducts towards its distal extreme. Passing the finger backwards along the external surface of the fish no groove is perceptible, in fresh specimens, between the region of the vertebral column and that of the interhæmal bones. Dissecting away the anterior muscles of the caudal region, we find that each ovary is continued backwards for a short distance alongside of the hæmal spines in a tapering process terminating in a moderately fine point.

The length of the posterior process, as compared with the distance between the first hæmal spine and the caudal peduncle, varies with the species and with the size of the individual, but probably in no case exceeds one third, and is usually much less. The whole structure is very plump and firm, and is firmly embedded between the hæmal arches and the caudal muscles. If a seeker is pushed backwards in the direction of the posterior process a considerable amount of closely set connective tissue will be ruptured in its progress.

On cutting into the ovary its lumen is found to be entirely or nearly occluded by germinal epithelium, beset with inactive ova of various degrees of minuteness.

* The terms "ocular" and "blind" are used in this paper, since they are intelligible in connection with Pleuronectids, and, while eliminating the confusion between right and left in dealing with a mixture of dextral and sinistral forms, do not, as it were, outrage morphology like Fulton's qualified use of "dorsal" and "ventral."

Now if we examine a spent female of the same group the conditions are very different. In the first place, the anterior or free region of the ovary is enlarged and flaccid; a distinct depression can be felt from the outside on either side of the hæmal spines, extending well-nigh to the caudal peduncle. On removing the muscular wall in this region we find the posterior process of the ovary much elongated, thin, and flaccid, and very loosely lodged between the spines and the muscles; whilst in the anterior region the connective tissue which formerly united the muscular and skeletal elements ventral to the front of the ovary may have to a great extent disappeared, so that a mesentery forms in this region the only boundary between what one may term the alimentary and reproductive portions of the visceral cavity. The length of the ovary is variable, but is seldom if ever less than half of that between the first hæmal spine and the caudal peduncle.

On opening the ovary the contents are found to vary according to the time which has elapsed since spawning. If the latter is recently over, the germinal epithelium shows traces of ruptured follicles, and more or fewer ripe and decomposing ova are to be met with; at this stage their nature will be at once obvious. In spent fish at any period which I know the lumen of the ovary is wide, and the germinal epithelium of the posterior process is arranged in conspicuous longitudinal ridges. It may contain, as in all plaice which I have examined, a number of small "active" ova, in addition to a host of "inactive" ones, but I am uncertain whether these represent the early condition of next season's crop, or only ova which, though they pass the inactive stage, are absorbed without ever reaching a considerable size. It appears most probable that after spawning the ovary continues for some time to produce a certain number of active ova, which, however, are successively absorbed, without ripening, until the approach of the next season. Otherwise it is necessary to suppose that an ovum in this species, and others which in this respect agree with it, takes the best part of a year to ripen after it has passed the "inactive" condition.

The dab is so far the only form in which I have found only inactive ova in the germinal epithelium of spent ovaries.

Of a number of females examined in August the ovaries of most exhibited the features which I have just described as characteristic of spent fish, but in three the characteristics were those of immature fish. There was no difference whatever in the ova in the germinal epithelium, but on instituting a careful search certain whitish gelatinous bodies were met with in the ovary ducts of some of the larger fish. These proved to be the remnants of ripe ova, the zona being the most recognisable feature. There could be no doubt that the fish which contained such bodies had spawned, and it was reasonable to suppose that those which showed no traces of retained ova had either spawned a little earlier or had lost these substances a little sooner than the rest. The chief question is whether the fish which agreed with my ideas of immaturity might not really represent a further stage in a period of inactivity after spawning. We know that when the ovary ripens for the first time its posterior process forces its way backwards between the caudal muscles and hæmal spines towards the tail, thus attaining the elongation which is familiar in the ripe condition. When the ova have been discharged the elasticity of the ovary walls causes a considerable shrinkage, apparently at once; so that a recently spent ovary is always shorter than one full of ripe ova, as well as much narrower. It may be suggested that this process of shrinking is continued until the ovary has reached the proportions and shape of an immature example, the muscles and connective tissue also closing in on it. If this were so, there could be no possible way of distinguishing the spent from the immature condition apart from the presence of the remains of ripe ova of a former crop.

My evidence, however, points to the opposite conclusion, viz. that the ovary, once spent, never reverts to a condition resembling that of an immature fish. The fish I have referred to were nine in number, and consisted of seven, diagnosed as spent, from $10\frac{3}{4}$ to $14\frac{1}{2}$ inches; the three apparently immature forms measuring 11, $11\frac{3}{4}$, and 12 inches respectively. Now, speaking as a general rule, it is the largest fish of a species which spawn the earliest; and since the ovary after spawning must needs pass through the wide-walled flaccid condition, with traces of retained ova, before it could reach the hypothetical stage in which it might ape the immature condition, one would expect to find the latter in the largest instead of, as is here the case, in nearly the smallest specimens. Eleven or twelve inches is a far larger size than that at which many dabs spawn for the first time; but this is of little importance, since some are quite immature up to 9 inches during the spawning season, and, from the rapidity of growth which Cunningham has demonstrated in the species, we can understand that a fish which fails to reach the required standard, whatever it be, at the time of year favorable to the maturation of the reproductive organs, will materially increase in length before the opportunity again presents itself.* Apart from this I do not see how it is possible for the ovary to shrink to such an extent. It would involve the atrophy of the greater part of the ovarian substance, and there is no evidence

* Probably the growth will be more rapid than in a mature fish, since there will not be the same drain on the resources of nutrition for the development of the sexual products.

of such a process. I have certainly met with an instance of atrophy of the ovaries in another species, but it was evidently of a pathological nature, and conducted along lines which seemed very unlikely to result in a simulation of the immature condition (*vide* p. 382).

To recapitulate, I would state that when retained ova are not present to place the matter at once beyond doubt, a spent can always be distinguished from an immature ovary by the wide flaccid anterior region, by the greater length of the posterior process,* and by the loose manner in which the latter is lodged in the cavity alongside of the hæmal spines. Indeed, if the specimen is fresh, a groove, which can be felt by passing the finger along the skin in this region, is almost a sufficient test; but if the fish is more or less stale, the groove is to some extent perceptible even in immature fish.

The members of group (*b*), viz. the common sole, lemon sole, and witch or pole dab, present rather more difficulty, as there is never any great dilatation of the anterior part of the ovary, and its posterior process is more or less elongated from a rather early period. In soles of three or four inches, and in lemon soles of six inches (the smallest I have been able to procure), it is already considerably developed. Moreover in all forms the backward extension of the gut on the ocular side prevents any constriction of the corresponding ovary by the caudal muscles; and in the case of the sole the same effect is attained on the blind side by the disposition of the hind part of the kidney and the urocyst. In the lemon sole and pole dab the ovary is the only occupant of the cavity on the blind side of the hæmal spines; yet in the former it is but little occluded by connective tissue in the posterior region at any period, whilst even the anterior part, which is so firmly fixed by the caudal muscles in immature members of group (*a*), is always comparatively loose. I have not been able to examine enough small pole dabs to know whether the same holds good for that species also, but I believe it is the case.

A recently spent ovary can, of course, be easily detected as such by the nature of the germinal epithelium, and usually by the presence of retained ripe ova. Thus in the sole the degenerating follicles, deeply coloured by hæmoglobin, are very conspicuous, much more so than in any other species I have studied. Again, ova which have passed the inactive condition have been present in all spent ovaries which I have examined, and entirely absent from specimens I have considered to be immature. The ovary itself is also longer and wider, and flaccid anteriorly in the former condition, and narrow, plump, and rounded in the latter, but more conspicuously so in the sole than in the lemon sole. The length is a matter of comparison; thus in the sole I have not found immature ovaries to exceed two

* This is, of course, a matter of comparison, according to the species.

fifths of the distance from the first hæmal spine to the caudal peduncle, whilst spent ovaries have always been longer. It is as yet too early to summarise the proportional differences in the lemon sole, as the spawning period is apparently very protracted in individuals as well as in the species; but it seems that a spent ovary is always wider and longer than an immature one. Nor is it yet possible to ascertain to what extent the shrinkage of a spent ovary is carried, either in the sole or in the lemon sole, or whether, by the absorption of the small active ova, an entirely inactive germinal epithelium is ever met with in spent examples. Should this occur, and no retained ova be present, it would be extremely hard to distinguish the condition in a lemon sole. An instance, which I suppose to be exceptional, of the degeneration of a spent ovary has come under my notice in the sole. The wall of the posterior portion of either ovary had become disintegrated, and fragments of the germinal epithelium had consequently found their way into the general cavity which lodges the ovary, whilst on the blind side similar matter, containing both active and inactive ova, had penetrated between the muscles of the interhæmal ridge and between the bases of several of the anal fin-rays and the skin. I suppose that this process of atrophy would in time have extended to the rest of the ovary, but clearly it would not result in any condition resembling that of an immature example.

It need hardly be said that when an ovary agrees with the immature condition in other respects, but exhibits an activity in the germinal epithelium, it is reasonable to suppose that the fish is about to spawn for the first time. Thus the distinction between an ovary ripening for the first time and for any subsequent time is not hard, so long as it is only in the early stage of maturation. The difficulty is felt when the organ has attained a considerable development, such as would, in the case of a fish that had already spawned, suffice to obliterate the traces by which such condition might otherwise have been recognised.

It has been difficult, notably in the case of the turbot and brill, to obtain sufficient numbers of females at the critical sizes, since amongst the smallest members of any species brought to market the males are always infinitely more numerous than the females; the converse, of course, holding good amongst the larger examples, which are of less interest for the purpose in hand. The accompanying figures must not be taken as indicating the relative abundance of the sexes at the different sizes, since, in selecting fish for examination, I have often had to reject large numbers of males, from want of time for the record of their condition.

I may here remark that, according to my experience, whenever a catch of fish from an offshore ground, especially in the spawning season, includes both large and rather small fish—say from the full size down to the smallest size of mature males,—the limit of size which divides mature from immature females will be found to practically separate the two sexes. Thus most of the larger fish will be mature females, and most of the smaller ones will be mature males, with a sprinkling of immature members of both sexes. This is in complete accord with Fulton's observations on the distribution of fish on the spawning grounds (Rep. S. F. B., 1890, 178), and it is noteworthy as an impediment in the way of the rigid application of a size limit based on the condition of the larger sex. But it is not of the highest importance, since the number of small fish in such cases is, by comparison, insignificant (thus following the well-known proportionate abundance of the sex), and it is only applicable to such species as show a marked change of habitat in apparent relation to the spawning instinct, and is variable within the limits of a species according to locality.*

Local Variation.—A comparison of the results obtained by work on the different coasts of Great Britain suggests a speculation on the rate of growth in relation to maturity.

Thus I understand from Messrs. Calderwood and Cunningham that at Plymouth the plaice spawns at about 10 inches, a marked contrast to the North Sea or even the west of Ireland conditions. Again, Cunningham has found mature lemon soles (*supra*, No. 3, p. 244) about as small as any which I met with on the west of Ireland. With regard to the common sole, the limit proposed for this district and for the west of Ireland is held by Mr. Calderwood to be equally applicable to the Plymouth district, whilst Mr. Cunningham would put it only a trifle lower.

Now soles appear to be much the same size on all three coasts, lemon soles are much larger in the North Sea than in the other districts, and according to Cunningham (*supra*, No. 2, p. 100) plaice are much smaller at Plymouth than in the North Sea. West of Ireland plaice appear to be intermediate in size, but in this respect approach the North Sea rather than the Plymouth fish, though, as I had not much material on which to base my Irish limit for this species, this is not of much importance.

We see, therefore, that where there is agreement in the size of fish of a species in any two or more districts, there appears also to be agreement in the size at which sexual maturity is reached, and that when there is variation maturity is reached at the smallest size in the district where the species is smallest.

* *E. g.* it appears to apply to turbot on the Dogger, whilst on the eastern grounds spawning and immature turbot may be caught together, the latter far exceeding the former in number.

We are aware, from Cunningham's researches on the rate of growth, that this varies with the size in different species; and from the remarks of the same author on the plaice (*supra*, No. 2, pp. 99, 100) it appears that the same principle is applicable to local variation of size within the limits of one species. Hence it would appear that local variation in the size at which sexual maturity is reached is explicable by, or implies, variation in the rate of growth, and involves no local difference in the age* at which fish spawn for the first time.

Size Limits for the North Sea District.—The following measurements are intended to represent the average sizes at which the female spawns for the first time in the North Sea district, so far as such are ascertainable from observations made during, shortly before, or soon after the spawning season:

Turbot	18 inches.	
Brill	15 ,,	
Common sole	12 ,,	
Plaice	17 ,,	
Lemon sole	12 ,,	
Halibut	36 ,,	(provisional).
Common dab	7 ,,	

I have not paid much attention to the common dab (*Pleuronectes limanda*); the smallest ripe female I have seen measured 6 inches, and the largest immature female, during the spawning season, 9 inches. Flounders (*P. flesus*) and long rough dabs (*Hippoglossoides limandoides*) have not been available in sufficient numbers for a satisfactory conclusion. The same applies to the megrim (*Rhombus megastoma*), which is rather a rare fish on the grounds usually worked by Grimsby trawlers, and the witch (*P. cynoglossus*); but it is worthy of note that twelve female witches of 12 and 13 inches and two of 14 inches were immature, whilst one of 14 inches was three parts ripe. Hence it seems likely that the fish does not spawn at so small a size (12 inches) as on the west coast of Ireland. I have never seen a sand or lemon sole (*Solea lascaris*), and only one solanette (*S. minuta*) and scald-fish (*Arnoglossus laterna*) in the Grimsby district. None of the remaining British Pleuronectids, the topknots, have been met with.

The following tables are abstracted from my records, and comprise only the fish at the critical sizes examined between the dates specified. It will be understood that all larger fish examined were found to be mature, the converse holding good in the case of smaller fish.

* Allowing for the individual variation in one locality which Cunningham has shown to exist in this feature (*supra*, No. 3, pp. 224, 225).

Turbot (*Rhombus maximus*).

April 1st to September 12th, chiefly during the spawing period.

Length.	MALE.				FEMALE.			
	No. examined.	Ripe or recently spent.	Approaching ripeness.	Immature.	No. examined.	Ripe or recently spent.	Approaching ripeness.	Immature.
At 11 inches	3	0	3	0	0	0	0	0
12 „	14	2	11	1	2	0	0	2
13 „	39	13	24	2	15	0	0	15
14 „	39	16	22	1	45	0	2*	43
15 „	25	13	12	0	41	0	6*	35
16 „	42	23	19	0	14	0	1*	13
17 „	73	50	23	0	25	0	13	12
18 „	78	54	23	0	28	2†	12‡	14
19 „	60	46	14	0	36	8	27	1
20 „	33	22	11	0	68	22	45	1§

The *male* seems to come to maturity at about 12 to 15 inches. Though I believe that some few females may spawn at 17 inches, I have no positive evidence to that effect, and I am convinced that 18 inches is the lowest size that could be usefully employed in defining a limit between mature and immature.

Spawning period.—A very few fish seem to spawn as early as the end of March, and a few during April. Spawning becomes more general towards the end of May. The chief period is June and July. The number of ripe females diminishes throughout August, but a few do not finish spawning until early in September.

Brill (*Rhombus lævis*).

April 1st to June 30th.

Length.	MALE.				FEMALE.			
	No. examined.	Ripe or recently spent.	Approaching ripeness.	Immature.	No. examined.	Ripe or recently spent.	Approaching ripeness.	Immature.
At 10 inches	1	0	0	1	0			
11 „	1	0	0	1	0			
12 „	9	2	2	5	0			
13 „	40	24	8	8	7	0	6	1
14 „	54	44	9	1	25	0	20	5
15 „	29	22	7	0	26	8	18	0
16 „	19	16	3	0	20	2	18	0
17 „	11	9	2	0	8	2	6	0
18 „	7	7	0	0	4	2	1	1

* Reproductive organs very little advanced.
† Exact size, 18½ inches.
‡ One three parts ripe, the rest half ripe.
§ Examined after the spawning period.

It appears that the *male* is mature at from 12 to 15 inches, as in the turbot, but probably some smaller specimens, if procurable, would be found mature.

The margin of variation in the size at which the *female* first spawns appears to be rather more narrow than in most other species; but it was impossible to obtain small females in sufficient numbers.

Spawning period.—Spawning appears to commence in the latter part of April, and becomes general by the beginning of May. It is continued throughout that month and the early part of June, after which it diminishes, and is practically over by the end of July. The spawning period is thus much the same as that of the common sole.

Plaice (*Pleuronectes platessa*).

From February to June, the larger fish chiefly during the spawning season.

Length.	MALE.			FEMALE.		
	No. examined.	Mature.*	Immature.	No. examined.	Mature.*	Immature.
At 6 inches	1	1	0	3	0	3
7 "	5	0	5	7	0	7
8 "	37	0	37	43	0	43
9 "	98	3†	95	114	0	114
10 "	71	1†	70	73	0	73
11 "	33	0	33	36	0	36
12 "	15	0	15	27	0	27
13 "	12	3	9	23	1	22
14 "	14	7	7	19	0	19
15 "	5	3	2	21	6	15
16 "	7	7	0	10	4	6
17 "	7	7	0	12	9	3
18 "	3	3	0	5 + ∾	5 + ∾	0

The occurrence of a ripe *male* at 6 inches is probably altogether exceptional, 15 inches appearing to be nearer the usual size at which the male becomes mature, but I did not pay very much attention to this sex during the spawning season.

At 17 inches the proportion of mature *females* is much greater than shown above, as in selecting fish of this size for examination I have picked out those which seemed likely to prove immature Conversely, at sizes less than 17 inches, those which appeared to be mature were selected.

At 18 inches I have seen in the market numbers of evidently

* Nearly ripe, ripe, or spent, except † in which the reproductive organs very little advanced.

mature fish, and am convinced that percentage of immature at that size during the spawning season is infinitesimal.

A female of 19 inches was found to be immature, but this was some months after the spawning season.

Spawning period.—From the middle of January to the end of March, but some seem to spawn in April, and a few perhaps as late as May. It seems probable that spawning also takes place to some extent earlier in the winter, but of this I have not yet sufficient vidence.

Common sole (*Solea vulgaris*).

From February to September 12th, chiefly during the spawning season.

Length.	MALE.				FEMALE.			
	No. examined.	Ripe or recently spent.	Approaching ripeness.	Immature.	No. examined.	Ripe or nearly spent.	Approaching ripeness.	Immature.
At 6 inches	0				2	0	0	2
7 ,,	4	0	0	4	3	0	0	3
8 ,,	29	1	3	25	45	0	0	45
9 ,,	28	4	13	11	66	0	0	66
10 ,,	38	15	22	1	28	1*	8	19
11 ,,	33	6	24	3	26	0	14	12
12 ,,	9	2	7	0	33	3	26	4
13 ,,	7	3	4	0	18	2	16	0
14 ,,	3	2	1	0	10	4	6	0

Ten inches appears to be the usual size at which the *male* reaches maturity.

Though, as appears above, a *female* may occasionally spawn at 10½ inches, I am convinced that comparatively few spawn at less than 12 inches, and I have no evidence of immature fish at more than 12 inches during the period of observation.

Spawning period.—Ripe females begin to appear at the end of April, and are abundant during May and June, which seems the chief spawning time. They become scarcer during July, and spawning is practically over by the early part of August.

Spent females begin to appear in the Humber at the beginning of July, and become more numerous as the month goes on, and continue to abound during August and the early part of September.

* Exact length, 10½ inches.

Lemon sole (*Pleuronectes microcephalus*).

February to September, chiefly during the spawning season.

Length.	MALE. No. examined.	Ripe or recently spent.	Approaching ripeness.	Immature.	FEMALE. No. examined.	Ripe.	Approaching ripeness.	Immature.
At 6 inches	1	1	0	0	2	0	0	2
7 ,,	20	10	4	6	22	0	0	22
8 ,,	12	10	1	1	22	0	1	21
9 ,,	39	29	10	0	34	0	9	25
10 ,,	60	56	4	0	51	3	24	24
11 ,,	41	31	9	0	47	1	22	24
12 ,,	23	20	3	0	14	1	12	1
13 ,,	11	9	2	0	10	2	8	0
14 ,,	5	5	0	0	10	7*	3	0

It appears that the *male* may be mature at 6 inches. No smaller specimens of either sex could be procured.

I do not think that many *females* spawn at less than 12 inches, though, as appears above, some spawn when only 10 inches in length.

Spawning period.—Ripe females first appear in the latter part of April; they are abundant in May, more so in June and July. No spent females were met with until the latter part of August, although search was constantly made for them. Many fish are still spawning in the early part of September.

The protraction of the spawning period is evidently due to the fact alluded to elsewhere (p. 368), that the ova of a single individual are produced in successive crops in one season, separated from each other by an unusually great interval of time.

Halibut (*Hippoglossus vulgaris*).

More of my material was derived from Iceland and Faroë than from the North Sea. I know very little about the spawning period. Parnell gives the spring for the coast of Scotland. Grimsby liners seem to know very little of it, and are divided in opinion; one of my informants thought he had seen spawning fish in April, but the general opinion seems to be that spawning does not take place until autumn or early winter. Probably, since the halibut is mainly a line fish, very few ripe females come under the notice of fishermen. Ripe males seem to occur more or less at all seasons of the year.

The only fully ripe female which I have seen occurred at the end of April. Another female, with enlarged ovaries, was found to

* One of these recently spent.

contain a few ripe ova at the end of August. The condition of other large females at about the same time and in the early part of September seems to indicate that some spawning will take place in the autumn, on the Iceland grounds, at any rate. Very likely, as in the case of the haddock, the North Sea fish spawn earlier, but of this I have no evidence.

The fish enumerated below were examined at various dates between February and September (inclusive); and do not take into account a number of large fish which I have looked into from time to time, in the hopes of finding ripe ova.

Owing to the large size and high price of halibut, their purchase in any considerable number was out of the question. I have, therefore, had to depend, for the most part, on eye observations made in the market, checked so far as possible by the careful examination of a limited number in the Laboratory. In the case of females, the method of observation is indicated in the accompanying figures.

Total number of fish examined, 150 ; males, 64 ; females, 86.

Males.—*Immature.*—1 at 15 inches, 2 at 16, 1 at 19, 1 at 20, 2 at 21, 2 at 22, 1 at 28, and 1 at 29.

Approaching ripeness.—1 at 24, 1 at 25, 1 at 27, 1 at 28, 6 at 30, 4 at 31, 4 at 32, 2 at 33, 4 at 34, 3 at 35, 1 at 36, 3 at 37, 1 at 38, and 9 from 34 to 37.

Ripe.—1 at 31, 1 at 37, 1 at 38, 1 at 41, and 2 over 50.

Spent.—1 at 30, 1 at 31, 1 at 33, 2 at 34, and 1 at 35.

It appears, therefore, that the male may be mature at about 30 inches, and is probably never mature at less that 25 inches.

Females.—*Immature.*—2 at 14 inches, 1 at 16, 2 at 24, 2 at 30, 1 at 31, 2 at 32, 1 at 33, and 1 at 35. Examined in the Laboratory.

Immature, or very little advanced towards maturity.—4 at 28, 1 at 29, 3 at 30, 2 at 32, 5 at 33, 4 at 34, 4 at 35, 3 at 36, 2 at 37, 3 at 38, 1 at 39, 1 at 40, 2 at 41, 2 at 42, 1 at 44, 1 at 47, 1 at 49, 11 from 37 to 47. Examined in the market.

Approaching ripeness, ovaries distinctly enlarged.—1 at 43, 1 at 45, 1 at 49, 1 at 50, 1 at 56, 1 at 59, and 15 over 60. Examined in the market.

Ripe.—1 at 73 inches.

The inference is that, if the observations made in the market are approximately correct, the female does not spawn until she is about 4 feet long ; but I would prefer to await the results of continued work in the later months of the year, and to make use, *pro tem.*, of a limit of only 36 inches.

II. On the Destruction of Immature Fish in the North Sea.

Introductory.—The subject has unfortunately become so familiar in recent years that it is unnecessary for me to refer, except very briefly, to its previous literature. The most important contributions have been those by Professor McIntosh, in the Report of the Trawling Commission, 1884, by Dr. Wemyss Fulton in the Annual Reports of the Scotch Fishery Board, 1890 and 1891, and by Messrs. Bourne and Cunningham in previous numbers of this Journal. I have contributed what information I could collect during the Royal Dublin Society's survey on the west coast of Ireland in the Scientific Proceedings of that Society, 1892, pt. 4, and at the recent meeting of the British Association the subject was dealt with in a joint paper by Mr. Calderwood, Mr. Cunningham, and myself.

In the present paper I have attempted to put in as brief a form as possible the information collected during the Association's investigations in this district, together with suggestions as to what appear to me to be the best methods of remedying the evil.

The methods of fishing in use by boats from Grimsby and its neighbourhood are as follows:

i. Beam-trawling, by steam and sailing smacks, from 60 to 100 tons each.

ii. Long-lining by similar vessels.

iii. Shrimp-trawling by small sailing vessels in and about the Humber estuary.

Other vessels are employed in the deep-sea oyster fishery, and a certain number of small boats are engaged in whelking.

The following shore fisheries are carried on along the southern shore of the Humber below Grimsby:

i. Stake-netting.
ii. Ground-seining.
iii. Shove-net shrimping.
iv. "Seine" shrimping.

I propose to glance very briefly at each of the above industries in so far as they are concerned in the destruction of immature fish.

Beam-trawling.—The conclusion arrived at by Mr. Bourne, as a result of observations made in the Plymouth district, was that no material damage was done by the above industry (*supra*, vol. i, No. III). Such is certainly not the case in the North Sea district.

From my own experience on board of trawling vessels on most of the North Sea grounds, and from the recorded observations of a number of trawling skippers, who have been kind enough to assist me in this matter, I find that a certain proportion of immature fish of valuable species are taken in almost every haul, whilst on certain grounds lying to the eastern side of the North Sea the catch consists almost entirely of immature plaice. This fact is only too well known to every one connected with the industry in this district, and has given rise to the periodical fishery conferences with which we are familiar.

At the same time I am not aware that any statement of the actual quantity of small fish which is destroyed on these grounds has ever been put forward, nor am I in a position to do so, since it is impossible to estimate the amount that is shovelled overboard, dead or dying, as failing to reach even the very modest standard of market requirements. I can, however, give the number of boxes which have been landed at Grimsby during the present season, containing only small fish. I am using the word "small" not in the biological sense, so as to include all sexually immature fish, but in the sense in which it is used by fishermen and others connected with the trade, so that it may be taken that the fish here enumerated are immature in every sense of the word. Very few of them are as much as 15 inches long, whilst in most boxes none exceed and few reach a length of 14 inches, the majority being from 7 to 13 inches in length. Boxes which, while containing a few fair-sized fish at the top, consisted otherwise of under-sized fish, are not included in the list.

There were landed at Grimsby—

In April, 1836 boxes of small plaice.
,, May, 830 ,, ,,
,, June, 3470 ,, ,,
,, July, 2059 ,, ,,
,, August, 1924 ,, ,,

Total number of boxes for the five months, 10,119.

It is probable that the number is actually greater, as some boxes may well have escaped my notice; at any rate, the number is not exaggerated.

Such boxes as I have counted contained about 300 fish, but probably some contain less when the larger fish are picked out and packed separately. We shall be well on the safe side in taking 250 as the average number, which gives us a total of 2,529,750, or, in round numbers, two and a half million fish.

It must be remembered that these figures represent only the fish landed at Grimsby. During the present year only a single small fleet, about twelve sail, has been working the small fish grounds from Grimsby, most of the smack-owners having given orders to their boats to keep away from them. So far as I know, only one steam trawler has visited them with any regularity, though a good many others have been making occasional trips there. The balance of boats bringing in small plaice has been made up by a certain number of smacks "single-boating," and sticking with more or less regularity to the eastern grounds. Now from Hull alone two fleets, each exceeding 200 sail, have this year visited the small-fish grounds, as has also the combined Yarmouth, Lowestoft, and Barking fleet, but as to how long they remained there I have at present no information. Steam trawlers have also been "across" from Hull and Boston. As the Board of Trade statistics do not discriminate between large and small fish of a species, I do not know how we can arrive at an accurate knowledge of the total number of small fish landed at all ports; but I think that there is sufficient evidence, from the results achieved by the small number of Grimsby vessels, that it must have been enormous. The small fleet alluded to is still on the same ground.

Space does not permit me to enumerate the different grounds frequented by these small plaice in any detail. Briefly, they extend along the coast of Holland, Hanover, and Denmark, as far north as the Horn Reef, and from thence to Hantsholm on the coast of Jutland. They derive their names in most part from those of the islands nearest to them, strangely transformed in some instances by British pronunciation. They differ considerably in the quality of the fish produced, some grounds yielding none which are too small for market, others yielding more unmarketable than marketable fish, whilst north of the reef some grounds which seem to produce only small fish in the summer yield fine catches in the autumn.

There is no doubt that nearly all the plaice which are too small for market are, nevertheless, destroyed, not wantonly, perhaps, but simply because the exigencies of the fisherman's business do not permit of much attention being paid to any but marketable fish, even if the rest are not fatally injured by the pressure exerted by the large catches usual on these grounds before ever they reach the deck.

Plaice are not the only sufferers on these grounds, as large numbers of immature turbot are also destroyed. So far as I can gather from observations on the total number in the market on various days previous to the opening of the season for the grounds referred to, the proportion of immature turbot does not exceed 30 per cent., but once the boats begin to go "across" it rapidly rises. This is easily accounted for when we examine the catches from the eastern grounds.

Thus in May a steam trawler from the Borkum ground landed 216 turbot in two trips. Of these only six were above 17 inches,* whilst in one of the trips, when 105 fish were caught, no less than 68 were under 13 inches.

During June the aggregate of thirty-one trips of steam and sailing vessels from the Dutch, German, and Danish coasts was 4623 turbot, of which 786 were mature and 3837 immature. The proportion of immature is thus 82 per cent. The highest proportion reached in individual cargoes is 100 per cent., and the lowest 28 per cent., but only in two instances does it fall below 50 per cent.

During July, eighteen trips comprised 2435 fish, the proportion of immature being 69 per cent., a diminution since the previous month, which is probably explicable by the fact that the body of the plaice on which the fishing chiefly depends had shifted from the inshore part of the grounds, which seems most frequented by young turbot.

It has been asserted that many immature brill are destroyed on the same grounds, but of this I can find no evidence. In fact, the brill seems rather scarce on the eastern side of the North Sea, and nearly all which I have seen brought in from thence have been sexually mature. Fishermen and fishmongers are apt to class turbot and brill alike in discriminating between large and small, which may account for the assertion I have alluded to. Brill of less than 15 inches reach the Grimsby market chiefly from about Mablethorpe, on the Lincolnshire coast, where they seem rather plentiful.

The common soles which are taken on the eastern grounds by our trawlers seem nowadays to consist chiefly of mature fish. One hears a great deal of the destruction of small soles in former years, but it appears that the boats at that time went much closer to the shore than they dare to go at present.

As may be supposed, young lemon soles and witches or pole dabs are not found on these grounds. The flounders there met with are mostly of fine size. A young halibut is sometimes taken, and common dabs of all sizes abound.

In the North Sea halibut are not usually caught in large numbers in the trawl, but in the spring I have occasionally seen large catches brought in. These consisted almost entirely of small fish, and, according to my information, were chiefly derived from the South-west Flat of the Great Fisher Bank. The trawlers that have visited the Iceland grounds this summer generally brought in only a few small halibuts, but the number was sometimes considerable when they had been fishing a ground known as Madam Piper's Bay, near Langenness.

* In dividing mature and immature turbot I made use of this limit of size, believing then that it represented the limit of sexual maturity in the female, which I have since found to be somewhat higher.

Considerable numbers of small round fish, chiefly haddock, skates, and rays, are taken on various North Sea grounds, but I do not propose to discuss this matter at present.

Long-lining.—Besides the larger skates, the only species which in its immature condition is a considerable sufferer from this method of fishing appears to be the halibut. I believe that not less than half the halibut which are brought ashore here fail to reach even the provisional standard of maturity which I have proposed elsewhere, but I have not determined the proportions with exactness. The smallest fish which I have seen landed by liners measured 15 inches, a size which, proportionally to that of the species, is less than that of the smallest plaice landed by trawlers from the eastern grounds. The matter can be better dealt with when more exact knowledge of the relation of size to maturity has been arrived at.

I understand that young coal-fish, in the "sillock" stage, are caught by liners in the Orkney and Shetland harbours for use as bait, but as the species is not of great value the proceeding seems perfectly justifiable.

Shrimp-trawling.—This industry is carried on by one boat of 22 tons, five from 15 to 18 tons, and nine from 8 to 11 tons, these last being known as "prawners." All carry similar gear, viz. a trawl of shrimp-mesh not exceeding 20 feet in beam. The larger boats were formerly in the habit of also carrying small fish-trawls or "sole-nets," but a bye-law of the Eastern Counties Fishery Committee now prohibits the use of fish-trawls in the Humber, and only permits the use of shrimp-trawls from the beginning of April to the end of September. No machinery exists to enforce this law, and I understand that, so far as the use of fish-trawls is concerned, it is generally evaded. However, as the fish brought to market by these boats purport to have been caught only in shrimp-trawls, they may be dealt with under this head. They consist of common soles, plaice, and flounders, with a few common dabs. Turbot, brill, and lemon sole are only rarely met with.

Soles are never brought to market in very large numbers, fifty or sixty pairs being considered a very fine haul for one boat in a night, but up to the latter part of June almost all the fish are under 12 inches, and sexually immature, whether males or females, so far as I can judge from the examination of a considerable number. Towards the end of June larger spent fish appear to find their way into the Humber from the off-shore grounds. Thus in the early part of June, of 126 fish 112 were under-sized, but on the last day of that month 242 fish, representing the catches of two boats, included 40 above 12 inches, some of them very fine fish. The smallest soles brought to market are from 6 to 7 inches long, any smaller ones caught being promptly returned. During the succeeding months the proportion of large fish rather increases, but the smaller ones always largely predominate.

Plaice and flounders are sold together. The former, which never reach any great size during the time they remain in the Humber, are considered by the Cleethorpers, who used to monopolise the Humber fisheries, to be a distinct species, which they call flat-fish or fluke. They consider that the gelatinous egg-capsules of certain Polychætes are the spawn of these fish. As in the case of the sole, very small plaice or flounders are returned by the shrimp-trawlers to the sea. Those brought ashore measure from about 6 inches up to about 11 inches. I found a box of Humber flat-fish to contain 425 plaice, from 6 to 11 inches, averaging in length 7·71 inches, and in weight ·18 lb., and 34 flounders from 5 to 13 inches. The total amount sold in the market from the beginning of the season to the end of July appears to be something under 300 boxes, and thus not more than a steam trawler will sometimes bring in from the Dutch coast in a single trip.

Numbers of small whiting and cod are sometimes caught, especially the former. I have received 254 whiting, from $2\frac{5}{8}$ to $4\frac{15}{16}$ inches, and 16 cod, $2\frac{3}{8}$ to $3\frac{7}{8}$ inches, from one boat, but they are not usually brought ashore, though the whiting, even if immediately returned, would probably not survive.

Shore Fisheries: Stake-netting.—There are only two stake-net stations below Grimsby, viz. one at Cleethorpes and one at Humberstone. Both nets are owned by the same man, a resident of Cleethorpes, and, as I understand, have not been very productive during the present year.

The mesh is 1 inch from knot to knot, or $\frac{1}{2}$ inch square, and the nets are intended for the capture of sprats or smelts according to the season. The Cleethorpes net was only up for about a month in January and February, but the Humberstone net remained in use until April. I examined a week's catch, in the latter net, at the end of January. It consisted of a large basket of sprats, 2 to $5\frac{1}{4}$ inches, but mostly about $3\frac{1}{2}$ inches; less than half a stone of small herring, locally termed "scad," $5\frac{1}{4}$ to $7\frac{3}{4}$ inches; about 300 whiting, 4 to $7\frac{1}{2}$ inches; 14 plaice, $1\frac{3}{4}$ to $7\frac{1}{2}$ inches, and a few other fish of less important species. These were removed from the net and carted up to the house, where the saleable fish were sorted out, the rest being used for manure. Later in the season I am informed that large numbers of small cod and whiting were taken in the Humberstone net, but I had not another opportunity of inspecting the catch.

Ground-seining.—Only two ground-seines are in use at Cleethorpes, and do not appear to be often worked. Eels, smelts, and plaice are taken in them, but only the larger plaice are kept, all small fish being allowed to escape. Thus, except that all Humber plaice are immature, there is no intentional destruction of undersized fish in this industry.

Shove-net Shrimping.—The hand shrimp-net in use along the Humber sands is a sufficiently formidable engine. It is shaped like the letter T, the cross-piece representing the beam, which is 9 feet long, with a short iron upright at each end, while the shaft, represented by the body of the letter, is somewhat shorter. The lower end of the net, either sprat or shrimp mesh, is laced to the beam and uprights, the upper end being gathered on to an iron ring, which is drawn up the shaft by means of cords passing through the handle of the latter. In this way the belly of the net is made exceedingly rigid, and its meshes are almost closed, so that shrimps, &c., slide right up it into a fine mesh bag or cod-end just below the ring.

There are a number of these nets in Cleethorpes, but most of them are not worked with any great regularity, as the incidence of the Cleethorpes "season," from Whitsuntide to September, brings other and more lucrative occupation to the owners. As a rule, however, a good many shrimpers go out every springtide, and some, engaged with pleasure-boats during the day, shove the net by night.

Great numbers of small fish are caught in these nets, and very many are undoubtedly destroyed, since the men are not always careful in sorting them out at the margin, but often carry the whole catch home; sorting by night is of course a difficult matter.

Small soles, turbot, and brill are usually promply returned if observed, and lesser weevers* enjoy an undeserved immunity, since their room is preferred to their company; but little "flat-fish," really plaice, are not held to be of much account.

The shrimps and small fish seem to accompany each other in approaching and leaving the margin, since a good haul of the former always involves a large number of the latter, and *vice versâ*. The minute metamorphosing stages of flat-fish are never found in this company, the smallest plaice and dabs which I have seen being about 1 inch long, and the smallest turbot, brill, and sole over 2 inches. As might be expected, the sizes vary with the season of the year, but not to any great extent; and the following list, representing the catch of one net for one tide about the beginning of the season (25th April), is sufficiently representative of the conditions during the spring and summer.

* Injuries from this fish are not uncommon, probably because the fishermen, in their dread of the harmless anterior dorsal fin, pay no attention to the opercular spine.

Shrimps	4 quarts.
Common sole	4, $2\frac{3}{8}$ to $3\frac{1}{4}$ inches.
Turbot	1, $3\frac{1}{8}$,,
Brill	2, $3\frac{5}{8}$ to $4\frac{3}{4}$,,
Plaice	896, $1\frac{1}{2}$ to $4\frac{1}{2}$,,
,, ...	12, $4\frac{3}{4}$ to 9 ,,
Flounder	6, $2\frac{1}{2}$ to $4\frac{7}{8}$,,
,, ...	3, 9 ,,
Common dab	3, $1\frac{1}{4}$ to $1\frac{3}{4}$,,
Smelt	5, $3\frac{1}{2}$ to $3\frac{7}{8}$,,
,, ...	1, $6\frac{1}{2}$,,
Dragonet	23, $1\frac{3}{4}$ to $2\frac{3}{4}$,,
Gobius minutus	261
Three-spined sticklebacks . . .	29
A few sand-eels, pogges, and pipe-fish.	

Dabs are sometimes rather more numerous, and occasionally a number of small whiting are taken. *Cottius bubalis* and young sprats are of frequent occurrence. Turbot, brill, and sole are never much more numerous. Towards the end of the summer one or two fine soles are sometimes taken. The catch always includes a number of shore-crabs, which are promptly returned, as they damage the shrimps in the net and basket.

It will be seen that the bulk of the injury falls on the plaice, and I need not say that the annual destruction of the young of this fish must be enormous. How far the prolonged existence of an insignificant fishery, so baneful to the objects of an industry of national importance, can be justified is a question that must be discussed elsewhere.

Shrimp-seining.—The shrimp "seine" of Cleethorpes is in reality a fine-mesh trawl, with a mouth about 18 feet wide, which is kept open by means of a pole. Two short wooden beams, heavily loaded at the lower end, serve to keep the wings upright, and to separate the head and ground ropes. The whole affair is attached by the bridles to the axletrees of a small one-horse trolley, driven by the fisherman, and might be better described as a cart-trawl.

Seven such "seines" are owned in Cleethorpes, and work the same grounds as the shove-nets, and as they differ from the latter only in being rather more efficacious, and thus making larger catches both of shrimps and of small fish, they may be classed in the same category. The only notable difference is in the method of disposing of the catch which in the present instance is shot wholesale into a box on the cart, and not sorted until the fisherman gets home.

III. Remedial Measures.

It will be admitted that the continued destruction of large numbers of valuable fish before they have had a chance of reproducing their species can only result in increased deterioration of the industry, and that some measures must be taken to put a stop to it, unless we are prepared, and able, by artificial propagation to re-stock the sea as fast as we deplete it. Briefly the various proposals that have been put forward fall under three headings, viz. closure of grounds frequented by small fish, restriction of sale of undersized fish, and enlargement or alteration of mesh. We have seen that some of the smack-owners have adopted the eminently practical method of forbidding their boats to fish where they are likely to catch much small stuff; but the buyers, though as loud as any in their outcry, do not appear inclined to avail themselves of their undoubted power to check the evil. The proposals for legislative action have been so much discussed of late that I need only advert to such as affect the North Sea district.

It is a matter of common knowledge that the bulk of the destruction by deep-sea trawlers takes place on the eastern grounds, to which I have alluded elsewhere; and since these lie wholly or in part outside the three-mile limit, it has been proposed that they shall be closed to trawling by international agreement. Whether such agreement could ever be arrived at is questionable; and if it were, it is not likely that the ensuing legislation could be easily enforced. The great extent of the grounds would involve an enormous and costly Marine Police force, of mixed nationality; and even were such a body much more efficient than one has any reason to expect, there might be considerable difficulty in adequately watching grounds which extend in some cases over fifty miles from shore. Indeed, on our own coasts and elsewhere the success with which legislation limited to the territorial area has hitherto been enforced is hardly such as to encourage us to extend the principle to the open sea.

The various standards of size which have been advocated, in proposals for prohibiting the sale or possession of undersized fish, differ according as the subject has been treated with regard to the marketable qualities of the fish, or to its powers of reproduction; and it may be assumed, I suppose, without argument that the latter is the more rational method of treatment. Still it may be as well to recapitulate the sizes proposed at the Fishery Conference at Fishmongers' Hall last February, since they may be taken to represent the most recent trade opinion on the subject.

They are for turbot and brill 12 inches, for soles and lemon sole (*Pleuronectes microcephalus*) 10 inches, and for plaice 11 inches. How far they fall short of the biological limits, at least for the North Sea district, can be judged by comparing them with the table of sizes on p. 384; and, indeed, I may remark that the prohibition of the sale of turbot and brill under 12 inches in length is rather a work of supererogation, since the number of smaller fish of these species that come to market, at all events at Grimsby, is utterly insignificant.

The benefit to be expected from any measure of prohibition depends of course on the vitality of the fish, and it is very generally asserted that the bulk of the small fish trawled on these eastern grounds would not survive if returned. My own experience leads me to believe that this view is correct* so long as the present system of long hauls is maintained. Hence we must seek for such a limit as will render the grounds most frequented by these small fish unprofitable to the fisherman (since any less limit would only involve an infinitely greater waste than takes place at present), and in doing so it is necessary to glance at the general conditions of this fishery.

Exclusive of less important forms, the species chiefly met with are plaice, turbot, and soles. The plaice, on most grounds, do not exceed a length of 15 inches, and are mostly less than 13 inches in length. The turbot are fairly abundant, but, as I have already shown, almost all immature; soles are scarce. It is only the certainty of being able to fill up with small plaice that induces the fisherman to cross to the eastern side, since the soles and turbot would not nearly pay his expenses by themselves. Now I am confident that if the Conference limit of 11 inches for plaice were enforced, there would still be enough saleable fish left to make the grounds worth visiting, whereas if it were raised to 15 or even 14 inches the grounds would assuredly be left alone; and although such would be below the biological limit, I believe the practical closing to our huge fleets of such a magnificent nursery for young plaice would be in itself a sufficient protection for the species. Certain rough patches of ground, practically surrounded by areas yielding only small fish, abound with only large fish; these would still be accessible to fishermen, whereas in any scheme of geographical restriction it would hardly be possible to exempt them. Moreover the restriction of size would probably do away with the destruction of small plaice by shrimp- or sole-trawls, since the fish are not injured

* Owing to the great mass of fish caught in a single haul, I consider it quite possible to hold this view without throwing any doubt on the value of the results obtained by my friend Dr. Fulton in his experiments on the vitality of trawled fish (Report S. F. B., 1891).

by being caught in these nets, and if unsaleable* would probably be returned.

For turbot, brill, and sole I would advocate the adoption of the biological standards. They are all rather hardy forms, and it appears that immature brill and such immature turbot as are found on our own coasts are chiefly caught on certain banks where the intricate nature of the ground renders short hauls a necessity, so that they could be returned to the sea in good condition, as indeed the smaller of them usually are at present by many fishermen. With regard to soles, I do not think that many undersized fish are caught by deep-sea trawlers,† and the substitution of a size limit for the present prohibition of the use of a fish-trawl in the Humber would do away with the anomaly of a law which is not enforced. There is a strong feeling amongst inshore fishermen that the bye-law alluded to is unequal in its operation, since it offers no check to the destruction of small fish on off-shore grounds, only accessible to large boats. Hence a regulation as to the size of fish landed is perhaps preferable to one based solely on territorial conditions somewhat imperfectly understood.

An objection which I have heard urged against any scheme for keeping our trawlers off the eastern grounds is that the summer sole trade in the North Sea would thereby be left entirely in the hands of foreigners. I think that this is, perhaps, rather overstating the case, but anyhow I cannot see that it furnishes any excuse for the present enormous destruction of small plaice and turbot, whilst it is at least possible that the abstention of our own fleet from these grounds in the summer would result in a corresponding increase in the number of soles in the localities where that species congregates in the winter months. I have no knowledge of the migrations of soles, but the Great Silver Pit is equidistant from the Humber and the nearest eastern ground, and as it is the nearest point at which similar physical conditions can be attained, it does not seem improbable that the winter supply of soles in the Pit is in part recruited from the east side of the North Sea.

Another objection is that boats of British nationality are not the only ones engaged in the small fish trade, and it is true that during the summer months a number of German, Dutch, and Danish boats are occupied in catching small plaice. But they are all of small tonnage, some of them only open boats ; and I understand that from

* The possession, as well as the sale, should be prohibited, to guard against the possible danger of small fish being utilised as manure when the fisherman is also a farmer in a small way.

† The small soles caught on the Dogger and on the Dowsing are really solanettes (*Solea minuta*).

the manner in which the trawl is handled by German and Danish boats no injury is done to the unmarketable fish, whilst the saleable part of the catch appears to be exported chiefly to London. Hence the proposed measures of prohibition would give no advantage to these nations. The German steam trawlers, according to my information, do not molest the small plaice at all. Of the proceedings of the Dutch bombs I have little knowledge, but from the small size of their gear, their share in the destruction cannot be a very large one. Foreign-caught fish, except Norwegian salmon and mackerel and Dutch soles, including only a small percentage of undersized fish, rarely come to the Grimsby market, but on two occasions large consignments of small plaice, comprising, as I compute, some 31,000 fish, were sent from Denmark, and recently a consignment of turbot has arrived from Norway. These last fish were about 300 in number, all undersized, viz. from 9½ to 17 inches, whilst 4 were only from 8 to 9 inches. This is the only instance which has come under my notice of any considerable number of turbot less than 12 inches being present in the market, and, as we have seen, our own fishermen were not concerned in it.

The last and perhaps the most important objection arises from the difficulty in allowing for that variation in the size of fish of the same species on different parts of our own coast to which Mr. Calderwood alluded in the last number of this Journal, p. 208. The impossibility of utilising a uniform size limit for all districts is sufficiently exemplified by the limit of 11 inches for the plaice proposed by the Conference of last February, which was the result of a compromise between the trade representatives of the North Sea and south and west coast districts. While perhaps unnecessarily high for the Plymouth district, we have seen that it is altogether too small for the North Sea. The difficulty of having different limits, of local application, will only be felt at such a central port or market as London, to which fish are brought, whether by rail or sea, from all districts, but with proper organisation the obstacle does not seem insuperable. It is conceivable that the law might be evaded by running cutters from boats fishing in one district to the parts of another, where the limit was lower, but it is little likely that the firms which are in a position to undertake them, would lend themselves to such operations. There is not the slightest reason to apprehend a general conspiracy of evasion amongst the fishermen, and the boats which respected the law would form a more efficient police than all the cruisers in the navy, so far as one may judge by the conditions on the Scotch coast, where convictions of trawlers for infringement of the territorial restriction are frequently secured by the evidence of local line fishermen.

I must leave to others, who are acquainted with the local conditions, to decide whether the imposition of a size limit is desirable in other districts, but for the North Sea I have not the slightest hesitation in recommending this method of legislation, in the terms I have proposed above, as cheaper and likely to be infinitely more efficacious than any other that can be devised in maintaining the supply of the more important kinds of flat-fish. I need hardly observe that its application to the halibut, which is chiefly a line fish, could not fail to be beneficial to that species, since there is no question but that fish caught on the hook will usually survive if returned;* but I do not think that the limit need be as high as the biological one, owing to the difference in the conditions of the trawl and line fisheries.

I am not prepared to enter at present into the question of mesh legislation, beyond pointing out that it appears to be the only method by which the destruction of immature round fish, notably haddock and whiting, can be checked, since these species are fatally injured by being caught in the trawl, and would not survive if returned. Any great enlargement of the mesh does not appear advisable, since it would afford an opportunity of escape to the mature sole, of which that active species would be extremely likely to avail itself. The remedy seems to lie rather in an alteration of the arrangement of the meshes in the cod-ends, so as to prevent them from closing. On this subject I have been making investigations, but they are not yet sufficiently complete to yield reliable deductions. It is sufficiently evident, as has often been pointed out, that the great breadth of some of the flat-fish render it impossible to deal with the whole question by restrictions of mesh alone.

The last matter with which I have to deal is the destruction of very small fish by shove-net and shrimp "seines." If it were only possible to induce the men to cull out the small fish in the water they would do no harm at all, and practically I suppose that, as matters are, they do not greatly injure any species of known value except the plaice, although the small number of sole, turbot, and brill destroyed may represent, from the relative scarcity of these species, a more considerable injury than one would suppose. When fishing by day the shove-net men usually return the fish to the sea, but by night this is impossible, and the seine men do not seem to make any effort in that direction either by day or night.

It is a difficult question to deal with, since the shrimp appears to be almost a necessity to some people; at the same time the small plaice which are destroyed must represent an infinitely greater value than the shrimps. If hatcheries were established, and young turbot,

* Except fish with air-bladders, caught at considerable depths.

brill, sole, and plaice were enlarged after they had been reared through the delicate larval and metamorphosing stages, it is reasonable to suppose that they would be conveyed or would find their way to the sandy margins, which seem best adapted to the succeeding stages of their life-history, only to fall into the net of the shrimper.

I should say that to prohibit the use of any sort of shore shrimp-net during night-time would be a beneficial measure, but there is perhaps sufficient reason for abolishing the industry altogether. Those engaged in it might be sufficiently compensated at a moderate expenditure, if indeed it be not contrary to public policy to admit the existence of a vested interest in an occupation which is essentially injurious to industries affecting a much greater section of the community.

Monthly Reports on the Fishing in the Neighbourhood of Plymouth.

By

W. L. Calderwood,
Director of the Laboratory of the Marine Biological Association.

II.

The four charts published in this number, being for the months of May, June, July, and August, form a continuation of the series of reports commenced in the last number (vol. ii, No. 3) and are intended to show the position of the fishing fleets.

The same symbols have been used, which, for convenience, are again given below.

I do not propose to attempt a full description of each month's fishing, but rather let the charts explain themselves, giving only a few necessary notes on the dates of the movements of shoals, which may be of use on a subsequent occasion.

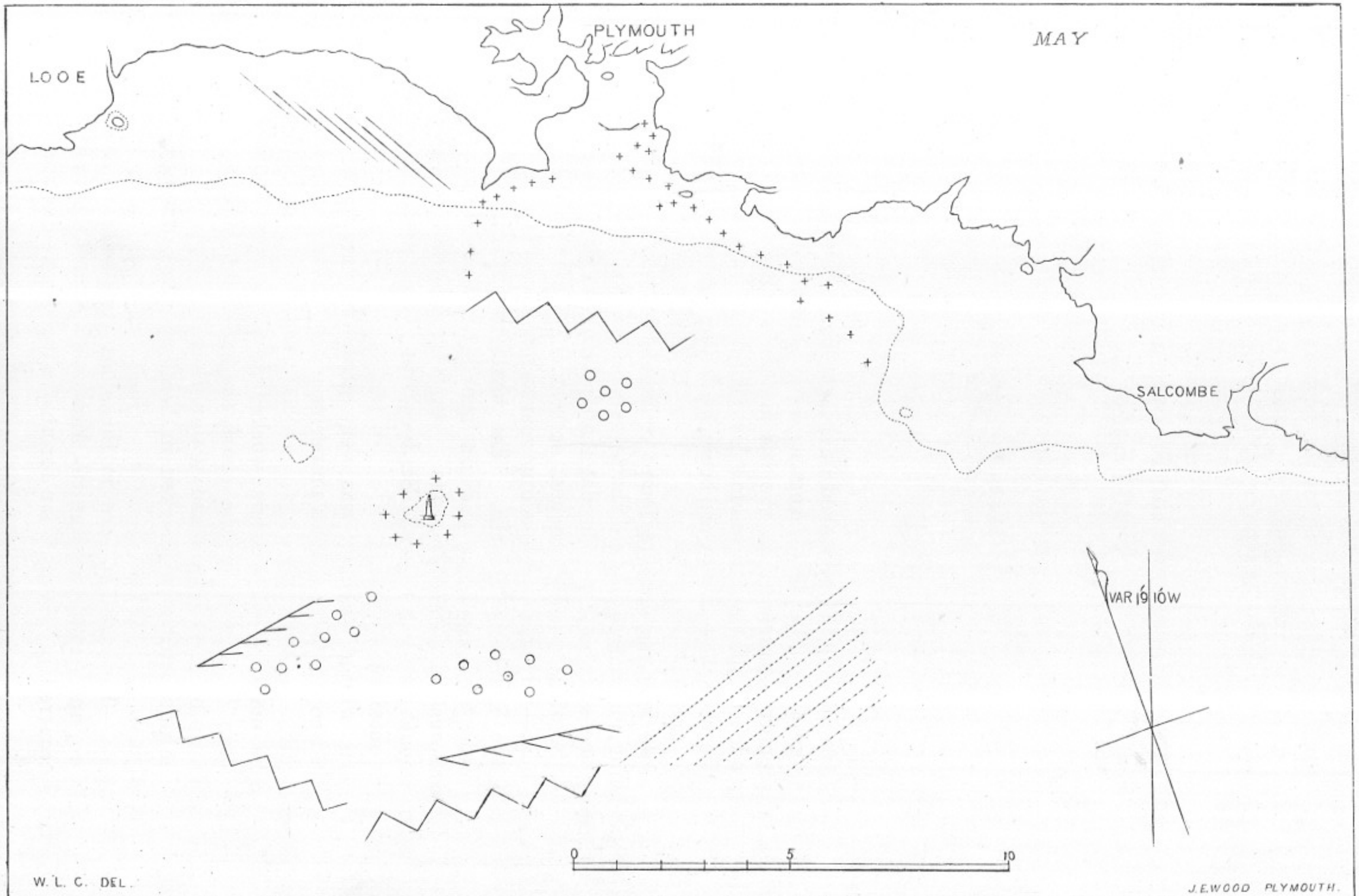
May.—The mackerel fishing marked on this chart only lasted till the 7th of the month. The shoals were travelling rapidly towards the westward, and on the 10th were found 20 miles south-west of the Eddystone. On the 14th all the fleet left Plymouth and proceeded to St. Ives, from which port large catches were obtained.

The whiting fishing was very poor, and the boats changed ground so frequently that a proper estimate of their position became difficult.

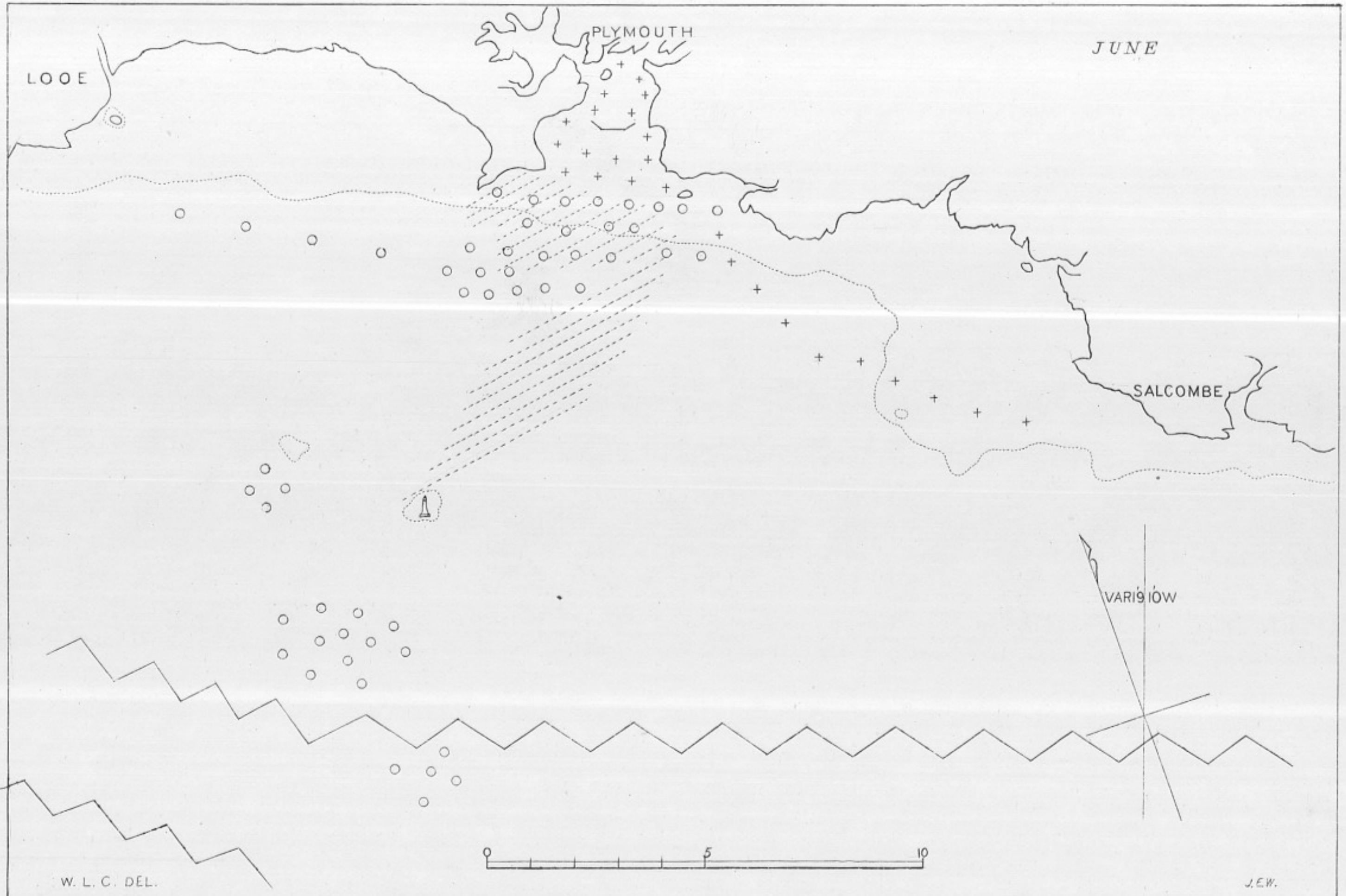
The majority of trawlers worked much more to the westward than can be shown on the chart, the positions shown being only taken up on the dates placed against them.

The pilchard fishing marked in Whitsand Bay occurred on the 22nd inst.

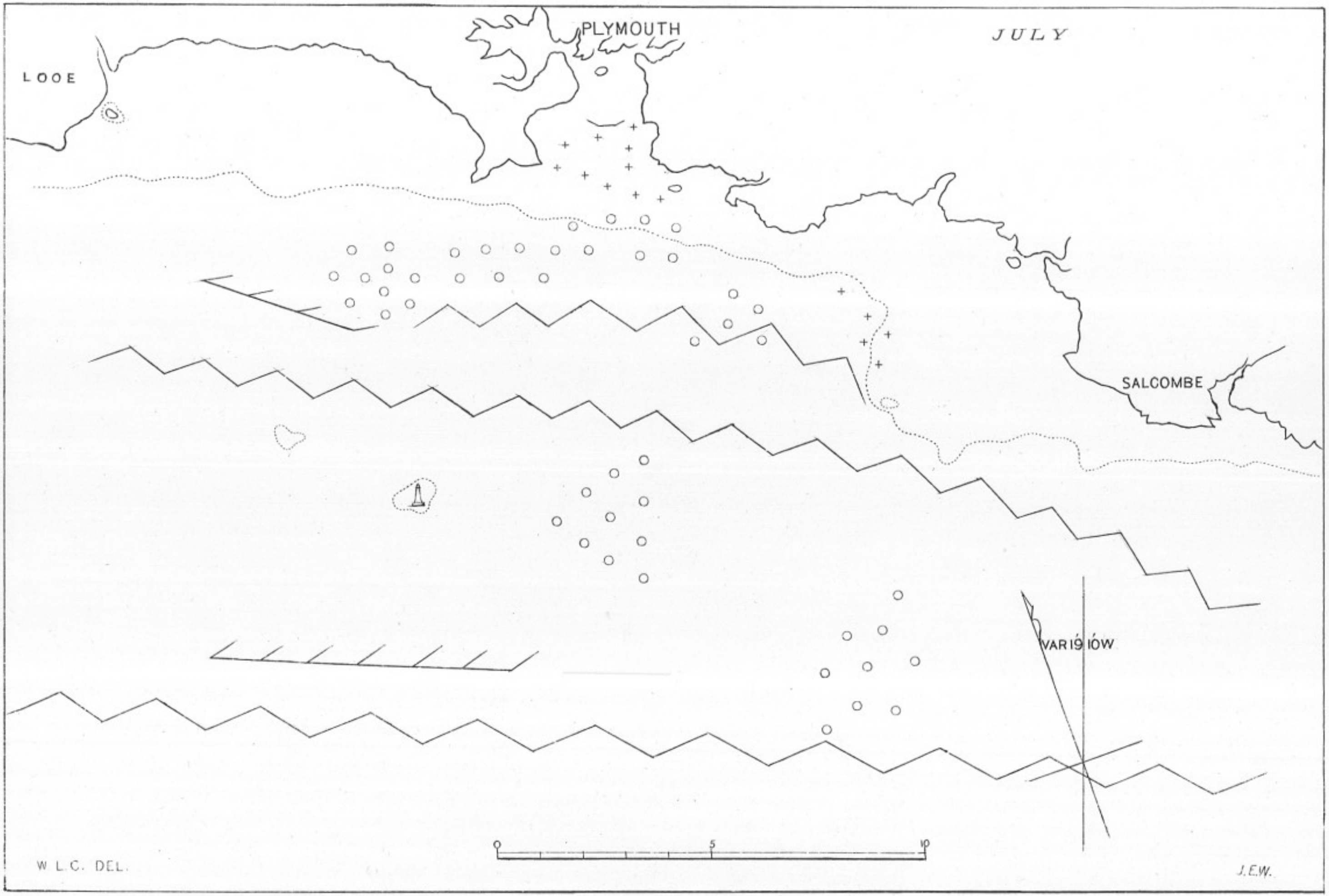
June.—The mackerel are in this chart marked as being close inshore, and extending from the Mewstone to the Eddystone. The fish occurred in this position for only a short time about the 10th ;

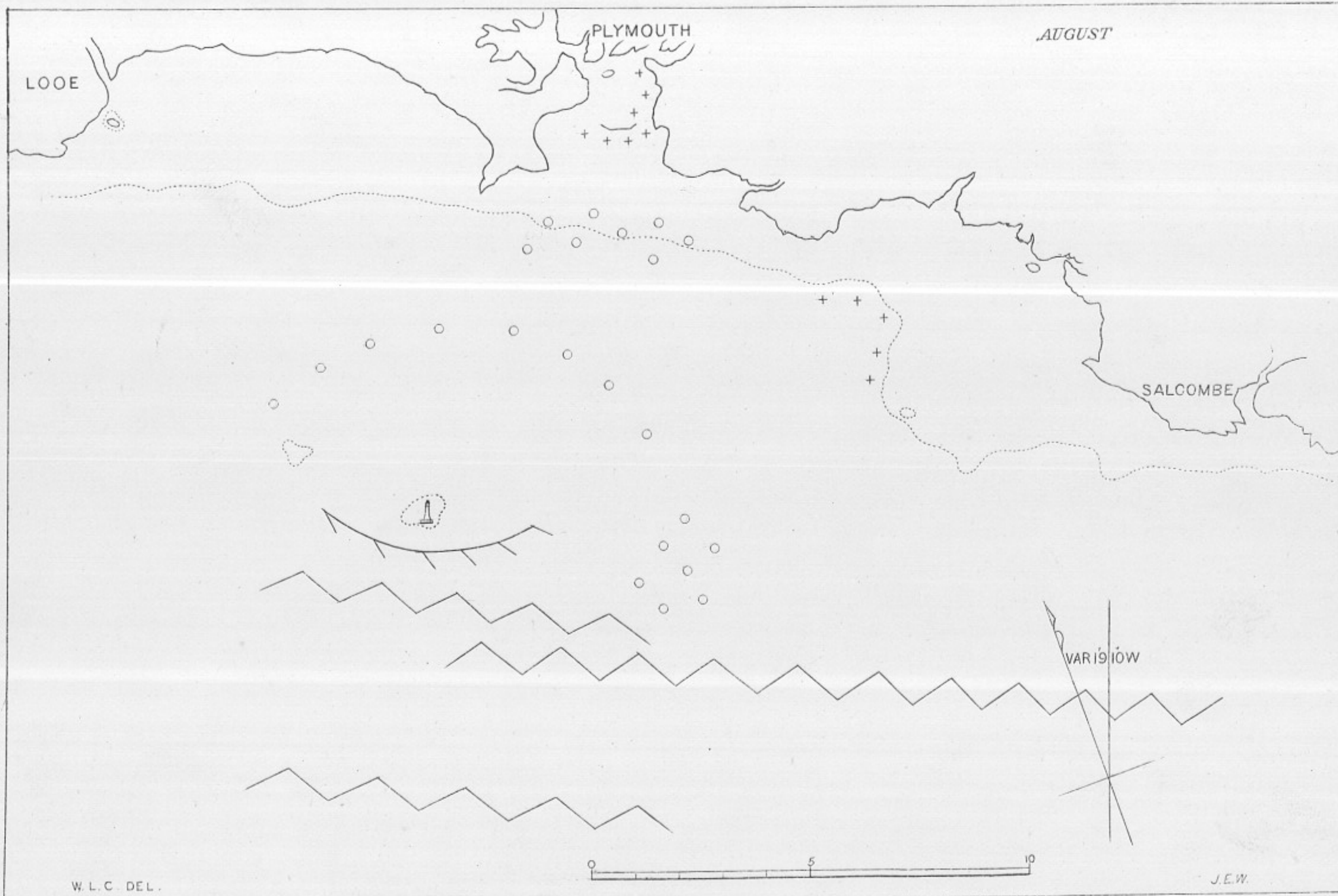


PLYMOUTH
MAY
LOOE
SALCOMBE
VAR 19 10W
0
5
10
W. L. C. DEL.
J.E.WOOD PLYMOUTH.



PLYMOUTH
JUNE
LOOE
SALCOMBE
VAR 19° 10' W
0
5
10
W. L. C. DEL.
J.E.W.


PLYMOUTH
JULY
LOOE
SALCOMBE
VAR 19 10W
0
5
10
W. L. C. DEL.
J. E. W.


PLYMOUTH
AUGUST
LOOE
SALCOMBE
VAR 19 10 W
0
5
10
W. L. C. DEL.
J.E.W.

the majority of the boats were fishing 40, 60, and 70 miles south and west of the Eddystone. A large number of the whiting boats, on account of their ill-luck, took to mackerel fishing. The long-liners are not marked. Only one boat was at work from 10 to 25 miles south-west of Eddystone.

July.—The mackerel boats are still far south of Eddystone (35 to 75 miles).

The whiting boats are still a good deal scattered, and more trawlers are working in the area included by the charts.

All trawlers not working on the "home grounds" (about half the fleet) are fishing the Bristol Channel.

Long-liners, besides those marked on the chart, are at work 10 to 20 miles south of Eddystone.

August.—The long-liners marked here just south of the Eddystone occupied this ground only during the last week of the month. During the early part they were fishing off Bolt Head and Prawl Point.

The mackerel fishing is now drawing to a close, the fish going further and further south. By the middle of the month they were captured from 60 to 70 miles south of Eddystone, some of the boats being within sight of the French lights. By the 20th the fishing ceased for the season. Trawlers still working largely on the "home grounds."

Key to Symbols used in Monthly Fishery Charts.

////////	=		position of herring boats.
//////// (dotted)	=	"	of mackerel boats.
\\\\\\\\	=	"	of pilchard boats.
/\/\/\	=	"	of trawlers.
o o o o	=	"	of whiting boats.
+ + + +	=	"	of crab and lobster boats.
(long-line symbol)	=	"	of long line boats.

NOTES AND MEMORANDA.

Polyprion cernium, Val.—Two specimens of this fish, the stone basse or wreck-fish, were obtained on September 21st. The one was sent by Mr. Dunn, of Mevagissey, the other captured by hook and line off Plymouth. The first specimen measured 19½ inches, the second 20½ inches.

It is singular that two of these fishes, which are by no means common, should have occurred at the same time. If the statement to the effect that these fishes are in the habit of following wreckage be true, it may be that several have arrived off our coast in this manner. The fish is common at Madeira.—W. L. C.

Scomber scomber, Linn (the Mackerel).—In sorting some young fish, chiefly the "mackerel midges" of *Motella tricirrata* which were taken at the surface at the end of July by Mr. F. Klotz, of the s.s. "Dominican," I found three specimens which prove to belong to this species, of which the later larval stages had not hitherto been recognised.

The total lengths are respectively 13·75, 16·5, and 18·5 mm. In the largest specimen the head and abdomen are about equal in length, and together a little longer than the caudal region, exclusive of the caudal fin. The eye and the snout are each about one third, and the greatest height of the body is about three quarters of the length of the head. The general shape of the fish is very much the same as that of the young Temnodon figured by Agassiz (*Young Stages of Osseous Fishes,* Proc. Am. Ac. Art. Sci., vol. xiv, 1878, pl. ii, fig. 5), but the upper jaw is slightly the longer. The caudal, which is completely metamorphosed, is separate, and appears to be notched in a similar manner, but is rather damaged in all my specimens. The same interval occurs between the anus and the anterior anal rays as in Temnodon. The differences in the rays of the permanent dorsal and anal fins, which are visible in the persisting embryonic fin-membrane of those regions, are also those of the adults. In my examples the first dorsal occupies the adult position, separated by a wide interval of embryonic membrane from the second. The ridges from which spring the rays of the continuous anterior parts of the permanent second dorsal and anal fins are continued backwards towards the caudal peduncle, and are strongly notched at intervals. Each notch marks the site of one of the finlets of the adult, but at the present stage it is occupied only by a single stout ray. There are five such isolated rays in the anal fin of the specimen of 16·5 mm. (in which the fins are the most expanded), thus corresponding in number to the finlets of the adult.

The colours in spirit specimens are as follows:—In the largest specimen the eye, gill-cover, and sides of the abdomen are silvery. There is a large deep black patch on the top of the head, due to pigment in the pia mater of the optic lobes; some smaller black patches occur on the snout, jaws, and isthmus. There is a dark line along the dorsum and at the base of the anal fin. From these lines dark pigment dots extend along the myomeres to the lateral line, the region of which is thickly powdered with such dots. The two smaller specimens differ only in exhibiting less pigment on the sides of the body, very little being present in the smallest, in which also the silvery matter is so little developed as to allow the black peritoneal pigment of the abdominal roof to be clearly visible.

In the early part of the same month I took at the surface a few much smaller fish, to which at the time I devoted little attention beyond noting the light blue colour of the eye, and the presence of yellow amongst the black pigment of the top of the head and abdomen. They are all rather badly injured, but the larger amongst them, about 9·5 mm., approach the smallest of the series previously described in the shape of the head and the distribution of black pigment. The permanent dorsal and anal fins are not yet represented, so afford no assistance. The differences in the proportions of the pre- and post-anal regions are not more than might be expected in the same species at such different stages. The smallest specimen sufficiently well preserved to be of any use measures 7 mm., and while certainly belonging to the same species as that of 9·5 mm., it also approaches the oldest stage to which I have been able to rear mackerel larvæ from the egg. The largest of such measures 4·88 mm., and the black pigment differs from that of the tow-net specimens only in quantity, and not in distribution. The large light blue eye, and the presence of yellow pigment in the regions indicated above, are features which both series possess in common.

Though, owing to the bad condition of the smaller tow-net specimens, absolute proof is wanting, I think it very probable that they are really mackerel. They were taken on the 8th July, about twenty miles N.N.E. (magnetic) of the Horn Reef Light-vessel, coast of Jutland. The locality and date of the larger specimens are mentioned elsewhere by Mr. Cunningham.—E. W. L. H.

Year-old Pilchards.—Since the last date mentioned in my paper in the previous number, our anchovy-nets have only been shot once, on April 23rd, when only eight pilchards were taken, all except one over 19 cm. (7½ inches) in length. But I was informed by W. Roach that a large number of sardine-sized pilchards were taken with a mackerel seine on May 23rd and June 8th in Whitsand Bay. We received one specimen of the former capture—it was 14·9 cm. long; and six specimens of the latter, which measured 15·4 to 16·6 cm.

Some of these yearling fish were said to have been sent to the Mevagissey factory to be tinned. Pilchard ova have been very abunndant in the tow-nets worked a few miles outside the Breakwater this September.—J. T. C.

Muggiæa atlantica.—Since the publication of my account of this Siphonophore in the previous number of the Journal I have obtained evidence that it appears annually in abundance in the neighbourhood of Plymouth South. I first noticed it this year in the produce of a somewhat large-meshed tow-net (mosquito netting) worked at a depth of about 20 fathoms, on the east side of the Eddystone, on August 25th; and soon after it appeared among the plankton collected a few miles outside Plymouth Breakwater. Towards the middle of September it became very abundant, and was secured in perfect condition and in various stages.

At the present date (September 26th) it still occurs, but its numbers have much decreased. Mr. Rupert Vallentin, of Falmouth, has drawn my attention to the fact that as long ago as 1849 a pelagic animal was described and figured by Charles Wm. Peach in the Twenty-ninth Report of the Royal Institution of Cornwall, which can be recognised as identical with *Muggiæa atlantica*. The title of the paper in which the description occurs is *Observations on the Luminosity of the Sea, with descriptions of several of the objects which cause it, some new to the British coasts.* The organisms I refer to are described in this paper under the name Diphydiæ, in which family is included also a Protozoan of the family Tintinnidæ. The description of the Siphonophore is by no means correct, the polypes of the eudoxomes being mistaken for ova; but the figures, though very rough and inaccurate, leave no doubt in my opinion that *Muggiæa* was the form which Peach had under observation. A remarkable feature of the paper is the record it gives of the pelagic organisms observed in successive months of the year in the course of four years, 1846 to 1849. In this record we find that in 1849, the "Diphydiæ" were observed for the first time on July 1st, and on July 20th occurred in thousands: in October they were also noticed. They are not mentioned in the observations of other years, but these were much less numerous, and the omission does not prove that *Muggiæa* did not occur in those years. Peach's collections were made in Fowey Harbour and just outside of it.—J. T. C.

Hippoglossus vulgaris, Linn. (the Halibut).—On the 30th April I succeeded in pressing some apparently ripe ova from a female halibut in the market. I had no opportunity of examining the ovary, but external pressure caused the extrusion through the genital orifice of a quantity of yellowish viscous putrid liquor, amongst which were a quantity of collapsed zonæ radiatæ, and the ripe ova referred to. The fish was dead, and appeared very stale. All the ova were dead and more or less decomposed, but some were sufficiently fresh to illustrate the living condition.

The diameter varies from 3·070 to 3·818 in my specimens; the yolk conforms to the condition met with in other dextral Pleuronectids, being colourless, translucent, and homogeneous, and destitute of an oil-globule. The zona is thin, measuring ·03 to ·04 mm. in optical section, and remarkably delicate and flexible.

Externally it is finely dotted; internally are a number of slight ridges, which give the whole structure the appearance of being irregularly scribbled with fine striæ. Laminæ are clearly visible, but radial pores cannot be seen in optical section in fresh preparations.

The ova are evidently pelagic, and the extreme delicacy and flexibility of the zona (which is such as to render it difficult to pick up an egg with the forceps without causing it to collapse) suggests that a large perivitelline space may be formed under natural conditions, since this takes place in the long rough dab (*Hippoglossoides limandoides*), which is the nearest relative of the form before us, and in which the conditions of the zona are very similar.

Ripe but unfertilized ova were obtained by Prof. McIntosh shortly afterwards, and from a brief note which he has published (Ann. Mag. Nat. Hist., July, 1892) it appears that some of them were a little larger than the largest of mine.

It is evident that the halibut's ova are not commonly to be met with along our coasts, since such relatively enormous structures could not fail to have attracted attention in the tow-nets.—E. W. L. H.

Rhombus maximus, Linn. (the Turbot).—I am not aware that the ova of this important species have ever been described in sufficient detail to ensure their recognition if met with in the contents of the tow-net, nor is there any description whatever of the embryonic and larval stages.

Ova taken from a number of females at Grimsby and on the North Sea showed but little variation, the usual diameter being 1·01 mm., and the extreme sizes ·99 and 1·06 mm. The oil-globule is nearly always ·21 mm., but may be as small as ·18 mm. Thus the ova of ·77 mm., supposed by Wenchebach to be ripe, must have been unusually small if they were really in that condition.

The yolk is colourless and homogeneous, but the oil-globule in recently spawned ova has a very pale ochreish tint. This is hardly visible unless a great number of ova are together in a vessel, when the globules impart their colour to the whole mass. Under similar conditions the ova of the brill (*R. bevis*) exhibit the colour of a very weak solution of ink, also due to the oil-globules.

The zona exhibits much the same characters as that of the brill, but the markings due to elevations of the internal surface are less closely set, forming a rather open network, of no regular pattern. They are retained, at all events in artificially fertilized examples, until a late period of development *in ovo*. The whole structure is less delicate than that of the megrim (*Rhombus megastoma*).

Fertilization does not appear to affect the dimensions; the perivitelline space is small. Unfertilized ova seem to retain their vitality for an unusually long period; some were successfully fertilized 17 hours after they were taken from the parents. Sir James Maitland's experiments with the milt of Salmonidæ will be remembered in this connection.

I was only successful in hatching one lot of ova. The larvæ began to emerge on the seventh day, but most emerged on the ninth day. None lived for more than a few days after hatching. They were very likely more feeble than those hatched under natural conditions, although as the attempt to rear them was made at sea, with plenty of good water available, I do not know why they should have suffered.

The newly hatched larva measures only 2·14 mm., of which considerably more than half is occupied by the yolk. The oil-globule is ventral in position instead of posterior, as seems to be the case in the brill. The marginal fins are narrow, the pectorals remote from the eye, and the whole larva appears less advanced than is usual in Pleuronectids at the time of hatching.

Both black and coloured chromatophores are present, the latter being the most numerous. In the newly hatched larva they are simple and almost entirely to the head, trunk, and tail, and to the periblast internal to the oil-globule; but they soon become dendritic and spread all over the skin, except at the caudal extremity, being less abundant than elsewhere on the yolk-sac. When first visible the coloured pigment is pale yellow, but by the time of hatching it has deepened to a very red orange by reflected, bright red rust-colour by transmitted light. A day or two after hatching it is an intense fiery orange by reflected, inclining somewhat to crimson by transmitted light. This coloration is more closely approached by the hybrid turbot and brill larvæ, described by Professor McIntosh (Reps. S. F. B., 1891), than by any other British form with which I am acquainted. It appears from subsequent observations by the same author (Ann. and Mag. Nat. Hist., July, 1892) that the true-bred brill larva does not materially differ from the hybrid.

It had been surmised by Professor McIntosh and myself, in the absence of any exact information on these stages of the turbot, that a minute Pleuronectid ovum and larva, the species F of McIntosh and Prince (op. cit.), might prove to belong to that form. The present observations show that this is not the case, since, apart from the differences in dimensions of the ovum, the pigmentation is entirely different, and the turbot at no stage exhibits the peculiar reticulate structure of the epidermis which always characterises species F. Hence the affinities of the latter must be sought elsewhere, probably amongst the top-knots.

A remarkable tendency was observed, which may render the artificial culture of the turbot a matter of difficulty.

In the several clutches which I fertilized the ova sank to the bottom at from two to seven days after fertilization. They did not appear unhealthy, and continued to develop as well as such as remained floating, but it was impossible to separate them from the dead ova, which always form an unpleasantly large item in the contents of a hatching jar.

The same behaviour was exhibited by four different clutches of ova fertilized for me by fishermen at sea: in one case I am informed that the ova sunk after only a few hours, though at the end of two days they still looked healthy; they were then thrown away, on the ground that if they were not dead they ought to be.

Thus we have pretty strong evidence that there is a general tendency in the turbot's egg to sink sooner or later after fertilization, and we know from Raffaele that this is a regular feature in the development *in ovo* of *Trachinus*; it happens also occasionally in the gurnard and some other forms.

I imagine that the successful culture of a pelagic ovum which assumes a demersal nature at an uncertain period will be difficult.

Later Stages.—Like the ova and larvæ, the younger metamorphosing stages seem to have escaped the notice of naturalists. In fact, the earliest examples which could indubitably be referred to this species are those enumerated by Mr. Cunningham in an earlier number of this Journal (N. S., No. 2, p. 105). The smallest of these meausres 15 mm. The series of younger examples, doubtfully referred by Professor McIntosh and Prince (op. cit., pp. 845—847) to this species, is acknowledged by these authors to be incomplete, and in the light of more recent observations it seems certain that some of them are not turbot.

It has recently been my good fortune to obtain such a series of specimens, ranging from 5·50 to 16·25 mm., as serves in great measure to fill up the existing gap in the life history. They were taken at the surface in various parts of the North Sea, partly by myself and partly by Mr. F. Klotz, skipper of the steam trawler "Dominican," to whom I am also indebted for much other valuable material. The localities and dates of capture are enumerated elsewhere by Mr. Cunningham, so need not be recapitulated here.

Reserving for the present a detailed and illustrated description, I think the following characters will serve to ensure the recognition of similar examples.

All specimens which I have examined possess a well-developed air-bladder. The snout is short and obtuse, less than the diameter of the eye in smaller examples, about equal to it in examples of 11 mm., and becoming slightly greater in larger specimens. The articular region is more or less prominent at all stages. In the smallest example the tail is narrow and the abdomen prominent, the body slightly flattened, and the eyes practically symmetrical. At about 7 mm. the asymmetry becomes better marked. By the deepening of the caudal region the prominence of the abdomen has disappeared. The greatest height of the body without fins is nearly a third of the total length, and occurs in the region of the clavicle. The marginal fins are still very narrow. At about 11 mm. the contour is roughly fusiform; the greatest height, about half the total length without the caudal fin, is situated just behind the anus, or midway between the snout and the origin of the caudal fin. The marginal fins are much broader and supported by rays. The right eye is just beginning to show above the ridge in a specimen of 13·5 mm. In the largest example about half of the right eye is visible from the left side, and the greatest height of the body is nearly two thirds of the total length without the caudal fin. The fin-ray formula, in specimens in which it is ascertainable, agrees sufficiently with that of the adult.

The most peculiar feature of these young turbot is the cephalic armature. In its maximum development it may be described as follows:—A pectinate ossific ridge overhangs the postero-dorsal region of each eye; a short ridge, bearing stout, postero-ventrally directed and somewhat curved spines, occurs on the articular region of the mandible, in such a position as to be almost masked by the maxilla when the mouth is closed. The pre-operculum bears short, outwardly directed spines along the entire length of its keel, and longer backwardly directed spines are present on its posterior portion, the margin of which is also serrated. The free edges of the sub-operculum and inter-operculum are strongly serrated near their union.

The spines above the eye seem the earliest developed, as they are present even in my smallest example. The ridge on which they are borne seems to represent the outer edge of the frontal scuta, which must ossify at an earlier period than the rest of that structure. The ridges of each side become opposed in the process of metamorphosis, and persist in the adult, but they lose their prominence and the serration of the edges before the oldest stage in my series is reached. The mandibular armature is early formed and early lost, but its (apparent) position is marked in the adult by the strong lateral keel of the articular. The opercular spines do not seem to be present in the smallest examples, in which the scutes of this region are probably not yet ossified. They reach their maximum development in specimens of about 10 or 11 mm., and thereafter tend to disappear, doubtless by the growth of additional bony matter around them. The serrations of the sub-operculum and inter-operculum persist longer than the rest, and are visible, though very blunt, in my largest example. Indentations exist in the margin of these scutes even in a specimen of 25 mm. kindly sent to me from Plymouth, and very faint indications of the same can be made out in a specimen of 175 mm., though none are perceptible in adult specimens. At no stage of which I have any knowledge is there any spinous process or processes in the region of the otocyst, and this serves to distinguish young turbot from certain of the small forms attributed by McIntosh and Prince (loc. cit.) to this species, and also from some remarkable Pleuronectid larvæ which were obtained during the survey on the west coast of Ireland. Since the smaller larvæ briefly described by the Scotch authors are said to agree in pigmentation with those which exhibit spines on the otocyst, it seems very unlikely that any of them are turbot, and therefore the North Sea series which I have described above are probably the first recorded examples at those sizes.

It is interesting to find a Pleuronectid passing through a stage in which its cephalic armature is as powerful as, and for the most part homologous with, that of a Percoid or Scorpænoid, though I cannot call to mind any form in which the mandibular spines of the young turbot are represented. Amongst Acanthopterygians we are familiar with instances in which, while the head is practically unarmed in the adult, it is well armed in the young (*e. g. Naucrates*), and it is frequently the case that the armature of this region is more powerful in the young than in the adult. If protective in function it is easy to understand that the spines of the turbot would only be required as long as the pelagic habit is maintained, but I think it is not less probable that their significance is simply ancestral.—E. W. L. H.

ERRATUM.

N. S., Vol. II, No. 3, p. 282.

Under *Gadus esmarkii*, for "30 to 50 fathoms cable" read "30 to 50 fathoms ca." (circa).

INDEX.

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INDEX.

A.

B.

C.

D.

E.

F.

R.

S.

T.

U.

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OBJECTS

OF THE

Marine Biological Association of the United Kingdom.

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.

Professor HUXLEY, the 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, Dr. 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 at present received some £20,000, of which £5000 was granted by the Treasury. The annual revenue which can be at present counted on is about £1820, of which £1000 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 £4000.

The ASSOCIATION IS AT PRESENT UNABLE TO AFFORD THE PURCHASE AND MAINTENANCE OF A SEA-GOING STEAM VESSEL, but has determined upon the purchase of a Sailing Trawler, 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. II, No. 4.

NOTICE

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

TERMS OF MEMBERSHIP.

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Life Members . .	. Composition Fee	15	15	0
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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, M. B. A. Laboratory, Citadel Hill, Plymouth.