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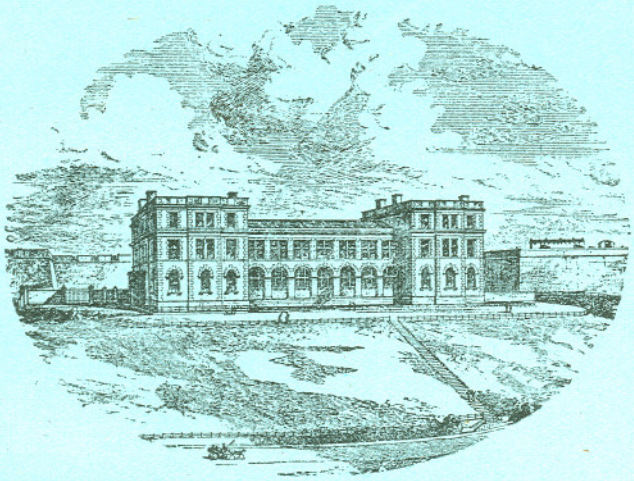

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The Reproductive Maturity of the Common Eel.

By

J. T. Cunningham, M.A.

In the Museum of the Royal College of Surgeons, in London, there are two specimens of the common eel, in which the ovaries are much enlarged, greatly distending the abdomen, and evidently very nearly ripe. Both those specimens were presented by Mr. Geo. Buckeridge, a salesman in Billingsgate Market, who deals largely in eels. The following are certain particulars concerning the specimens :—

(1) Length 15 in., weight 4½ oz. Presented Jan. 4, 1894.

(2) Length 19 in., girth round the abdomen 5½ in., weight 10¼ oz. Presented Sept. 25, 1895.

Both specimens are in spirit, mounted for exhibition, and the ovaries are seen to be of opaque milk-white colour, and generally to present the same appearance as the nearly-ripe ovaries of the Conger described by me in Vol. II. of this Journal. The greatest width of the ovaries is 1⅞ in. or 4·8 cm. The eggs are scarcely visible as distinct grains to the naked eye. Microscopically examined in a small piece which Professor Stewart kindly gave me from the larger specimen, the largest eggs were found to be from ·13 to ·16 mm. in diameter, while the smallest were only ·07 mm. It is a remarkable fact that eggs considerably larger than this have been found in the unripe ovaries of eels in the ordinary condition. Mr. Williamson (*Thirteenth Annual Rep. of Scottish Fishery Board*, 1895) states that in a specimen 70·7 cm. long (28⅛ in.), some of the eggs measured ·27 mm., and several other observers have given the maximum size as ·25 mm. In the ripe specimen described by Rathke, in 1850, the eggs were also small, not exceeding ·2 mm. In the specimen here under description, the microscope showed that the ovarian lamellae were composed almost entirely of ova in close apposition, the adipose tissue so plentiful in the ordinary condition of the ovary having been absorbed. It should be remembered that the eggs were measured after preservation in spirit, which must have caused contraction; but Rathke, who examined his specimen when it was fresh, also remarks that the eggs were distinctly smaller than in eels with small ovaries.

Fig. 1 represents accurately the appearance of the second specimen when mounted, the abdomen having been opened in the mid-ventral line. The figure is printed from a block prepared for the *Field*, and lent to me by the kindness of W. B. Tegetmeier, Esq.

The time of year at which these specimens were obtained agrees with the conclusion drawn from other evidence, that eels spawn in autumn or winter, and serves to determine the actual fact that some eels are on the point of spawning at the end of September and beginning of January. The equally important question of the place of their capture has next to be considered. Mr. Buckeridge, who very kindly answered the enquiries I made to him on the matter, told me that both specimens were found among consignments of eels from Toom Bridge, in Ireland. Now Toom Bridge is at the point where the river Bann leaves Lough Neagh, and is about 26 geographical miles from the sea. It is certainly an extraordinary fact that an eel so near the ripe condition should be found in fresh-water. We can only suppose that the case is exceptional. There is a possibility that the specimen had been kept in captivity for some time after being caught, and that thus its ovaries had had time to develop. But, on the other hand, when eels have been kept in salt-water aquaria, as they have been at the Plymouth Laboratory, in order that ripe specimens might be obtained, the ovaries have not developed to any obvious degree.

Rathke's specimen is described in *Müller's Archiv. für Anat. Physiol. &c.* 1850. It was brought to him, presumably in Berlin, by a fisherman on May 24th. It was dead, but in fresh condition. Nothing is stated concerning its place of capture. The ovary was $1\frac{1}{2}$ in. wide in its middle part. The fat, which in ordinary eels is abundant between the eggs, was almost entirely absent. The importance of the condition of this specimen to Rathke's mind was the evidence it supplied that the eel was oviparous, and not viviparous.

It would appear that in addition to Rathke's specimen and the two here described, only one other nearly ripe female eel has been recorded. This fourth specimen is that mentioned by Calderwood, in a note in the *Ann. and Mag. Nat. Hist.* (6), vol. xii. 1893. But the description given is very scanty. The specimen was $29\frac{1}{2}$ in. long, and was captured on December 27, 12 miles south of the Eddystone Lighthouse, or 20 miles from Rame Head, the nearest point of land. The width of the ovary and the size of the eggs are not mentioned. All that is stated is that the ovaries corresponded exactly in appearance with those figured and described by Brock in 1881, but Brock did not mention a ripe specimen. The ova are said to have been apparently ready to drop from the surface of the ovary, and to have been richly stored with oil globules.

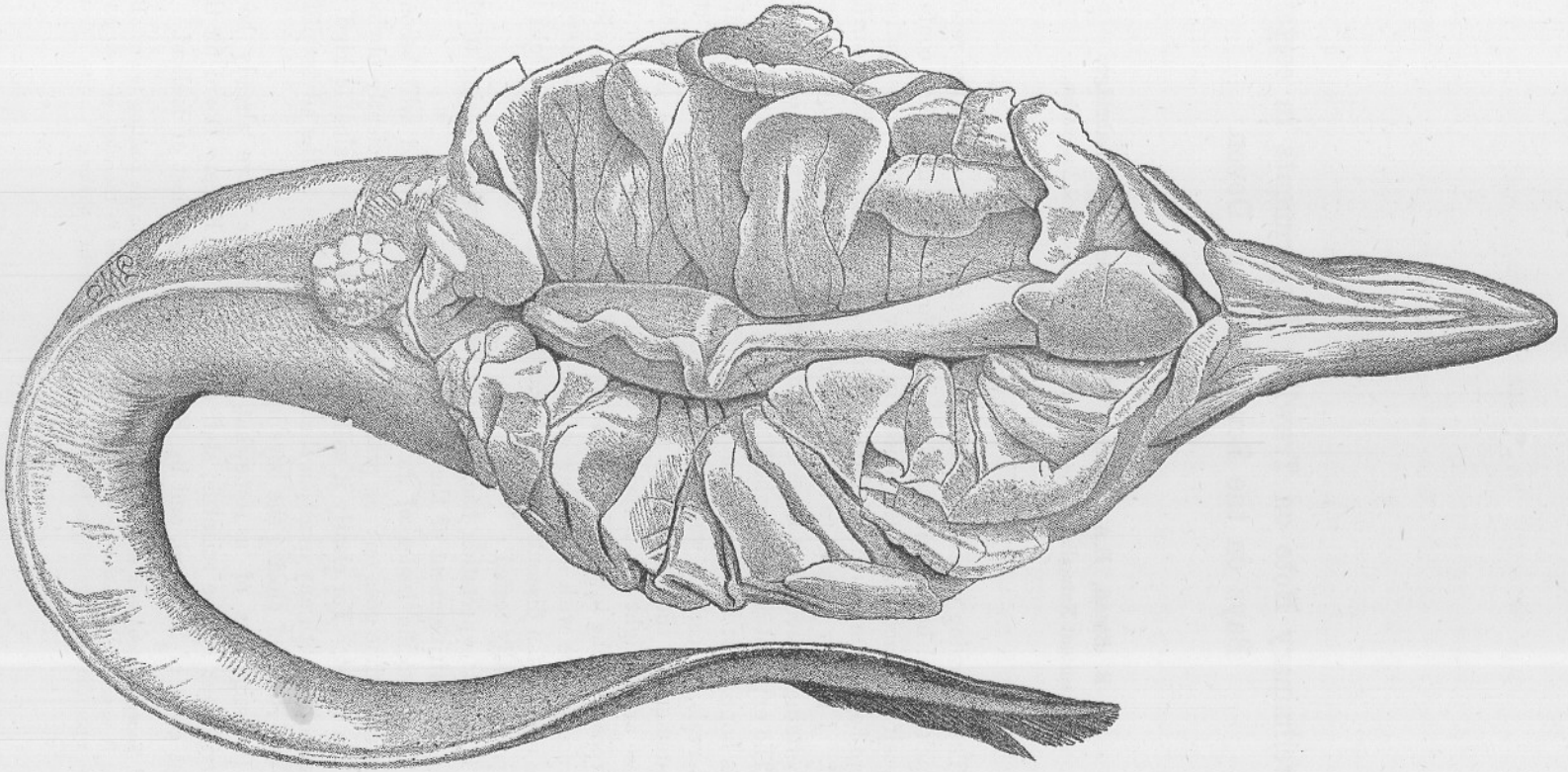

FIG. 1.—Female eel, with ovaries much enlarged and nearly ripe. (From specimen in the Royal College of Surgeons' Museum.)

Preliminary Note on Trawling Experiments in certain Bays on the South Coast of Devon.

By

F. B. Stead, B.A., Scholar of King's College, Cambridge,
Assistant Naturalist on the Staff of the Marine Biological Association.

THE following pages are intended to be preliminary to a fuller report which I shall hope to publish later on. For the present I shall confine myself to an account of the objects in view of which these investigations were begun, and of the method by which they have so far been carried out. I further propose to append a brief summary of some of the facts ascertained, reserving a more detailed statement for a future occasion.

The expectations with which the work was begun were twofold. It was hoped that by carrying out systematic experiments at fairly regular intervals, in certain well-defined areas within territorial limits, the characters of the populations of fishes of different species inhabiting these areas might be ascertained; and, further, that by selecting, for the purposes of the investigation, certain bays at present closed to trawlers, in accordance with a bye-law of the Devon Sea Fisheries Committee, the effects of a discontinuance of trawling within these areas might be experimentally tested.

This last expectation has, however, been disappointed, owing to the frequent infringement of the bye-law in question.*

The scientific issues of an investigation of this kind will become clearer as time goes on: its practical bearings were sufficiently obvious at the outset. For clearly it will afford evidence of a valuable kind in connection with any question that may be raised as to the advisability, or otherwise, of closing the bays investigated.

Investigations of a somewhat similar nature have already been carried out by the scientific staff of the Scotch Fishery Board for the east coast of Scotland, and by Holt for the west coast of Ireland. A

* To what extent such illegal fishing has gone on, I am not in the position to say. But that it would be impossible to draw scientific conclusions as to the effect of closing the bays when the bays have not, in fact, been closed, is sufficiently obvious.

comparison of the results obtained by me with those obtained for the above-mentioned districts, will be held over until my own results are more complete. But I may perhaps take occasion to point out that my object is not so much to arrive at conclusions, as to the general distribution of fish of different species and of different sizes, as to acquire a more exact knowledge of the changes which take place in the populations inhabiting particular areas.

The areas selected in the first instance were Start Bay, Tor Bay, and Teignmouth Bay; and the 24-ton smack *Thistle*, of Brixham, carrying a trawl with a 40 ft. beam, was hired by the Association for the purposes of the investigation. I desire to take this opportunity of thanking the skipper and crew of this vessel for the willingness they showed in carrying out my wishes. At the same time, it may not be superfluous to point out that in undertaking work of this kind the Association is very seriously hampered by the want of a suitable steamer. Much time is necessarily lost on a sailing-vessel, even under favourable conditions, and calm weather may stop work entirely. Further, the necessity of making special arrangements as to hiring, and the delay that this entails, renders it impossible to make use of short spells of favourable weather. Moreover, the lack of accommodation on board a small smack puts any but the most cursory examination of specimens while on board entirely out of the question. In fact, it is not too much to say that the work might have been done with half the expenditure of time, and with far greater completeness, if the Association had had a steamer of its own.

So far, I have made two separate trips to the above-mentioned bays. On each occasion I was accompanied by the Association's fisherman, H. Roach.

The first of these trips lasted five days, from October 28th to November 1st; on the second, bad weather rendered all further work impossible at the end of the third day—December 4th.

The mode of procedure was as follows:—The times of shooting and hauling the trawl, the direction of the wind, the set of the tide, the depths in fathoms and the exact position of the vessel at the beginning and end of a shot, were all recorded. Notes were made of the "rubbish" that was brought up in the trawl; and, lastly, all the food-fish caught were measured to the nearest quarter of an inch. The measurements were, in all cases, made from the end of the snout to the tip of the tail.

Hauls were taken both by night and by day; and my efforts were directed, on the first trip, to obtaining fair samples of the populations of the several bays, and, on the second, to conducting operations in such a way that the successive hauls obtained in December might fairly be compared with those obtained in the same bays a month before.

It is not, of course, pretended that the same conditions, with the single exception of the difference in time, prevailed for corresponding hauls in two trips. When the physical circumstances are so complex and so variable, no such identity of conditions can be realised; and, in the absence of a scientific theory of trawling, it is quite impossible to appreciate, except in the roughest manner, in what way an observed difference in the physical conditions may be expected to affect the catch. All I would venture to claim is that, so far as it is possible to do this on a sailing boat, the same ground was towed over on the second trip as on the first, and that, further, when the physical conditions were manifestly unfavourable, and the catch was, in consequence, small, the facts were recognised, and the value of the evidence afforded by the catch in question was duly discounted. Thus, in summing up the statistics so far obtained for Start Bay, I have omitted to include the measurements of the fishes caught in the first two hauls—when, owing to the light winds and calm weather that then prevailed, the catches were relatively small, and the practical experience of the skipper informed me that we had not had "a fair trial."

Of the three bays selected for investigation, no adequate examination of one—Tor Bay—has, as yet, been made. Two hauls were made in this bay on November 1st. On each occasion the net came up filled with sea-weed—which had drifted into the bay owing to the rough weather that then prevailed outside—and with little else. On the second trip, which was cut short by a change in the weather, no trial could be made in this bay; nor has any opportunity since been given me of doing what was previously left undone.

Before proceeding to state the results thus far obtained for Start and Teignmouth Bays, I may make mention of the fact that it was originally my intention to make a certain number of hauls in the deeper water of twenty fathoms and more, outside the limits within which trawling is forbidden. Once more my constant enemy, the weather, has prevented more than one such haul being made; but the results of this haul deserve to be recorded.

The trawl was shot 3½ miles from Berry Head, which bore N.N.W., at 7.30 a.m., on December 3rd, at a depth of 21 fathoms, and was hauled at 11.30 a.m. from a depth of 18 fathoms—after being towed over a distance of about 3 miles in a straight line. The conditions as to wind, &c., under which the haul was taken, appeared to be favourable, and a remark to that effect was made to me by the skipper before the net was hauled.

The total catch consisted of 157 whiting, whose middle length* was

* By the "middle," or "mid" length, I mean the length on either side of which half the fish measured were found to lie.

$10\frac{1}{4}$ inches; 55 dabs, with a middle length of 9 inches; 18 pouting, all under 7 inches; 7 grey gurnards, with a middle length of $10\frac{3}{4}$ inches; 1 tub, of $11\frac{1}{2}$ inches; 1 turbot, of 19 inches; and only 5 plaice, respectively $10\frac{1}{4}$, $11\frac{1}{2}$, 12, $12\frac{1}{4}$, and $12\frac{1}{2}$ inches in length. It will be seen that the quantity of saleable fish in this haul, which lasted four hours, under conditions apparently favourable, was extraordinarily small. Too much importance must not, of course, be attached to the results obtained by a single haul; but I have given the facts as they stand, because, so far as they go, they tend to corroborate the statements again and again made to me by the fishermen. For it is alleged by these men, firstly, that, at this time of year, the fish are plentiful "in the bays"; and, secondly, that they are present in relatively small numbers "outside," though good catches may be made by the large smacks which can venture far out to sea. It is this, then, that constitutes the grievance, of which one result is that trawling can scarcely be said to have entirely ceased in the nominally closed areas. It would be premature, in this preliminary report, to offer any opinion on the much-debated question of the wisdom, or otherwise, of the legislation now in force; but it may perhaps be as well to point out that, assuming the statements above mentioned to be correct, they do not, in themselves, furnish an argument against the closure of the bays.

Setting aside, then, a consideration of the entire question till a future occasion, I may now pass on to a brief statement of the facts ascertained by trawling in the bays. In what follows no attempt is made to distinguish between the hauls taken on the first and those on the second trips; still less between the individual hauls in the same bays on either occasion. All that I have done is to add together the numbers of each species of food-fish caught in all the hauls considered in each bay, giving, at the same time, the middle length in each case. The results are tabulated below:—

	START BAY (3 HAULS).		TEIGNMOUTH BAY (4 HAULS).	
	TOTAL NUMBER CAUGHT.	MID LENGTH.	TOTAL NUMBER CAUGHT.	MID LENGTH.
Plaice	559	$12\frac{1}{2}$ in.	1088	$10\frac{1}{2}$ in.
Dab	890	$8\frac{1}{2}$ in.	511	$7\frac{1}{2}$ in.
Common Sole	35	11 in.	8	$12\frac{3}{4}$ in.
Merry Sole	—	—	4	12 in.
Turbot	1	$15\frac{1}{4}$ in.	2	13 in.
Brill	2	$11\frac{7}{8}$ in.	2	11 in.
Whiting	144	$10\frac{5}{8}$ in.	61	6 in.
Pouting	4	5 in.	40	$6\frac{1}{2}$ in.
Cod	1	$20\frac{1}{2}$ in.	—	—
Grey Gurnard	57	$11\frac{3}{8}$ in.	2	$9\frac{1}{8}$ in.
Tub	8	$11\frac{7}{8}$ in.	—	—
John Dory	11	11 in.	—	—
Herring	1	9 in.	—	—

An inspection of the above table will show that of the different species captured, plaice and dabs occurred in far the largest numbers. With regard to the relative numbers in which these two species were present in the bays, the table gives no certain information; for the proportionate numbers of plaice to dabs in the several hauls varied very considerably, and the number of hauls made was too few to make it possible for any conclusion to be drawn. It should, however, be noted that of these two species the plaice are alone important from an economic point of view, since the large number of competing dabs ought probably to be regarded as a positive hindrance to the well-being of the plaice; and that, therefore, any discussion as to the merits or demerits of the present bye-law should be almost wholly occupied with the question whether the closure of the bays to trawlers is necessary *for the protection of the plaice.*

It will further be observed that the plaice in the two bays differed from one another in respect of size; that while half the plaice caught in Start Bay were under 12½ inches, in Teignmouth Bay the mid-length was only 10½ inches. A similar difference obtains in the case of the dabs, whose mid-length was 8½ inches in Start Bay, and 7½ inches in Teignmouth Bay. These differences are of considerable importance; they appeared in a marked manner in all the hauls taken on either trip, and they imply a striking difference in character between the two bays.

Of these differences two explanations alone appear to me to be possible. They may be due in each case (1) to a difference in the ages of the fish caught in the two bays; (2) to a difference in their rate of growth.* As for the first of these explanations, it is difficult to see why there should be a larger proportion of older fish in Start Bay than in Teignmouth Bay; and with regard to the second, I am unable to point to any causes to which a difference in the rate of growth might be ascribed. Whichever explanation is adopted, a striking difference between the two bays, in respect of the most important fish they contain, appears to be indicated—a difference which is the more remarkable in that the bays in question are not more than 15 miles apart, and open into the same sea. Whether such a difference is constant throughout the year I am not yet in a position to say; but that it held good from October to December of this year there is no reason to doubt. Further, though it would be out of place in this preliminary paper to enter into further details, I may, perhaps, add that while the differences in the *mid-lengths* of plaice and dabs for

* The possible influence of differences in the depths at which hauls were taken in the two bays has not been overlooked; but a comparison of the soundings taken does not appear to favour such an explanation of the differences between their respective populations.

these bays are the most obvious, they are not the *only* differences which appear, when the statistics are examined. The general impression which such an examination has so far given me is that each bay has a certain individuality of its own in respect of the populations it contains.

While plaice and dabs appeared in every haul in considerable numbers, the other species captured were obtained in relatively small numbers, and, in most cases, not in every haul. Thus the 144 whiting recorded for Start Bay were all obtained in the two hauls made in that bay on December 4th; while of the 57 grey gurnards, 29 were obtained on the first trip, and 28 on the second; and of the 35 soles, 33 were taken in the first haul made in Start Bay, and only two in the two last hauls.

Hence, for the present, at least, in attempting any comparison of the population of the bays examined, little account can be taken of the species captured other than plaice and dabs.

A careful comparison of the corresponding hauls in each bay has led me to believe that the attempt to obtain a fair idea of what a vessel provided with a similar net might be expected on the average to catch, was attended with success. And if we were only concerned with the practical and economic side of this investigation, this is all we should have to consider. As it is, the further question arises, How far do the catches so obtained represent the actual populations of the bays? It must be admitted at once that the results are *incomplete*, since they do not apply to the shallower portions of these bays, with depths of less than 5 fathoms. I intend, therefore, to supplement the facts ascertained by trawling, by an investigation into the catches of the inshore fishermen. It remains to consider to what extent the results are imperfect, for those portions of the bays to which they do apply. That the width of mesh of the net employed exerts some selective influence, in permitting the escape of small fish, seems tolerably certain. But in the case of the plaice, at least, there is good reason to think that this factor did not operate to any serious extent. Dr. Fulton's investigations* have shown that with an ordinary net of $1\frac{1}{2}$-inch mesh from knot to knot, out of a total number of 1080 plaice under 8 inches, only 58 escaped (*i.e.* 5·3 per cent). In my own investigations, the total number of plaice captured under 8 inches in length is only 71. Unless, then, the proportion of the plaice that escaped was far larger in these experiments than in those carried on by the *Garland*, the selective influence of the net, in permitting the escape of small plaice, may be neglected.

The same cannot, however, be said for dabs. For these fish, Fulton's

* *Twelfth Annual Report of Scotch Fishery Board*, iii. p. 307.

results show "that with an ordinary net of 1½-inch mesh, the great majority of the specimens at or below 6 inches escape."

It must further be remembered that other factors may come in—of which we know little or nothing—tending to create a discrepancy between the apparent results as ascertained by trawling, and the actual populations existing in the bays. But this fact, while it should make us cautious in drawing inferences from the former to the latter, does not invalidate any comparison we may institute between the results obtained under like conditions in the two bays.

It would be unwise at this juncture to attempt in any way to forecast the results to which these investigations may lead us. But apart from the practical object in view of which they were begun, there are at least three subjects on which these experiments, if systematically carried on, ought to throw light: (1) the rate of growth of the more important fishes captured; (2) the migrations which may take place from the areas in question for the purposes of spawning, or from other causes; (3) the nature and influence of local conditions as affecting variations. To what extent it may be possible to attain these ends is uncertain; but that the method of this investigation—consisting, as it does, in an attempt to study the characteristic features of particular localities—is a sound one, I have become more and more convinced as the time has gone on.

North Sea Investigations.

(CONTINUED.)

By

J. T. Cunningham, M.A.

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I. The Size of mature Plaice, Turbot, and Brill, on different Fishing Grounds.

In the previous number of the Journal, I described my reasons for doubting whether the conclusions drawn by Mr. Holt, concerning the size at which plaice become mature, would hold good for the whole of the North Sea; and also whether the evidence he relied upon, in distinguishing mature and immature plaice, was sufficient. I stated that, as an actual fact, one sample of mature plaice, which were much below the limits of size determined by Mr. Holt, had come into my hands. I suggested, as a probability, that the presence of dead degenerating eggs in the tissue of the ovary was a proof that the fish had spawned, was a spent, and therefore a mature specimen. My words were: "It cannot be asserted as a certainty that these granular masses never occur in an immature ovary; to settle the doubt it will be necessary to make a careful examination of plaice in November and December, when all fish which are about to spawn will have a large amount of yolk in the eggs, and all fish in which the eggs are transparent and yolkless must be immature." It was already known that these degenerating eggs do occur in spent ovaries, from which the ripe eggs have recently been discharged, and which bear

evidence of the fact in their somewhat large size, flaccid and collapsed condition, and usually in the presence of a few detached ripe eggs in their interior. Observers were agreed that the explanation of this fact was that when spawning was finished, a certain number of eggs were still only partly developed, and that these, instead of completing their development, degenerated, and were gradually removed by absorption in their place without being discharged. It seemed natural to infer, therefore, that in every ovary in which microscopic examination showed the presence of these degenerating eggs, spawning had previously occurred.

This supposition has proved, however, to be incorrect. The granular opaque masses have been found in the ovaries of the plaice in every month of the year from February to December, and in November and December have been found to occur nearly always in ovaries, which showed no trace of the development of yolk in the healthy eggs, which were, therefore, undoubtedly immature, the mature ovaries at this time being much enlarged and far-advanced in development. At this time no fish had begun to spawn, and none were in the spent condition. It is clear, then, that aborted partially yolked eggs do occur in immature ovaries. In different specimens these aborted eggs are seen in different stages of degeneration, and it is evident that in an immature ovary a small number of eggs are constantly beginning to develop yolk, as though about to become ripe eggs, but almost immediately die and degenerate instead of continuing their development. The same process is going on in mature ovaries between the spawning seasons. When the fish becomes mature, then some months before the spawning season a large number of eggs continue to develop without check or interruption until the crop of ripe eggs is produced.

The plaice which, on February 27 last, I found to be mature at sizes below Mr. Holt's limits, were said to have been caught off the Leman Shoal, at a depth of 12 to 17 fathoms. I do not feel sure that this was really their place of capture, for reasons which will appear in the sequel. But I have found that the plaice, taken by the Lowestoft trawlers in the neighbourhood of the Brown Ridges, are certainly mature at sizes similar to those which characterise the sample mentioned, and considerably below Mr. Holt's limits. On October 2nd, I made a complete examination at Lowestoft of a box of plaice from the Brown Ridges. As it was so considerable a time before the commencement of the spawning season, I did not attempt to distinguish between mature and immature males. But in many of the females yolk-formation had distinctly commenced, or was even somewhat advanced, and these I put down as mature, the others as immature. The results are as shown in the following table:—

BOX OF PLAICE FROM BROWN RIDGES, OCTOBER 2ND, 1895.
Total number, 176.

Length in inches.	Males.	Females. Mature.	Females. Immature.	Totals.
9	1	1 (9¾ in.)	2	4
10	6	—	12	18
11	25	6	24	55
12	27	12	24	63
13	10	14	5	29
14	2	1	—	3
15	—	—	—	—
16	—	3	—	3
17	—	—	—	—
18	—	—	—	—
19	—	1	—	1
	71	38	67	176
	(40·3 per cent.)	(21·6 per cent.)	(38·1 per cent.)	

On November 18, I examined another sample, sent from Lowestoft to me in London. The information given me, concerning the place of capture, was that it was on the track of the Harwich boats, nearer the Dutch than the English coast. This would be somewhere to the west of the Hook of Holland. The condition of these plaice was as shown in the following table:—

PLAICE FROM LOWESTOFT, NOVEMBER 18TH, 1895.
Total number, 197.

Length in inches.	Males. Mature.	Males. Immature.	Females. Mature.	Females. Immature.	Totals.
8	—	1	—	—	1
9	6	9	—	4	19
10	17	14	2	21	54
11	21	7	12	27	67
12	17	4	11	9	41
13	4	—	5	1	10
14	1	—	1	—	2
15	1	—	—	—	1
16	—	—	1	—	1
17	—	—	—	—	—
18	—	—	1	—	1
	67	35	33	62	197
	(34 per cent.)	(17·8 per cent.)	(16·7 per cent.)	(31·5 per cent.)	

It is possible that, in this last sample, some of the males set down as immature would have become mature before the end of the spawning season, but this is not a question of great importance. In both samples

the limits of maturity and immaturity in the females agree with those seen in the sample examined at Grimsby: these limits are 9 in. and 14 in. Below 9 in. no females are mature, above 14 in. none immature. The limits at Plymouth were almost exactly the same, except that three specimens were found to be immature at 14 in. Mr. Holt's limits, on the other hand, were 13 in. and 18 in., so that there is a difference of 4 in. between both the upper and lower limits in the two cases. There is every reason to believe that the maximum size actually attained by the fish corresponds to the size at which it begins to spawn. As a matter of observation we find that the largest plaice caught in the neighbourhood of the Brown Ridges are considerably smaller than the largest caught on grounds further to the north. The largest plaice in the samples above described does not exceed 20 in. in length.

The ground named extends between thirty and fifty miles from the Dutch Coast, and to a great distance in a north and south direction. It is limited by the "edge of the deep water" towards the English coast, and this boundary (the twenty fathom line) lies at about fifty-five miles from the coast of Norfolk. The ground is undulating, being traversed by ridges running north and south, over which the depth decreases to a minimum of 11 fathoms, while, in the valleys between, there is, in some places, a depth of 24 fathoms. The ground is therefore neither uniformly shallow, nor close to the land.

I was strongly inclined to think that the small plaice of the German Bight would prove to be of the same character as those from the Brown Ridges. My theory was that the race of smaller plaice actually proved to exist off the coast of Holland would be found to extend along the Dutch and German coasts, probably as far as the Horn Reef, and that this would be the explanation of the small size of the plaice landed at Hull and Grimsby, from the German or Heligoland Bight. In order to examine samples of the plaice caught on these eastern grounds in November and December, I considered whether it would be advisable to go to the Biological Station of Heligoland, or to some fishing port on the German coast, or to have samples sent over the sea to me in London. I made enquiries from Dr. Heincke, the Director, and Dr. Ehrenbaum, the Zoologist of the Biological Station, and have much pleasure in here expressing my thanks for the courtesy and thorough efficiency with which they assisted me to obtain the facilities I required. They informed me that plaice were not landed in Heligoland regularly or in large numbers, but that they would assist me in my undertaking if I visited one of the fishing ports on the mainland. I thought, however, that, under the circumstances, I might just as well have samples sent to me in London, and accordingly Dr. Ehrenbaum put me in communication with Herr Düge, the harbour-master at Geestemünde,

who undertook to forward me samples of plaice, with most careful attention to all the precautions and conditions I required. The first sample reached me on November 20th, and the following table shows the result of their examination :—

PLAICE FROM GEESTEMÜNDE, NOVEMBER 20TH, 1895.

Total number, 186.

	Males.		Females.	
In.	Mature.	Immature.	Mature.	Immature.	Total.
10	—	5	—	2	7
11	2	43	1	35	81
12	7	27	—	36	70
13	1	3	—	17	21
14	—	—	—	2	2
15	—	—	—	—	—
16	1	—	—	—	1
17	1	—	—	—	1
18	—	—	1	—	1
19	—	—	—	—	—
20	—	—	2	—	2
	12	78	4	92	186
	(6·5 per cent.)	(41·9 per cent.)	(2·1 per cent.)	(49·5 per cent.)	

It will be seen, at once, what a striking contrast these fish present to those from the grounds south of the Texel. The single mature specimen at 11 in. is of no importance in comparison with the large numbers of immature. We may say that all below 15 in. were immature, so that they correspond very closely with the plaice examined by Mr. Holt, at Grimsby.

Among the males there are a larger proportion mature at 12 and 13 in. than Mr. Holt found, but in the females there is no evidence of maturity at a smaller size than that fixed by him. We must conclude, then, that these fish are small because they are young and immature, not because they are of a smaller race. These fish were stated by Herr Düge to have been caught at 53° 58′ north latitude and 7° 10′ east longitude from Greenwich, a position about 15 miles north of the island of Nordeney, at a depth of 13 to 14 fathoms.

In a letter which I received on December 5th, Herr Düge informed me that among the plaice landed at Geestemünde, he found the smallest ripe males were 32 cm. long (12⅝ in.), the smallest mature females 40 cm. (16 in.), an observation which agrees with the results of my examination of the German plaice in London.

The above sample does not afford complete evidence concerning the range of size, or the proportional numbers at different sizes, of the plaice taken on the ground from which it came, because it consists, as Herr

Düge informed me, of the marketable fish selected from the whole number brought up by the trawl, the smaller being rejected. This, of course, makes no difference with regard to the minimum size of mature specimens; all those rejected less than 10 in. in length must have been immature. The smaller fish, which were thrown overboard, however, when the sample was taken, were stated to be very few in number, although Herr Düge tells me that it sometimes happens, even in winter, that, in the same locality, plaice mostly from 9 to 12 in. in length are taken.

I was desirous of obtaining a sample sent, without selection, just as they came on deck, and Herr Düge was good enough to send me a second consignment. These fish were trawled on December 20th, in 54° 35′ north latitude, 7° 40′ east longitude, at a depth of 11 fathoms. This position is about 24 miles from the Amrum Light, and in the very same neighbourhood in which the steam trawler, *John Bull*, was fishing, in June, when I was on board her. The sizes and conditions of these fish are shewn below :—

PLAICE FROM GEESTEMÜNDE, DECEMBER 20TH, 1895.

Total number, 121.

	Males.		Females.	
In.	Mature.	Immature.	Mature.	Immature.	Total.
9	—	1	—	—	1
10	—	4	—	1	5
11	—	5	—	6	11
12	—	7	—	17	24
13	2	8	—	35	45
14	3	3	—	13	19
15	—	1	1	7	9
16	—	—	—	4	4
17	—	—	1	—	1
18	1	—	—	—	1
19	—	—	1	—	1
	6	29	3	83	121
	(4·9 per cent.)	(24 per cent.)	(2·5 per cent.)	(68·6 per cent.)	

It will be seen that these unselected plaice were, on the whole, not smaller, but somewhat larger than those in the previous sample from German waters, and with the quite insignificant exception of the one specimen at 9 inches, did not include any smaller specimens. With regard to immaturity, the second sample agrees with the first, no less than 92·6 per cent. of the whole number being immature. In both samples the proportion of mature female specimens below 18 inches is even distinctly lower than in Mr. Holt's records taken at Grimsby.

A comparison between these plaice, caught off the German coast in November and December, and those which I have described in the previous number of the Journal, as caught under my own observation in June, in the same neighbourhood, is worthy of careful attention. Firstly, with regard to the locality of capture. The position given by Herr Düge, for the second sample, is 24 miles west of Amrum Light; and in the cruise of the *John Bull*, the Amrum Light was seen, on two nights, at a distance of 20 miles. Thus, the *John Bull* was fishing on these occasions 4 miles nearer the land, and it is true that sometimes she was steered nearer the land than this; but she was also fishing sometimes out of sight of the Amrum Light, and the ground she covered must have included the position where the December sample was taken. Next, with regard to the depth: during the fishing of the *John Bull*, it varied from $7\frac{1}{2}$ to $12\frac{1}{2}$ fathoms, while the December sample was taken at 11 fathoms. At the seventh haul in the record of the trip of the *John Bull* the depth was 12 fathoms, and at this haul a number of plaice, $7\frac{1}{2}$ to 10 inches long, were taken, two baskets 10 to 12 inches long, and two baskets 12 to 15 inches long. The comparison shows, therefore, that although the *John Bull* extended her operations to positions nearer the land than that where the December sample was taken, yet it is clear that she also fished at the same depth and distance from land, and obtained there numbers of plaice of small sizes, which are not represented in that sample. On the other hand, the December sample includes specimens larger than any taken on the same ground in June, when the maximum was $16\frac{3}{4}$ inches. It appears to me quite probable that these differences are due simply to the growth of the fish in the six months' interval. We must either conclude that the fish taken on the German grounds in early summer are of the same race as those taken in December, and therefore, with the exception of a small minority, principally males, immature; or we must suppose that they are fish of a smaller race which migrate to these grounds from some other, *e.g.*, more southern region. This latter supposition is at present unsupported by any evidence, and I think we must seek to explain the facts on the view that the summer and winter fish are of the same race. This is not difficult, if we suppose that the smaller fish—6 to 10 inches long—are the year-old fish, which move out from the shallow inshore waters on to those grounds at the beginning of their second summer. The larger immature fish, broadly speaking, from 10 to 15 inches long, must be two-year-old fish, while the number of mature fish over three years is in small proportion. The dispersal of the year-old fish to greater distances from land, and their gradual increase in size, would account for the fact that the fish on the Eastern Grounds become

both much less numerous, and generally larger in late summer and autumn.

I have found that the condition of the plaice along the English coasts of Norfolk and Suffolk is not the same as along the opposite Dutch coast. It would appear that the Channel conditions extend northwards along the Dutch coast, while the size of the mature plaice, which is characteristic of more northern grounds, extends southwards to some distance along the English coast. Some of the Lowestoft smacks were fishing in October, near the Leman Shoal, and on neighbouring grounds, and were landing plaice considerably larger than those from the Brown Ridges. I examined a box of these large plaice on October 4th, in the same week in which I examined the sample from the Brown Ridges. The results were as follows:—

PLAICE FROM LEMAN SHOAL, OCTOBER 4TH, 1895.
Total number, 115.

Length in inches.	Males.	Females. Mature.	Females. Immature.	Totals.
9	1	—	—	1
10	5	—	4	9
11	15	—	6	21
12	6	1 (12⅞ in.)	9	16
13	14	—	7	21
14	7	5	5	17
15	4	8	1	13
16	—	6	2	8
17	—	5	—	5
18	—	3	—	3
19	—	—	—	—
20	—	—	—	—
25	—	1	—	1
	52	29	34	115
	(45·2 per cent.)	(25·2 per cent.)	(29·6 per cent.)	

The Leman Shoal is somewhat further north than the Brown Ridges, being in the same latitude as the island of Texel, and the depth in its neighbourhood does not exceed 20 fathoms. The contrast between these plaice and those from the Brown Ridges is very marked. It will be seen that the proportion of mature females among the former is not much greater, 25·2 per cent., as compared with 21·5 per cent. of those from the Brown Ridges. If we take the females separately, the proportion of mature individuals among these is certainly higher in the sample from the Leman Shoal, *i.e.* the sample of larger fish: it is 46 per cent. among these, 36·1 per cent. among the fish from the Brown Ridges. But this is not a very great difference, and appears to be due chiefly to the fact

that, in the one sample, there were more males and fewer immature females than in the other. The general difference in size in the two samples is sufficiently obvious from the fact that one box contained 176 fish, the other only 115, the box in both cases being of the same size. If we compare the limiting sizes of the mature and immature, they are 9 in. and 14 in. in the case of the smaller, 12 in. and 17 in. in that of the larger, a difference of 3 in. By limiting sizes, I mean the smallest mature and largest immature. Thus the relation of size to maturity in the Leman Shoal plaice agrees closely with that observed by Mr. Holt at Grimsby.

I have endeavoured to obtain samples of plaice from the English side, further south than the Leman Shoal. Opposite the coasts of Norfolk and Suffolk there is a depression of the sea-bottom, ranging from 20 to 27 fathoms in depth, its eastern boundary being about midway between the English and Dutch coasts. I tried to obtain a sample taken in this deep water. The box that was sent to me from Lowestoft, in response to a request to this effect, was stated to have been taken 40 to 45 miles E.S.E. of Lowestoft, a position which would be near the eastern limit of the deep water.

The fish proved, on examination, to be much more immature than the samples from more eastern grounds already described, although, if the place of capture is correctly reported, it is only about 20 miles further from the Dutch coast than the Brown Ridges, where the smaller fish were taken. The sizes and condition were as here shown.

PLAICE CAUGHT 40 TO 45 MILES E.S.E. OF LOWESTOFT, DEC. 23RD, 1895.
Total number, 132.

	Males.		Females.	
In.	Mature.	Immature.	Mature.	Immature.	Totals.
9	—	1	—	2	3
10	—	9	—	7	16
11	9	9	—	9	27
12	8	5	1	23	37
13	6	4	1	14	25
14	—	1	—	7	8
15	2	—	1	1	4
16	5	—	2	—	7
17	—	—	3	—	3
18	—	—	2	—	2
	30	29	10	63	132
	(22·7 per cent.)	(22 per cent.)	(7·5 per cent.)	(47·8 per cent.)	

This sample is intermediate in its limiting sizes between the Dutch plaice and the more northern plaice, the limits being 12 in. and 16 in. for females.

In order to make a direct comparison between the samples already mentioned with one from more northern grounds, I obtained a box from Billingsgate. Mr. Richard Vivian, agent of the Hull Steam Fishing and Ice Co., kindly undertook to send me a box, with reliable information concerning the ground on which the fish were taken, and was in a position to obtain this information from the master of the steam carrier which brought the fish from the fishing fleet to London. Accordingly I received, on December 6th, a box of plaice which had been trawled on the south side of the Dogger Bank, in 55° 20′ north latitude, 4° 30′ east longitude, at a depth of 24 fathoms.

The following is the record of the sizes and condition in this sample:—

PLAICE FROM SOUTH SIDE OF NORTH-EASTERN PORTION OF THE DOGGER BANK, 24 FATHOMS, DECEMBER 6TH, 1895.

Total number, 68.

	Males.		Females.	
In.	Mature.	Immature.	Mature.	Immature.	Totals.
10	—	4	—	2	6
11	—	4	—	8	12
12	1	3	—	2	6
13	—	7	—	3	10
14	2	1	—	6	9
15	3	1	—	4	8
16	9	—	1	1	11
17	1	—	1	1	3
18	—	—	—	—	—
20	—	—	—	—	—
21	—	—	2	—	2
23	—	—	1	—	1
	16	20	5	27	68
	(23·5 per cent.)	(29·4 per cent.)	(7·4 per cent.)	(39·7 per cent.)	

The upper limit of the immature here is as high as in Mr. Holt's results; the lower limit of the mature is unusually high. The reason of the latter fact is to be found in the small number of specimens at each size in the sample. Mr. Vivian informed me that the plaice were packed in two sets, some boxes containing only large fish, others containing mixed sizes. My sample was one of the latter. We cannot, therefore, look upon this sample as representing the general condition of the plaice caught on the ground from which it came, but it is important to notice that considerable numbers of plaice from 10 in. to 13 in. long, and quite immature, are caught right in the middle of the North Sea, about 150 miles from the coast either on the east or west.

The sizes and conditions of the turbot and brill which I examined in May and June last year, are shown in the two tables here given. Most of them were examined on board the two trawlers on which I made the two voyages described in the previous number of the Journal; but in addition are included 20 brill from the same grounds, which I examined on shore. Some smaller specimens, which were only 8 and 9 in. long, were measured, but their sex not ascertained.

TURBOT ON THE GERMAN GROUNDS, SOUTH OF HORN REEF, AND OFF AMRUM, 7 TO 15 FATHOMS, MAY AND JUNE, 1895.

	Males.		Females.	
In.	Mature.	Immature.	Mature.	Immature.
11	1	—	—	1
12	1	—	—	2
13	14	—	—	2
14	10	—	1	5
15	1	—	—	4
16	2	—	—	—
17	—	—	—	—
18	—	—	—	—
19	3	—	—	—
20	4	—	1	—
21	1	—	—	—
22	—	—	2	—
23	—	—	—	—
24	—	—	2	—
25	—	—	1	—
26	—	—	—	—
27	—	—	1	—
28	—	—	1	—
29	—	—	3	—
30	—	—	—	—
31	—	—	1	—

BRILL ON THE GERMAN GROUNDS, SOUTH OF HORN REEF, AND OFF AMRUM, 7 TO 15 FATHOMS, MAY AND JUNE, 1895.

	Males.		Females.	
In.	Mature.	Immature.	Mature.	Immature.
10	4	—	—	2
11	3	5?	—	16
12	1	2?	—	23
13	—	—	1	8
14	1	—	1	3
15	—	—	2	—
16	1	—	1	—
17	1	—	3	—
18	—	—	1	—
19	—	—	—	—
20	—	—	1	—

2 ft. 1½ in. female, not ripe.

Fifteen more hauls were made in or close to the Sole Pit with varying fortune, but several of them were failures, in consequence of the trawl catching fast and the net being torn. The ground in this part is rough, and necessitates short hauls and much net mending. The scruff was always abundant and of much the same composition. I made a careful examination of all the waste fish from one haul. The marketable fish from this haul was:—1 basket plaice, 1½ baskets kit haddock, ½ basket dabs and codling, ½ basket lemon soles and whiting, 14 soles, 2 cod, 1 crab, 12 small rays.

The waste fish filled nearly a basket, and comprised:—220 dabs, 3¼ in. to 10 in. long; 86 haddock, 7 in. to 11 in. long, measured to the end of the middle ray of the tail; 46 grey gurnard, 6¾ in. to 11¼ in. long; 11 codling, 5¾ in. to 10½ in. long; 3 whiting, 9¼ in. to 10 in.; 8 plaice, 8¼ in. to 10 in.; 7 lemon soles, 7 in. to 10 in., the smallest a ripe male; 3 scad, 11½ in. to 12½ in.; 1 bib (*Gadus luscus*), 6¾ in.;

II.—Observations at Sea and in the Markets.

1. *Grimsby.*

At Grimsby there are a number of trawlers—some steamers and some sailing vessels, which are locally called Cleethorpers, and regularly fish on the grounds near the Humber, returning to port at the end of the week. I went out in one of these, the s.s. *Rhine*, on July 22nd. My object was to examine the grounds near the mouth of the Humber and the Wash, in order to compare them with the grounds off the German coast. We shot the trawl at 2 p.m. the same day, having steamed 55 miles by the log from the Newsand Lightship, at a position a few miles west of the Coal Pit or N.E. Hole, as it is named on the chart illustrating Mr. Holt's description of the Grimsby Trawl Fishery. The depth during the haul was 13 to 18 fathoms. The temperature at the surface was 58° F.

The trawl was hauled up at 7.15 p.m. The scruff was plentiful, and consisted of Hydroids, chiefly *Sertularia* and *Hydrallmania*. *Alcyonidium*, called by the fishermen "curly cabbage," was also extremely abundant. Another Polyzoan, namely *Crisia*, was plentiful, and there were many *Solaster papposus*. The quantity of marketable fish was very small. The smallest plaice was $8\frac{3}{4}$ in. long, and there were 7 from this size to $10\frac{3}{4}$ in.; these were thrown overboard. Some lemon soles $8\frac{3}{4}$ to $9\frac{1}{2}$ in., a few haddock of $8\frac{1}{2}$ in., and some small dabs $6\frac{1}{2}$ in., were also rejected. The fish packed away were:—1 basket plaice, $\frac{1}{2}$ basket haddock, $\frac{1}{4}$ basket lemon soles and whiting, $\frac{1}{2}$ basket dabs, with a few codling, 4 soles. There were also 10 roker, or rays, and 1 lobster, 10 in. long.

The next haul we steered N., down the Coal Pit, and sounded $22\frac{1}{2}$ fathoms. The trawl was hauled at 11.30 p.m. The scruff again was very abundant, consisting chiefly of the *Alcyonidium;* Hydroids also were very plentiful. There were present also *Alcyonium*, compound Ascidians, and *Solaster papposus*. Among the Hydroids were large clusters of *Antennularia antennina*.

The smallest plaice was $8\frac{1}{4}$ in. long; smallest haddock $7\frac{3}{4}$ in.; smallest whiting $8\frac{1}{4}$ in.; smallest lemon sole $7\frac{3}{4}$ in., a female, immature.

There were 1 solenette $3\frac{3}{4}$ in., a mature female, and 2 others; 1 latchet, a small specimen; 1 scad (*Caranx trachurus*), 1 cod, and 2 rays. The other marketable fish were:—$\frac{3}{4}$ basket plaice, $\frac{1}{4}$ basket haddock, $\frac{1}{4}$ basket dabs, $\frac{1}{4}$ basket lemon soles and whiting.

Third haul, also in Coal Pit, 11.45 p.m. to 5.0 a.m. on Tuesday. As before, a large quantity of scruff and a small quantity of fish. Besides the other items seen in the scruff before, there were several

sea-urchins (*Echinus miliaris*). Of the fish, a basketful of small haddock, whiting, and dabs, and a few small gurnard, were thrown overboard; the small haddock measured 6¾ to 8¼ in., there being only 2 or 3 of marketable size. The smallest dab was 5 in., a male, the largest 14½ in., a female. The smallest plaice was 7½ in., a female, the largest 20½ in., but only 2 were small enough to be thrown overboard. The marketable fish were:—1 basket plaice, ¼ basket dabs, 6 rays, and 4 lemon soles.

Fourth haul, in the Sole Pit which lies to the N.W. of the Coal Pit, and has a maximum depth of 43 fathoms. We sounded 40 fathoms once, and afterwards 13½ fathoms. The trawl was hauled at 8.30 a.m. There was less scruff than before, but *Alcyonium*, or "teats," were very plentiful in it. Only a small quantity of fish. The smallest plaice was 10 in., an immature female; there were altogether 28 females, the largest 21½ in.; 19 males, the largest 20½ in. There were a few lemon soles, haddock, roker, cod, grey gurnard, and dabs. Up to this time we had not taken a turbot or brill.

Fifth haul, 11.30 a.m., June 23rd, to 4.30 p.m., along the east side of the Sole Pit. Scruff as usual, with the addition of whelk-spawn and *Flustra*, sometimes known to the fishermen as "scented weed."

The smallest plaice was 9½ in., and only one thrown over: largest 21¼ in. Some small haddocks 8½ in. Smallest lemon sole 8¼ in. The fish thrown away were ¼ basketful of small haddocks, whiting, gurnards, dabs, the haddocks up to 10½ in., dabs up to 9½ in., and all the grey gurnard. The fish kept were 1¼ baskets plaice, 1 basket kit haddock, ¼ basket dabs and codlings, ¼ basket whiting and lemon soles, 3 small roker (*Raia clavata*), and 2 turbot, one 22 in. male, ripe; one 2 ft. 1½ in. female, not ripe.

Fifteen more hauls were made in or close to the Sole Pit with varying fortune, but several of them were failures, in consequence of the trawl catching fast and the net being torn. The ground in this part is rough, and necessitates short hauls and much net mending. The scruff was always abundant and of much the same composition. I made a careful examination of all the waste fish from one haul. The marketable fish from this haul was:—1 basket plaice, 1½ baskets kit haddock, ½ basket dabs and codling, ½ basket lemon soles and whiting, 14 soles, 2 cod, 1 crab, 12 small rays.

The waste fish filled nearly a basket, and comprised:—220 dabs, 3¼ in. to 10 in. long; 86 haddock, 7 in. to 11 in. long, measured to the end of the middle ray of the tail; 46 grey gurnard, 6¾ in. to 11¼ in. long; 11 codling, 5¾ in. to 10½ in. long; 3 whiting, 9¼ in. to 10 in.; 8 plaice, 8¼ in. to 10 in.; 7 lemon soles, 7 in. to 10 in., the smallest a ripe male; 3 scad, 11½ in. to 12½ in.; 1 bib (*Gadus luscus*), 6¾ in.;

2 solenettes; 3 *Trachinus vipera*, the lesser weever; 2 thornback rays, 8 in. to 9½ in. across pectorals; 1 long rough dab, 9 in. long.

Plaice up to 24 in. and 26 in. in length occurred in these hauls, and as in the above instance only an insignificant number under 10 in., which were thrown overboard.

After this a haul was made 7 or 8 miles to the east of the Dowsing Lightship, at a depth of 9 to 11 fathoms. The marketable fish caught were:—1¼ baskets plaice, 1¼ baskets lemon soles, codling, and haddock mixed; 2 rays, 2 brill 23¾ in. long. The largest plaice was 24 in., and 4 plaice of 9 in. were thrown overboard.

There was an extraordinary quantity of *Alcyonidium*, or "curly cabbage," about 1½ basketfuls, the scruff consisting almost entirely of this. One horse mussel (*Mytilus modiolus*), and 2 sunstars were seen.

At the next haul the trawl was down 6 hours, from 9 p.m., July 26th, to 3 a.m., July 27th. A still greater quantity of *Alcyonidium* was brought up—3 or 4 basketfuls. The fish were:—2 baskets plaice, ¾ basket kit haddock, ¾ basket lemon soles and whiting, ½ basket dabs and codling, 14 soles, largest 18½ in., smallest 7 in.; 2 cod, 1 ray, 8 crabs.

A basket of plaice is rather more than half a boxful, as the boxes are packed for sale, and the number in a basketful may therefore be estimated at about 50 fish.

Only two short hauls of no importance were made after this on the same ground, and then we returned to Grimsby.

It will be seen that the grounds visited in this voyage were all too far from the English coast to be considered as corresponding to the grounds visited in the s.s. *John Bull*. The nearest of them is the Outer Dowsing Ground; the Outer Dowsing Light is 30 miles from the nearest coast, and we fished on the farther side of the Lightship. The depth off the Dowsing was scarcely greater than off the Island of Amrum. We sounded 11 fathoms, and, doubtless, trawled in shallower water than that. The other grounds are narrow gullies, surrounded by fairly level ground less than 20 fathoms in depth. In the character of the bottom, these grounds differ very greatly from those visited in both my voyages on the German side. The latter were nearly all sandy, and very little scruff was brought up: pieces of *Flustra foliacea*, and *truncata*, and *Hydrallmania* were entangled in the net, but the total bulk was inconsiderable. On the English Grounds, on the contrary, the quantity of scruff was enormous, and indicates a coarse varied ground of stones and shells.

With regard to the character of the fish, the grounds above described resemble those to the south of the Horn Reef Lights, a voyage to which

was described by me in the previous number. That ground was farther seaward than the ground where the small plaice were taken; it was mostly from 24 to 30 miles from Blaavand Point, the nearest land, and the depth 11 to 15 fathoms. The plaice were in both voyages mostly between 12 and 26 inches in length, although about twice as abundant on the German side. The haddock, too, were abundant at the Horn Reef, scarce in the voyage of the *Rhine*, and most other kinds of fish were more abundant on the German Ground, but in the absence of small turbot and brill the two grounds agree. My expectation, therefore, of examining during the voyage of the *Rhine*, grounds which corresponded in their depth and distance from the Lincolnshire coast with the small plaice grounds to the north of Heligoland, was disappointed. Nor could I find other opportunities of making such an examination. I questioned some of the skippers of sailing smacks which fished the home grounds near the Humber, and was informed that they trawled chiefly in the Yorkshire Hole or Little Silver Pit, and the Westernmost Rough, grounds mostly about 20 miles from the coast. The plaice which I saw landed from these boats were small, but there was no great quantity of them, not more than one box from any one boat. Besides the plaice they had about 3 boxes of soles, 3 or 4 boxes of haddocks, and a few cod, lemon soles, and turbot. I bought a sample of the small plaice, and found there were 18 females $8\frac{1}{2}$ in. to $12\frac{1}{2}$ in. long; 19 males $8\frac{1}{2}$ in. to $12\frac{1}{4}$ in. long.

The evidence is, therefore, still incomplete, but as far as it goes it does not support a supposition I had formed that large plaice 20 in. and upwards were found in shallower water, and nearer the land on the English coast than on the German. This supposition was suggested to me by the fact that whereas only small plaice were brought from certain grounds on the German side, I could not discover that there were any grounds off the Lincolnshire coast where only small plaice were caught. At present we have no proof, however, that the larger plaice are to be taken at depths of 7 to 12 fathoms on the Lincolnshire coast. The shallow grounds, close to that coast, are not so extensive as on the German side, and according to my experience the Grimsby trawlers usually find more profitable fishing in the deep gullies, to which there is nothing corresponding on the German coast, and in which large plaice are taken It may also be noticed that even in the voyage of the *John Bull* the small plaice became scarce as soon as the ship steamed to a somewhat greater distance from the land. Thus our course from the Spurn Lightship was E.$\frac{1}{2}$S., which would take us to a position S.E. of the Sylt Island: at our first haul the depth was 13 to 14

fathoms, and we got none of the small plaice, that is to say, none under about 12 inches. The captain said we were 18 or 20 miles west of the Sylt, but this was merely an approximate estimate, and we were probably somewhat farther out. Again, in the fourth haul, the vessel was steered away from the coast out to the depth of 12 to 13 fathoms, and small plaice were taken in insignificant numbers.

2. *Scarborough.*

I was at Scarborough from August 12th to August 21st, and during that time was not entirely occupied in the study of the fishing industry. Consequently I do not pretend to give a complete description of the fishing at this place. Scarborough did not present any features of sufficient importance to demand a long and close investigation.

The harbour is small, and situated in the angle between the south side of the Castle Rock and the shore of the bay, which runs towards the south-east. A large number of drift-net boats belonging to Lowestoft were fishing out of Scarborough, and landing their catches there, but they did not use the harbour much, anchoring for the most part outside in the bay in the morning, and sailing out to shoot their nets in the evening. There were a considerable number, about twenty, of similar boats belonging to Scarborough. These had a fore-and-aft rig like the Lowestoft boats, with a foremast which could be lowered on to the deck. But I found that none of them were engaged in drift-net fishing: they were all employed in long lining. I asked a man belonging to one of them, why it was that Scarborough drift-net boats had thus abandoned the work for which they were built, and left the herring fishery in the neighbourhood, which was by no means unimportant, to be carried on entirely by boats from Lowestoft. He said the Scarborough boats could not make the herring fishing pay, and that the Lowestoft men only made a profit out of it because they fished on Sundays.

The real reason is probably that increasing competition has led to more complete specialisation in fishing operations. A few boats which remain at one station and change their mode of fishing according to the season, cannot compete with the large number of Lowestoft and Scotch boats, which are always employed in drift-net fishing, and fleets of which move from one part of the coast to another, making their headquarters wherever herring or mackerel are to be found at the time. The Scarborough boats were forced by circumstances, either to become nomads in the same way, or to find some other profitable employment, and they have found the latter in the long-lining which, in the deeper waters off the north-eastern

coast usually affords some return, while off the Norfolk and Suffolk coasts, the conditions favourable to long-lining do not exist.

I was told by a fish buyer that there were only eighteen sailing trawlers and nine or ten steamers belonging to Scarborough, and most of these were landing their fish elsewhere during the herring season. The fish trade at Scarborough Harbour is of no great extent, and when herrings are being landed there is very little market for trawl fish, the salesmen and buyers being unable to spare much attention for them. Many of the steamers are old paddle boats, but there are a few modern screw trawlers.

So far as I could ascertain the question of immature fish does not present itself in an acute form at Scarborough. Inshore trawling has been prohibited by a bye-law of the North-Eastern Committee. When I was there no hand-net shrimping was being carried on, the long-shore men being more profitably employed in taking out visitors to sail or to fish in the "cobles" and "mules," as the local shore boats are called. The trawlers fish for the most part in the neighbourhood of the port, on the Scarborough Off Ground, where, the depths being from 30 to 40 fathoms, the fish chiefly taken are large plaice, lemon soles, and haddocks. Plaice, from the German side or Eastern Grounds are not landed at Scarborough. Fishing for soles by hook and line is a remarkable local feature, not to be met with, I believe, anywhere else. I did not gain any personal experience of this mode of fishing, concerning which a good deal of information was indirectly given by Mr. Holt in his account of the Territorial Fishing Grounds of Scarborough in this Journal, Vol. III., p. 176. I ascertained, however, from one of the practitioners, that the instruments used are long lines, furnished with hooks at intervals, and set after sunset in the evening. The lines are of course on a much smaller scale in every way than those used in deep-sea work for larger fish. I examined the hooks, and found them to be 1 in. long and $\frac{3}{8}$ in. from the shank to the barb. The peculiar character of the narrow sandy wykes, supporting a numerous population of annelids, and so attracting numbers of soles in the summer season, is perhaps the reason of the development of line fishing for soles in this locality.

A Fishery Exhibition was held at Scarborough last season, and I had the pleasure of giving a short lecture at it daily for a week. It was organized by Mr. J. W. Woodall, and occupied a wooden building, specially erected for the purpose in that gentleman's grounds on the foreshore. Among the exhibits were a model of Captain Dannevig's Arendal Fish Hatchery, and the collection of various stages of marine food fishes and marine animals, specially mounted for exhibition by our Association.

3. *Hull.*

THE ADOPTION OF THE OTTER TRAWL IN STEAM TRAWLING.

When I was at Scarborough and Hull, last summer, a remarkable revolution was taking place in the steam trawling industry; the old-fashioned beam-trawl, previously in universal use, was being rapidly discarded and replaced by a beamless trawl constructed on the principle of the otter trawl, used formerly only by yachtsmen and amateurs, or for scientific purposes. The innovation was due to the ingenuity and enterprise of Mr. Scott, son of the manager of the General Steam Fishing Company, of Granton, on the Firth of Forth. The modification of the otter trawl, which Mr. Scott invented, will be understood from the following description, and the figures which accompany it, and which are reproduced from those circulated by the inventor's firm. The boards (Figs. 1 and 2) are each 10 feet long by 4½ feet broad, shod with iron, and very thick and heavy. In the centre of the hinder edge of the board is fixed an iron ring, to which the ends of both the head-line and the foot-rope are attached. The head-line is 75 feet long, the ground-rope or foot-rope is 120 feet. The attachment of both head-line and ground-rope to a single ring placed at the end of the axis of the board, is one of the features in which the new gear differs from the ordinary otter trawl, and which are patented. In the ordinary otter-trawl the head-line is attached to the upper corner of the board, the foot-rope to the lower corner, and both are of the same length. Consequently the advantage of the beam-trawl in having the ground-rope, when the trawl is working, some distance behind the head-line, is lost in the ordinary otter-trawl, and a fish disturbed by the ground-rope may swim upwards and rise above the head-line, and so escape the net altogether. In Scott's patent gear this particular advantage in the construction of the beam-trawl is retained, and as shown in Fig. 3, the trawl, when working, has the same shape as the beam-trawl. The net is, therefore, constructed with a square piece of netting in the front part of the upper side or back, a piece technically known as the "square," and 58 feet in length. (Fig. 1.) The only other peculiarity on which the patent depends is the arrangement of the two triangles of iron on each board, to which the towing ropes are attached. The advantage claimed for these is, that being rigid, they ensure that the strain on the board shall always be in the right direction, and if the strain should be temporarily interrupted so that the boards fall on the ground, nothing can easily get foul.

The trawl is towed, not by means of two bridles and a single towing rope, but by two separate ropes, one from each board, one of which is

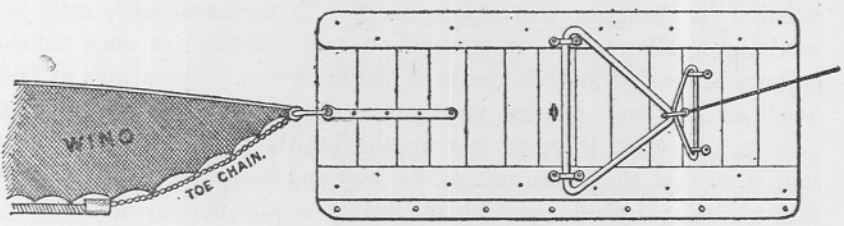

FIG. 1. Side view of Board.

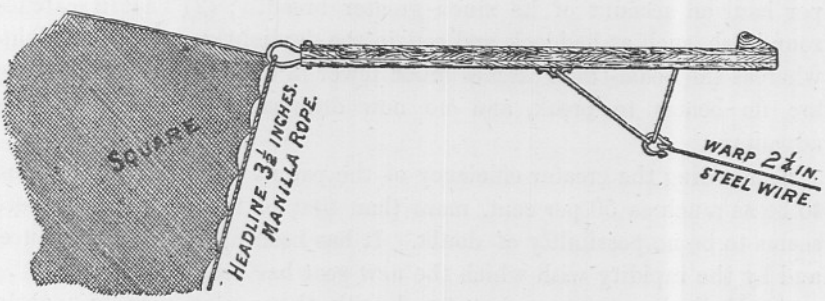

FIG. 2. Board seen from above.

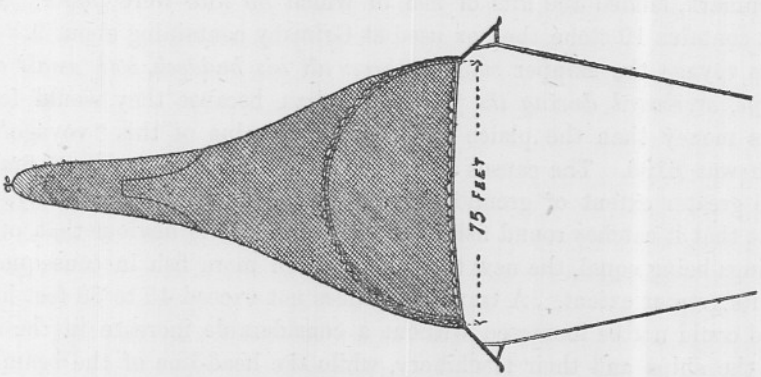

FIG. 3. Trawl. Seen from above.

SCOTT'S PATENT BEAMLESS TRAWL.

brought up over each quarter of the vessel to the steam winch. For hoisting in the gear, two oblong wooden frames are used, each resembling a gallows, with an upright on each side, and at once named gallows in the figurative language of the fishermen. These were at first fixed on the rail of the vessel, one near the bows, one on the quarter, and, when the gear was up, the boards were secured to these frames, so that they were out of the way and incapable of doing harm through being dashed about by the waves or the motion of the ship. The frames were afterwards fixed on the deck inside the bulwarks, the boards being allowed to drop between them and the latter when not in use, an arrangement which was thought to be still more convenient.

The advantages claimed for this gear are (1) That it catches more fish per haul on account of its much greater breadth; (2) That it catches round fish, such as haddock and cod, in the daylight as well as at night, whereas the beam-trawl catches much fewer in daylight; (3) That there are no beams to break, and no new drawbacks to neutralise this advantage.

Concerning the greater efficiency of the patent trawl, which is stated to be as much as 50 per cent. more than that of the beam-trawl, there seems to be no possibility of doubt. It has been proved by experience, and by the rapidity with which the new gear has been adopted.

At Hull the steamers first fitted with the patent gear frequently caught twice as much fish, and made twice as much money, as those still using the beam-trawl. One steamer, after a voyage of seven days, fishing on the Holman Ground, *i.e.*, off Hantsholm, in the North of Denmark, landed 400 kits of fish, of which 80 kits were plaice. The kit contains 10 stone, the box used at Grimsby containing about 9. On this voyage the skipper said *he threw all his haddock, both small and large, overboard during the first three days*, because they would fetch less money than the plaice and cod. The value of this "voyage" of fish was £196. The causes of this greater efficiency are two; firstly, the greater extent of ground covered by the new trawl; secondly, the fact that it catches round fish in the daytime. It is obvious that, other things being equal, the new trawl must catch more fish in consequence of its greater extent. A trawl beam does not exceed 45 to 50 feet long, and could not be increased without a considerable increase in the size of the ships and their machinery, while the head-line of the beamless trawl is 75 feet long, and may be more. I have not heard that the beamless trawl catches as many soles in the daytime as at night, the reason for the fact that these are caught more at night being their nocturnal habits; in the day they remain buried in the sand. But with the beam-trawl it was nearly always found that more cod and haddock were caught at night, and some fishermen believed that this was because

they swam some distance above the bottom during the day. The fact appears to be that the movement of the beam through the water, and its size, alarms the fish in daylight, and that they see it while they have time to avoid it. With the beamless trawl, on the other hand, there is scarcely anything to be seen or to create alarm. It is probable, too, that the head-line of the beamless trawl is not stretched quite straight in the water by the boards, but rises upwards towards the centre, and for this reason a fish would have more difficulty in avoiding the mouth of the net.

Mr. Scott was led to turn his attention to the improvement of the trawl, in consequence of the gradual diminution in the earnings of the Granton Steam Fishing Company. After various experiments he elaborated and patented the mode of construction above described, and the new apparatus was fitted to some of the Granton Company's vessels in June, 1894. He then chartered three steamers on his own account, had them fitted with his patent gear, and caused them to fish for a time out of different ports in succession, finally taking them to Hull, where he was established at the time of my visit. The new gear was first adopted in Hull by the Anglo-Norwegian Steam Fishing Company, and afterwards by other firms. Mr. Scott informed me that, at the time I was in Hull, it was in use on sixteen or seventeen steamers in that port, on eight at Granton, on one at Boston, two at Grimsby, and two at Milford Haven, and I also saw it on one at Scarborough.

The patentee, however, charged a considerable sum for the right of using his patents. I heard that the charge was £100 a year, but it will be understood that I was not anxious to obtain, or to publish, information which business men might consider to be in some degree of a private nature, and am only concerned with these matters as far as they are of public interest. Whatever the amount of the charge, it is a fact that many owners of steam trawlers in Hull thought they might obtain the advantages of the beamless trawl without rendering themselves liable for the charges of the patentee, or infringing the patent rights. Their view was that the principle of the otter-trawl was free to everyone, and that the patented special features were not essential. Accordingly, a large number of steamers were fitted with beamless or otter-trawls of a somewhat different construction. The boards of these were smaller and lighter than those of the patent gear, being each about six to eight feet long, and four feet broad. The hinder edge of the board was provided with holes along its whole length at equal distances, and the ends of the head-line and ground rope were shackled into these holes separately. Thus the attachments of the two ropes could be made near together or far apart at pleasure. The head-line was made 74 to 94 feet long, and the ground rope longer, and the net was made with a

"square" in the back as in the patent trawl. The attachment of the towing rope to the board was made by means of four short iron chains fixed to the board at four separate points.

These unpatented beamless trawls were working with apparently satisfactory success at the time of my visit, which lasted from August 27th to September 5th. In working them no frames were used for hoisting, but the towing ropes were brought in over the pulleys fitted in the bulwarks forward and on the quarter rail for hoisting the beam trawl. The boards were simply hoisted over the rail, and stowed on deck when the trawl was hauled. Other contrivances were being tried for greater convenience in handling the gear. On one vessel I saw an aperture being made and fitted with rollers in the bulwarks of the quarter, similar to that which was used in the fore part of the ship in hoisting the beam trawl. In fact, at the time I was in Hull, it was very remarkable to see the amount of work going on all about the fish dock, in connection with the construction of new trawls and the fitting of new contrivances on the vessels for their more convenient operation, while collections of discarded beams and iron trawl-heads were lying neglected in various places.

From the circumstances of the case, and from a few trials that had been made, it did not appear possible to use the beamless trawl with advantage on sailing vessels. Its use apparently requires a strain that shall be constant and not below a certain degree of strength, so that a sailing smack could only use it when the wind was steady, and fairly strong, and, under ordinary conditions, would be better off with the beam trawl. It is evident, therefore, that the greater efficiency of the new gear on steam trawlers makes the inferiority of the smacks greater than it was before—and even before they had considerable difficulty in earning enough for their maintenance.

Another question which arises from a consideration of the greater efficiency of the beamless trawl, is its probable effect on the available fish supply. It is true that its chief advantage lies in the greater number of haddocks and cod it captures to supply a demand which is usually all but insatiable, and a failure in the supply of haddock has not yet made itself very evident. I have not at present any evidence of importance of the use of the new gear on grounds which produce soles, but it certainly brings in an increased number of plaice, *e.g.* from the Holman Ground. Probably, therefore, as the supply of plaice has already diminished, the advantage of the new gear with respect to this fish can be only temporary, and we may expect that, in a few years, a trawl spreading 75 ft. will not be able to capture more plaice than the beam-trawl of 50 ft. could in the year 1895.

Although compelled to adopt it by the necessity of self-preservation,

many of those who depend on the fishing industry at Hull have not rejoiced at the introduction of the new gear. When I was at Scarborough I attended, by Mr. Woodall's invitation, a small conference, held at the Exhibition, to discuss the artificial propagation of marine fishes. One of the gentlemen present, who belonged to Hull, argued that it was absurd to consider the proposal to hatch fish-eggs, when the new beamless trawl was bringing in such numbers of small haddock that the market was glutted with them. Another gentleman replied to this that, in the warm weather of the middle of summer, gluts of haddock had occurred in previous years, though always of very temporary duration, and that there was never any glut of plaice, soles, or turbot, which were the fish it was proposed to propagate.

The following week I was at Hull, and enquired, as far as I could, into the circumstances of the glut. I found there had been no excess in the supply of any other fish but the small haddock, and satisfied myself that the use of the new trawl did not involve the capture of any more small fish of any kind in proportion to the total catch, than the beam-trawl. It was the fact that the supply of small haddocks in the previous week had exceeded the demand. But these were haddocks of a size which are always brought to market, namely, from 9 in. to 12 in. in length, and they are chiefly bought for the fried fish shops, whose custom falls off in summer time. One vessel landed 500 kits of these, and only 200 kits were sold. The manure works took a good many, but they were also glutted. During the week that I was in Hull, many of the vessels threw overboard their small haddock, to avoid the same disappointment again, and it happened that prices were so good that they had reason to regret doing so. On September 2nd the price was 8s. to 10s. a kit, while on the next day it fell from 6s. to 2s. in the course of sale.

The headquarters of the fishing industry at Hull are at the St. Andrew's Dock, the most western of all the docks of the port. A new and larger dock for fishing vessels is in course of construction, on adjoining ground on the west side of the existing dock, which does not now contain sufficient accommodation for the increased business. No other fishing is now carried on from this port except deep-sea trawling, and long lining, and the latter branch of the industry is only pursued by about a dozen steamers. A large number of sailing smacks, 250 according to the annual reports of the Inspectors, are still owned and managed at the port. All of these are worked on the fleeting system. The principal fleets are the Red Cross and the Great Northern, and the fish from these is conveyed to London by steam carriers. At present a considerable number of steamers are regularly employed in fishing with

the fleets, and the statement in the *Eastern Morning News* of September 1st, that, on the previous day, the "cutter," or carrier, from the Red Cross Fleet was in London with fish from 19 steam trawlers and 64 smacks, and the Great Northern cutter with fish from 10 steamers and 70 smacks, illustrates the extent to which this practice has been carried.

The local market at the St. Andrew's Dock is supplied almost entirely by steam trawlers. A great deal of the variety in the modes of fishing and in the kinds of fish brought to market at Grimsby, is missed by the visitor to Hull. The Hull market has not such extensive relations as that at Grimsby, and does not offer the same demand or price for prime fish. The Hull trawlers, therefore, attach more importance to quantity than quality, and one does not find either smacks or steamers there, as at Grimsby, which make a special point of fishing for soles, turbot, and brill. There are no welled cod-smacks, or cod-chests, in the dock, and the line fishing for halibut, tusk, cod, ling, skate, etc., on the distant grounds of Faröe and Iceland, is not pursued to the same extent as at Grimsby. During my visit a number of the steamers landing their fish at Hull were fishing on the Holman Ground, and in the Skager Rack, or Sleeve, as the fishermen call it. One steamer, using the otter-trawl without the patented arrangements, landed 82 kits of plaice, 45 kits of large haddock, 58 kits of medium haddock, 24 kits of cod, 5 kits of codling, 2 kits of hake, 6 kits grey gurnard, 8 stone turbot, 13 stone halibut, 3 score cat-fishes, 5 score ling, 5 score skate, 4 score rays.

The Hull market does not offer such good facilities for observation as that at Grimsby. The fish, as it is landed in baskets on the quay, is nearly all weighed, and then thrown into the kits, which are somewhat narrow deep open casks, and when these are moved away for sale, the various parts of a single vessel's catch are not kept together. To ascertain the nature and amount of a vessel's catch, it is necessary, therefore, to watch the whole process of landing, whereas at Grimsby the wide shallow boxes, and the fact that the whole of a vessel's catch is placed together in one spot on the pontoon, enable one to see at a glance what a vessel has landed.

The Hull steamers, and the fleets too, fish a good deal in spring on the Eastern or small plaice grounds, but while I was in Hull the quantity of fish on these grounds was too small to remunerate them. I ascertained in the case of three steamers that they had visited these grounds and fished there for a part of their voyage, but none of them landed the smallest plaice which are usually there. None of the plaice landed in these cases were less than 9 in. long, and the largest quantity landed from one vessel was 30 kits, the largest fish not exceeding 16 in.

It is important, however, to note that the beamless trawl, with its enormous spread, has been already used on these grounds, and it may be expected that next spring it will sweep up the small plaice in more wholesale fashion than the beam trawl has done in previous years.

The other vessels concerning which I made enquiries, had been fishing in the neighbourhood of the Dogger, from which one vessel, after a voyage of eight days, landed 31 kits of rather small plaice, 12 kits of large plaice, and 180 kits of haddock.

I did not see at Hull any small vessels employed in fishing in the Humber, or in territorial English waters.

4. *Lowestoft.*

I arrived in Lowestoft on September 5th, and the next day saw a heap of small soles in a fishmonger's shop. I bought a sample of these and found it consisted of 4 immature females $7\frac{1}{4}$ in. to $8\frac{3}{4}$ in., and 3 immature males 7 in. to $8\frac{1}{4}$ in. No less than 4 of these 7 soles were under 8 in. in length, and I found afterwards that soles similar to this sample were frequently on sale at the same shop. It naturally occurred to me that this observed fact was strikingly inconsistent with the statement made to the Parliamentary Committee of 1893, that soles under 8 in. in length were never brought into the Lowestoft market in sufficient quantities to make a sale of them. On referring to the Report of the evidence taken by that Committee, however, it appeared that the statement in question was made in reference to the trawl market, and was intended to refer to the trawlers. I found that the soles which I examined were caught in the inshore waters by the shrimpers, two of whom gave evidence before the Parliamentary Committee. One of them stated that they threw the undersized soles overboard alive, the smallest kept being between 7 and 8 in. My own observation shows that the limit is as low as 7 in.

On September 17th, I had a conversation with the master of one of the shrimping boats in Lowestoft Harbour. He had just come in from his morning's work. The boat was open, and rigged with two masts, carrying two lug sails. There was only one trawl on board, an ordinary beam-trawl of 15 feet beam, the net of shrimp-mesh at the cod end. The man informed me that there were about forty such boats at Lowestoft, and they were to be seen moored in the outer harbour, though I could not count them. They were not all at work at this season, many of the men being employed in the herring and mackerel boats. The principal shrimping season is from May to August.

The shrimps brought in by this boat had been sent away for sale; but there were some fish on board—plaice, soles, and whiting—evidently of no great value, as the man allowed me to take what I pleased from them for a shilling. Those that particularly interested me were 3 small soles, true *Solea vulgaris*. They were $2\frac{1}{4}$ in. to $2\frac{5}{8}$ in. long, and could be confidently considered to be of the year's brood, hatched in May and June, and therefore three or four months old. I have shown that in the Plymouth Aquarium a sole $\frac{5}{8}$ in. long in April grew to $3\frac{3}{4}$ in. on the following September 2nd. These small soles were not brought in intentionally, but had simply been overlooked when the rest of the valueless part of the catch was thrown overboard. The other fish in the boat were brought in for sale. I took all the soles; their sizes were—3 at $6\frac{3}{4}$ in. length, 2 males, 1 female; 1 at $7\frac{1}{4}$ in. length, female; 1 at $7\frac{7}{8}$ in. length, female; 1 at $8\frac{1}{4}$ in. length, female; 1 at $8\frac{1}{2}$ in. length, female; 1 at $9\frac{1}{8}$ in. length, male.

All these were immature. If we apply here the method of the Danish biologist, Petersen, and notice the sizes at which the greater number of specimens group themselves, although the number of specimens is small, it is clear that we have at least two groups, those of the first year and those of the second, the former being 2 to 3 in. long, the others mostly about 7 in.

The plaice from this boat were few in number. Their sizes were—1 at $7\frac{7}{8}$ in., female; 2 at 8 in., female; 1 at $9\frac{1}{2}$ in., female; 1 at $9\frac{1}{4}$ in., male; 1 at 11 in., female.

In order to examine the ground where the small boats worked, and their methods of operation, I accompanied the master of this boat on one of his trips. We went out at 6.30 a.m., on September 18th. The trawling took place on the Newcome Sand, which stretches parallel to the shore from Lowestoft southwards. It is separated from the beach by a channel 4 to 5 fms. deep at low water, the depth on the sand itself being only $1\frac{1}{2}$ to 2 fms. The flood was going up, *i.e.* south, and we towed with the tide, with the wind on the starboard side, off the land.

When the net was hauled the first time, there were a large number of the small soles of the year's brood, about $2\frac{1}{2}$ in. long. I counted 42.

Plaice of corresponding size were extremely scarce; there was only 1 $2\frac{1}{4}$ in. long, and 1 dab $1\frac{1}{4}$ in. 7 soles were kept for market, 6 to 9 in. long; there were 2 marketable dabs, and 4 marketable plaice, 7 to 10 in. long; also 1 large plaice, $22\frac{3}{4}$ in. long. There were 9 marketable whiting.

Second haul, same direction. Of the smallest soles, 22 were thrown overboard, besides some which I kept.

After this, having passed the Barnard Buoy, which is near the end of the Newcome, we shot off Kissingland Lifeboat House, and steered north again nearer the shore.

Third haul, a short one, the trawl having caught fast. There were 17 soles 2 to 2½ in. long, 6 soles about 6 in. long.

Fourth haul, same direction. There were caught 23 small soles about 2¼ in. long, a number of whiting, some of the previous year's and some of the same year's broods. Many of the latter were thrown overboard; the size of these is stated below.

Fifth haul, a long haul northwards towards Lowestoft Harbour on the ebb tide. I counted 38 of the small soles when the cod end was first emptied out, besides a large number picked out in the process of sorting afterwards. There were also some whiting and small plaice, mostly kept for market.

The mode of working was as follows:—When the trawl was hauled, the cod end was emptied out into a wooden box in the boat. There were always a number of the little soles in the meshes of the net, alive and apparently, in most cases, uninjured. Except those which I kept, they were all thrown overboard alive. There was always a large quantity of Hydroids, chiefly *Hydrallmania* and *Sertularians*, with pieces of red seaweed occasionally. A considerable number of fish of unsaleable kinds were also taken, namely, *Agonus cataphractus*, *Trachinus vipera* (the lesser weever), *Gobius minutus* (the sand goby), one or two small *Syngnathus* (pipe-fish), a small *Acanthias vulgaris* (spiny dog-fish), and a small *Galeus vulgaris* (locally called "Sweet William"). The invertebrates were some *Portunus*, or swimming crabs, *Carcinus*, the shore crab, one *Cancer* (edible crab), a number of Isopods and Amphipods, including *Idotea* and others. We also took several living specimens of the bivalve *Mactra stultorum*, var. *cinerea*, Gwyn Jeffreys. These things were all thrown overboard. The marketable fish were placed in a separate box, and then the shrimps were riddled over the side and the sorting completed, after which they were placed in a basket to be taken ashore. The shrimps were thus not as in the Thames shrimping boats, which are much larger, boiled on board. There were no *Pandalus*, or pink shrimps, only the brown *Crangon vulgaris*, and the catch of the whole trip amounted to about two pecks. The man told me that there had been little "call" for shrimps that season, and his earnings had not averaged more than £1 a week. The only assistance he had in the work was that of his son, a lad of seventeen. The boat was the property of a widow, whom he paid for the use of it.

I brought ashore a large number of the whiting caught, and measured them to see if I could distinguish the broods of different

years by Petersen's method. The lengths in inches were as follows:

Length.	Number of Whiting.	
3 in.	9	
4 in.	12	maximum.
5 in.	12	maximum.
6 in.	2	
7 in.	4	
8 in.	7	maximum.
9 in.	4	
10 in.	2	
11 in.	2	
12 in.	1	

It will be seen that the number of fish was at a maximum at two sizes, namely 4 to 5 in., and 8 in. The former length is, therefore, that of the majority of the whiting of the year, hatched in the previous spring, and the latter that of those in their second year.

The results of examination of the contents of the stomachs in the small soles are of interest. It is known that the larger soles feed almost entirely on worms, but in these young specimens I found only small Crustacea, with a certain quantity of sand. In one was a Copepod, in three were specimens of Cumacea, minute Crustacea which live on sandy ground. The smallest sole was only $1\frac{1}{2}$ in. long. Plaice and dabs of the year's brood were remarkably scarce; there were 3 dabs $1\frac{1}{2}$ to $1\frac{3}{4}$ in., 1 plaice $1\frac{7}{8}$ in., and 4 plaice $3\frac{3}{4}$ to $4\frac{1}{2}$ in.

Of larger soles which I brought ashore there were 8 of 5 in., 2 of 6 in., 1 of $9\frac{1}{4}$ in. The food in all these was the tail end of the lug-worm, Arenicola.

The chief interest of this ground is, of course, the very considerable number of soles of the year's brood, as well as of those of a larger size, 6 to 8 in., and a year old, which occur upon it in September. It is by no means certain that any great injury is done to the little soles which are trawled and thrown overboard again, though probably a certain percentage of them are thereby killed. But it is clear, I think, that a limit of 10 in. for the landing and sale of soles would be a distinct and very beneficial protection to this species on this ground, and could do no great injury to the men who get their living from the inshore trawling.

The next branch of the industry at Lowestoft to be considered, and one which is vastly more important than the inshore trawling, is the deep-sea trawling. This is carried on exclusively by sailing smacks. The absence of steamers at Lowestoft is largely due probably to its

greater distance from the coal and iron centres as compared with Hull and Grimsby, and the more northern ports generally. It is true that the steamers could be built elsewhere, and the coal and other requisites could be conveyed to Lowestoft. But the grounds in the immediate vicinity are not extensive enough, nor productive enough, to enable a steamer to pay a profit on her working, and if she is to work the grounds more to the northward, she finds a more convenient port for landing and working from, in Hull, or Grimsby, or Boston. In fact, the scarcity of haddock and cod in the shallower waters of the narrow southern part of the North Sea is alone enough to account for the absence of steam trawlers, and their failure, when they have been tried, at the East Anglian ports.*

The number of trawling smacks at Lowestoft is stated, in the Inspector's Report for 1894, to be 320. They are all ketch-rigged and provided with steam capstans. In size they are smaller than the majority of the Hull and Grimsby smacks, the largest being not more than 60 tons. The crew of each consists of four men and a boy, the latter acting as cook. It is a remarkable fact that all these vessels land their fish at Lowestoft, each one landing its own. The boats do not practise the fleeting system, and none of the fish is sent to London direct from the smacks by sea. At Yarmouth it is just the opposite, the trawlers there all fish in fleets, and their fish is conveyed to London by steam carriers. Some few years ago there were few fish buyers at Lowestoft; the usual custom of smack owners was to send the fish to London by railway, and there it was sold on commission by the salesman at Billingsgate or other market. But now the fish is sold by auction when landed, as at Grimsby or Hull, and the smack owners and fishermen have no further interest in it. The same man is sometimes both buyer and smack owner, or has interests in both branches of the business, but, nevertheless, the two branches are perfectly distinct. I was assured, and the prosperity of the industry at Lowestoft is good evidence of the fact, that prices have been better, and the profits of fishermen and smack owners greater, under the present system. This is certainly one case in favour of the much-accused middleman. It is not difficult to understand that under the circumstances of the fish trade the "buyer" performs a very useful function. It is his special business to know where to place his fish according to the demand, and thus the Lowestoft smacks have the whole country opened to them, instead of being restricted to London, or any other single market. Moreover, a man who has paid for the goods he has to sell, and deals with them at his own risk, is naturally more interested

* In the Inspector's Report for 1894 it is stated that 10 steamers were working from Yarmouth. Probably several of these act as carriers for the fleets.

in finding a market for them than the man who sells on commission, the chief risk being borne by the consigner.

The harbour at Lowestoft is divided by wooden piers into several compartments, and one of these is allotted to the use of the trawlers, the market for trawled fish extending along the side of it. During my stay I was allowed to use one of the small offices in this market for my work, and I received a great deal of assistance and courtesy from members of all classes of men engaged in the fish business, from fishermen, smack owners, and dealers, for which both personally, and on behalf of the Association, I am glad to express my thanks. I was especially indebted to Mr. Sladden for permission to make a voyage in one of his boats, and to Mr. Alfred Turner for information and guidance in the market.

I have mentioned in the first section of this paper that the Lowestoft smacks were during my visit trawling partly in the neighbourhood of the Brown Ridges, partly around the banks and shoals off the English coast to the northward, from the Smith's Knoll and Winterton Ridge to the Outer Dowsing. The smacks usually remain out for seven or eight days and more of them land fish on Sunday than on Saturday, for the reason that buyers prefer to send fish for Monday's market on the former day than on the latter. On September 9th a smack, which had fished 55 miles E.S.E. of Lowestoft, at depths of 11 to 23 fathoms, landed 18 boxes of rather small plaice; 4 boxes of dabs; 1 box (level) of soles; ½ box of turbot; 2 or 3 rays. A box of these plaice contained 109 males, 117 females, and the size was 9¼ in. to 15 in. The price was 8s.

A catch on the same date from the Swarte Bank, which is on the English side, a long way to the N.W. of the Brown Ridges, consisted of 8½ boxes plaice; 1 box dabs; 1 box (level) of soles; 1 box turbot and lemon soles; 1 box dabs; 1 box rays; 1 box haddock. The largest plaice was 21½ in., the smallest 9½ in.

There were frequently seen in the market large heaps of mixed fish of little value. They consisted of a few small plaice, dabs, and chiefly of gurnards and large weevers (*Trachinus draco*). I afterwards found that these fish came from the neighbourhood of the Brown Ridges. The gurnards in these heaps were the grey gurnard (*Trigla gurnardus*) by far the most numerous, the red gurnard (*T. cuculus*) and the tub or the latchet (*T. hirundo*). Catches from the eastern side also often included a box or half a box of large latchets. The number of boxes of plaice varied from 15 to 25. Haddocks and lemon soles were conspicuous by their absence. On September 20th, at 10.30 a.m., I counted all the small plaice in the market, and found there were 440 boxes; but this does not include all landed in the day—some had already been removed, and others were landed later. The fishermen, in packing their

plaice, reserve all the largest for putting at the tops of the boxes, and for this reason the appearance of the small plaice from the eastern side is quite different from that of the plaice from the banks off the Norfolk coast, the largest visible fish in the former case seldom exceeding 16 in., in the other reaching 22 in. or more.

In the catches landed from the Norfolk coast, latchets and weevers are not seen, while some haddocks and lemon soles are usually present; but the number of both these kinds is very small, one box of haddocks and half a box of lemon soles being the usual limit. Plaice from these grounds are less plentiful than from the eastern. A voyage from Smith's Knoll and Leman Shoal comprised 3 boxes plaice; 2 boxes lemon soles; 1 box soles; 1 box turbot and brill; 1 box dabs; 3 boxes whiting.

Another voyage from the Leman Shoal was 12½ boxes plaice; 3 boxes dabs; 1 box soles; 2½ boxes lemon soles; 1 box turbot and brill; 1½ boxes codling; 1½ boxes of haddock; ½ box whiting; 3 boxes rays or roker.

A voyage, stated to be caught off the Winterton Shoal, landed on October 9th, contained 8 boxes rather large plaice; 1 box roker and whiting; 1 box dabs; 1 box soles; ½ box turbot and brill; 1 box cod and haddock; 3 boxes whiting. The Winterton Shoal is about 15 miles from the coast to the north of Yarmouth, the depth where these fish were caught 16 to 19 fathoms.

A voyage from the "deep water," 20 miles off Lowestoft, consisted of 10 boxes small plaice; 1½ boxes soles; ½ box lemon soles; 4 boxes cod, 2 boxes whiting; 4 conger.

On Wednesday, October 9th, I saw a boat landing a catch with scarcely any plaice, only a dozen small specimens altogether. The skipper said he went out on the previous Saturday, and had been fishing in the "deep water." He had 1½ boxes of soles, ¼ box of slips or small soles, 1½ boxes of rays, ½ box of lemon soles, a few soles, a few brill, 1 box of whiting, and 1 box of whiting and codling. The number of small soles was remarkable, many were under 10 in., and some no more than 7 in. in length. The box of soles was sold for £9 15s., the slips for 25s.

It is well known that level ground, less than 20 fathoms deep, stretches in a W.N.W. direction from the Dutch coast to the Swarte Bank. I cannot say how far the *smaller race* of plaice, which I have shown to exist at the Brown Ridges, extends, but a voyage landed on October 8th, caught 25 miles east of the Swarte Bank, was apparently similar to one from the Brown Ridges. It included 40 boxes of small plaice, 1 box of latchets, ½ box of soles, 1 box of turbot and brill, 1 box of cod, 3 boxes of dabs. There were no haddock or lemon soles.

These indications are useful in giving a correct picture of the character of the trawling at Lowestoft, but the products of the grounds can be more completely examined on board a vessel during her fishing. I made one voyage on a smack from Lowestoft, and was able to ascertain very thoroughly the character of the ground called the Brown Ridges.

We sailed out of the harbour on Monday, Sept. 23rd, and steered to the east in fine weather, with a light breeze. The skipper informed me that £20 was a large sum for the catch of one of these vessels, that they did well if they got £800 in a year as total gross receipts.

At noon on Tuesday our skipper took an observation of the sun, and made our latitude to be 52° 41′. We shot the trawl at 2.30 p.m. Our distance from the English coast I do not know exactly, as we could not log it as the steamers do, but it was between 50 and 60 miles, and about 40 or 50 miles from the Dutch coast. At first we towed towards the south, and at 5 p.m. we tacked round, and towed northwards. At 6 p.m., the depth was between 19 and 20 fathoms.

The trawl was hauled at 11.30 p.m., having been down nine hours. There was a fair quantity of fish in the net, consisting of rather small plaice, whiting, weevers, latchets, and gurnards. There were a large number of small whiting, dabs, and grey gurnards. The smallest plaice was $9\frac{3}{4}$ in. long, the largest $17\frac{3}{4}$ in., and none were thrown overboard. The fish kept for market were: $3\frac{1}{2}$ baskets of plaice, $9\frac{3}{4}$ in. to $17\frac{3}{4}$ in.; $\frac{1}{2}$ basket of dabs; $\frac{1}{2}$ basket of latchets, largest 20 in. long; 1 brill; 1 turbot; 9 pair of soles. The larger dabs were saved, and all the smaller thrown overboard; the smallest was $4\frac{1}{2}$ in. long. All the whiting, weevers, and gurnards—about a trunk full altogether—were thrown overboard, but not the latchets (*Trigla hirundo*), which, though a species of gurnard, are of larger size. These fish—weevers, small dabs, whiting, and gurnards—are saved from the last hauls, but do not pay for icing if kept from the first day or two of the voyage. The weevers were of two kinds, the small (*Trachinus vipera*) and the larger (*Trachinus draco*). There was one scaldback (*Arnoglossus laterna*), a female mature, and two dragonets (*Callionymus lyra*). Of invertebrates there were 1 squid, starfishes, a few hermit crabs, and whelks.

The trawl was shot again at once, and the second haul was made at 10 a.m. on Wednesday, trawl having been down about 10 hours. At 9 a.m. we sounded 13 fathoms, being then on one of the ridges. The marketable fish from this haul were: 2 trunks of plaice; $\frac{1}{2}$ basket of dabs; $\frac{1}{2}$ basket of gurnards, whiting, and weevers; 10 latchets; 5 pair of soles.

The largest plaice was $16\frac{1}{4}$ in., evidently ripening for next season, the smallest was $9\frac{1}{4}$ in., a female immature. The smallest sole was 10 in. long.

About a trunk of small whiting, dabs, gurnards, and weevers were thrown overboard. The largest weever (*T. draco*) was 13¼ in. long, the smallest (*T. vipera*) 2¾ in. There was one solenette (*Solea lutea*).

Of invertebrates there was 1 edible crab, 1 *Astropecten*, 1 *Spatangus purpureus*, and a great number of large hermit crabs (*Eupagurus bernhardus*) in whelk shells.

We did not shoot again at once, but sailed to the southward and eastward, the wind having taken us too far to the north, or "down," as the fishermen term it.

At noon our latitude was 52° 44′. At 3 p.m. I took the surface temperature of the sea, and found it was 62°.0 F. The density was 1027, as well as I could read it in a bucket on deck.

At 5.45 p.m. the trawl was shot again, the ship's head being N.E., and the wind from the east. We hauled at 6.30 a.m. the next day. There had been a calm all night, and in the net were only 1 pair of soles, about 12 plaice, and a few small gurnards, dabs, and weevers. The net was much torn.

We could not shoot all day for lack of wind, but put the trawl over at 6.30 p.m., again towing to the north with the wind from the eastward. We hauled at 7.45 a.m., and again had scarcely any fish, the wind having been very light. There was 1 turbot 18½ in. long, a male, mature. There was about ¼ of a trunk of plaice, 8 soles, 10¾ in. to 16½ in. long, and, as usual, some small whiting, gurnard, weevers. The plaice were 11 in. to 16¾ in. long. There were 1 *Astropecten*, 1 sandstar (*Ophioglyphya lacertosa*), and several *Echinus miliaris*, and common starfishes.

The trawl was shot again at once, and hauled at 7 p.m. The latitude at noon was 52° 36′. Still the wind was deficient. The novel occurrence this haul was a piece of black friable substance, which the men called "moor-log," apparently a submarine soil or peat.

There were 1 turbot 17¼ in., and 1 brill 16¼ in., the latter a mature male, half a box of plaice and dabs, and 1 pair of soles. There were 5 dragonets (*Callionymus lyra*) and the usual invertebrates.

The trawl was shot again immediately, and hauled at 8 a.m. the next day, after about 12 hours. This time a fair quantity of fish was brought up. The marketable portion was, 5 trunks of plaice, largest 16½ in.; 3 trunks of whiting and dabs, smallest dab 7 in., largest 13 in.; ½ trunk of soles, 40 pairs and 2 or 3 slips; 3 latchets, 3 rays, 12 in. across pectorals.

The largest whiting was only 12½ in. long, the smallest 8 in. There were two scaldbacks, one 3¾ in., and one 5 in., neither having the fin-rays elongated. The smallest sole was 8¼ in. long, the largest 18 in. About a trunk of small gurnards, small dabs, small whiting, and a few weevers were thrown overboard.

In one of the plaice which I opened, the food was chiefly *Pectinaria*, a worm which builds a pretty, smooth, conical tube out of grains of sand. The invertebrates, as usual, included starfishes and hermit crabs, but there were also numerous lumps of *Alcyonium*, or dead man's fingers, and one piece of *Antennularia*. Hydroids were absent from all the other hauls.

The trawl was not shot again until 12.30 p.m., the interval having been spent in sailing to windward, *i.e.* to eastward. It was hauled at 10.15 p.m. There was a great mass of "moor-log" in the net, measuring 2 ft. by 18 in. by 8 in. It contained a number of specimens of a boring mollusc, probably *Pholas*. The marketable fish were:—2 trunks of plaice; ¾ trunks of dabs; 10 soles, 9¾ to 14¼ in.; 3 latchets, largest 17½ in.; ¾ trunk grey gurnards, 7 to 12 in. long; weevers many, largest 13 in. long. The smallest plaice was 9¼ in. long. The gurnards and weevers were saved for market, as in consequence of the lack of wind and scarcity of fish, they were expected to make 1s. a box. Among the worthless fish were some solenettes, one scaldback (*Arnoglossus laterna*), one tope (*Galeus vulgaris*), and a few dragonets. In the stomach of one large weever which I opened were two sand-eels. The invertebrates were large numbers of common starfishes and *Astropecten*, and some anemones (*Actinoloba dianthus*).

The trawl was shot again immediately, and was hauled again for the last time at 10.30 a.m. on Sunday, September 29th. On the net were a piece of *Halidrys siliquosa*, two pieces of *Tubularia larynx*, and swarms of small Amphipods; also some pieces of a branching Polyzoan.

The marketable fish were:—2 trunks plaice: 1 trunk dabs; 2 trunks gurnards, mostly rather small; 8 pair soles; 2 turbots; 1 brill. One of the turbots was 19½ in., male mature; one 18¼ in., female, apparently mature. The brill was 17¼ in., female mature. There was one lemon sole. The smallest plaice was 9¼ in. long. There were no whiting, some larger weevers, but few of the smaller species. Of invertebrates there was one living *Natica*, and there were several shells of this form containing hermit crabs.

After this we made sail for Lowestoft; our latitude, at noon, after a short run, was 52° 19′.

A comparison between the above observations and those made on the ground off the German coast, north of Heligoland, at the beginning of June, and recorded in the previous number of the Journal, shows completely the differences and resemblances between the two districts. The difference in latitude is about 2°, the central part of one district being 52° 30′; of the other 54° 30′. The distance from the Dutch coast of the southern ground is mostly between 30 and 50 miles, of the northern from the German islands, between 10 and 25 miles. The depth on the

southern ground was 13 to 20 fathoms, on the northern 7½ to 14 fathoms. It is plain, therefore, that the ground of the Brown Ridges is considerably deeper and farther seaward than that which I studied in June, in the s.s. *John Bull*, from Grimsby.

The comparison of the fish on the two grounds is as follows:—

The *plaice* on the northern ground did not exceed 17 in.; the largest was 16¾ in. long. On the southern ground very few plaice exceeded this limit, but I measured one which was 17½ in. long. On the northern ground the minimum length of plaice was only 5 in., while in the southern none were taken which were under 9 in. On the northern ground two or three basketfuls, or even more sometimes, of small plaice under 10 in. were thrown over at each haul; on the southern ground there were no such fish to throw away. The difference in the maturity of the plaice has been fully stated in a previous part of this paper. The relative abundance of the plaice it is not possible to estimate, as the fishing in one case was by a steamer, in the other by a sailing smack.

Turbot and brill. The smallest turbot on the Brown Ridges was 17¼ in. long, the smallest brill 16¼. Off the German coast, in June, numbers of brill and turbot, 11 to 14 in. long, were taken, and one turbot taken was only 8½ in. Sometimes 29 per cent. of the number taken were under 12 in., and, of course, quite immature.

Soles. The smallest sole caught off the German coast was 9⅞ in. long, on the Brown Ridges 8¼ in. In both cases a large proportion of the soles were adult, and of fair size.

Lemon Soles absent on both grounds.

Dabs. In both cases numbers of dabs, both small and large, were captured, and the larger, about 10 to 13 in., were kept for market.

Haddock. Absent on the Brown Ridges, few small on the northern ground, but some larger. These were less abundant than the plaice, and decreased towards the land and the shallower water.

Cod. Absent on the Brown Ridges, scarce on the German coast.

Whiting. Numbers about 13 in. long on both grounds, but only saved from the last hauls of the voyage.

Latchets. A considerable number taken on both grounds, and mostly mature and of large size.

Gurnards. Grey abundant on both grounds, red (*cuculus*) in smaller numbers.

Weevers (Trachinus draco and *vipera).* The abundance of these, especially of the larger species, is very characteristic of the Brown Ridges. I saw none on the German coast.

Sand-eels. I frequently found one or two of these entangled in the net on the German coast.

Some solenettes occurred on both grounds, but dragonets (*Callionymus*

lyra) I saw only on the Brown Ridges; a few specimens of scaldbacks also occurred only on the latter ground. Scruff, in the form of Hydroids, was very scarce on both grounds. *Alcyonium*, or "teats" as the men call it, was abundant, as were starfishes and hermit-crabs, whelks, and whelk spawn. *Natica* occurred on the Brown Ridges, and its semicircular band of spawn, believed to be turbot spawn by the fishermen, on the German coast.

I examined a piece of the "moor-log" which I brought ashore, with the microscope, and saw only vegetable tissue-cells, brownish in colour. I also saw, with the naked eye, some grass-like stalks in it. It is evidently turf or peat.

I also made a study of some of the waste fish which I brought ashore. There were 105 *Trigla gurnardus*, 7 in. to 13 in. long, and I brought these chiefly to examine the very conspicuous change of coloration which takes place in this species during growth. At first sight the younger and smaller fish might be taken for a different species. They are of a uniform reddish colour, without spots, but not so bright a red as *Trigla cuculus*. The elements of coloration are the same as in the grey or older stage, namely red chromatophores, with definite outline and rounded form, yellow chromatophores less distinctly defined, black chromatophores, and small granular iridocytes, with indistinct outlines. In the older livery the red elements are diminished in comparative abundance, and all the rest increased. Iridocytes massed together with yellow pigment, but without either black or red, form bright, yellow spots, usually surrounded by a black ring, forming ocelli. Elsewhere the skin is mottled with yellow and black and grey, with red patches here and there. The intermediate stage is at 9 in. in length, in which only a few of the yellow spots are present.

I also examined the specific characters of the two species of weever. I had 15 *T. draco* $9\frac{3}{4}$ in. to $12\frac{3}{4}$ in. long, and 8 of 5 in. to $9\frac{1}{4}$ in. Of *T. vipera* I had 18 of 2 in. to $4\frac{3}{8}$ in. in length.

A comparison of the smallest *draco* and the largest *vipera*, showed the specific characters to be perfectly constant. They are:—

(1) Greater vertical depth of body in *vipera*, especially from the angle of the jaw to the anus.

(2) Oblique lines of scales in *draco*, with yellow patches along the sides; *vipera* is silvery, without yellow spots or lines.

(3) Scales longer than broad in *draco*, broader than long in *vipera*.

(4) Two spines on front of orbit in *draco*, none in *vipera*.

(5) Second dorsal in *vipera* has 24 fin-rays; in *draco*, 30.

The herring and mackerel fishery, at Lowestoft, has a separate part of the harbour, and a separate market to itself, and is of very considerable

magnitude and importance. In September there were no herrings to be caught at Lowestoft, and a large proportion of the boats were away fishing for these fish off the coast to the north of the Humber. Some boats were catching mackerel at Lowestoft during this month. I several times opened the stomach of mackerel to see what the food was, and only twice found anything except a little white chyme. In both these cases the tail and backbone of a fish were present, and belonged apparently to a clupeoid: very probably they were feeding on sprats. I saw no Copepods or other Crustaceans in any of the stomachs. Up to the date of my departure from Lowestoft—October 22nd, the herrings, though full, had not begun to spawn.

III. Causes of the Observed Distribution of Fish in the North Sea.

As my paper in the previous number indicates, my interest in these investigations was chiefly excited by the fact that no satisfactory explanation appeared to have been discovered for the remarkable abundance of small plaice in the German Bight of the North Sea. The explanation suggested, and held by many to be sufficient, was that there was a current from west to east which carried floating or buoyant objects towards the German shores, and that, therefore, the buoyant eggs and larvæ of the plaice were carried thither in great numbers. Dr. Fulton* has recently made direct experiments on the course of the drift, by putting floating bottles into the sea in the neighbourhood of the Firth of Forth. In certain cases, out of groups of bottles put overboard at the same spot, some were afterwards found on the English Coast to the south, and others on the coast of Schleswig and the Island of Heligoland. The course thus determined for the general circulation would probably cause more of the plaice spawn, shed in the North Sea, to be conveyed to the German and Danish Coasts than to English. But the difficulty that perplexed me was that the peculiarity of the German grounds seemed to consist not in the greater numbers of plaice generally, but in the exclusive occurrence of small plaice at distances from land at which, on the opposite English Coast, large mature plaice seemed also to occur with the small.

It is not certain that this difficulty exists; if it does exist at all, it is not to be explained by the suggestion that the plaice of the German Bight are a smaller race. The smaller race, similar in the size at which maturity is attained to the Channel plaice studied at Plymouth, exists on the Dutch coast as far as the Texel, and extends to a distance of 50 miles from that coast.

* Thirteenth Annual Report of the Scottish Fishery Board, 1895.

The character of the plaice in the intermediate region from the Texel to Nordeney has not been examined, and the limit of the smaller race cannot be exactly stated. It is more probable that there is a transition from one race to the other than a definite boundary between the two.

It is important, as well as interesting, to notice that other biological features of the English Channel, as well as the small size of its plaice, are found to extend into the North Sea along the Dutch coast, and some of these extend as far as the German Bight, although the plaice there are *not* similar to those of the Channel. I am referring here to the fact that certain southern fishes which are found in the Channel, are also found along the Continental coast as far as the neighbourhood of Heligoland. The first of these to be mentioned is the anchovy. The history and migration of this fish has been repeatedly discussed in previous numbers of the Journal, and it has been often mentioned that there is a regular fishery for anchovies in summer in the great Dutch estuaries, namely, the Schelde and the Zuyder Zee. Dr. Ehrenbaum on one occasion found the eggs of the anchovy in abundance in the open sea farther east, near the Island of Nordeney. On the East Coast of England the anchovy occurs but rarely, and in very small numbers, except in the Straits of Dover. The second case is that of *Trigla hirundo*, called by the east coast fishermen the latchet, by Plymouth men the tub. My records show how constantly this fish is taken in the trawl, both on the Brown Ridges and in the German Bight, as far north as the Horn Reef, while on the English side it is seldom taken. The third case is that of the mackerel. Mackerel fishing takes place off Lowestoft in May and June, and again in September and October. South of the Horn Reef, in May, we took several large mackerel in the trawl, but I believe there is no regular fishery for mackerel in that neighbourhood. Mackerel are usually found in summer in the Moray Firth, but there is no fishery for them between that region and the Wash.

It would be interesting to discuss fully the relation between the biological facts here described, and the physical conditions in different parts of the North Sea. A series of careful physical observations has been carried out recently, according to an international scheme, in which Britain and Denmark, Germany, Sweden, and Norway have co-operated, the initiative in Britain having been due to the Scottish Fishery Board. The investigation of the channels connecting the North Sea with the Norwegian Ocean and Atlantic have been described by Mr. H. N. Dickson, and a paper on the observations in the more southern parts was read before the British Association last year. But these latter observations have not yet been published in full, and therefore their consideration in relation to the present subject must

be deferred. A few general facts may, however, be mentioned. The movement of floating objects, which Dr. Fulton found to occur in his experiments, is in accordance with the fact previously accepted that there is a current to the southward along the east coast of Britain, and another to the north-east from the English Channel along the Continental coast. The meeting of these two currents would necessarily cause a current across the North Sea, from the east coast of England, in a curve towards the Heligoland Bight. This movement, carrying with it the pelagic eggs and larvæ, is probably a very important factor in the explanation of the abundance of young plaice, soles, turbot, and brill in the Eastern Grounds, and generally along the Dutch and German coasts. The northward movement of Channel water along the Continental coast is also probably, in great measure, the cause of the extension of the range of the anchovy, latchet, and mackerel in that direction. But there are details which require further consideration. The anchovy, mackerel, and latchet clearly migrate towards the Dutch and German Coasts only in summer, and we know in a general way that along those coasts the summer temperature of the shallow waters is considerably higher than in the northern and western parts of the North Sea. But in winter the sea temperature along the Continental coast is lower than on the English coast; and although this agrees with the retreat of the migratory fish in winter, we cannot say how it affects the plaice, which appears to migrate very little, except from the shore to deeper water, as it grows larger. Another peculiarity of the water along the Continental coast is its lower salinity, due to the quantity of fresh water poured out by the great Continental rivers, and this may be one of the favourable conditions to which the abundance of plaice, soles, turbot, and brill, especially in their young state, is due.

A brief discussion of the growth and ages of the fish decribed in the present communication may not be without interest, and is inevitably suggested by the perusal of the memoir on the flat-fish of Denmark, recently published by the Danish investigator, Dr. C. G. Joh. Petersen.* According to the observations described in that memoir, it is possible, by measuring large numbers of plaice of all the sizes in existence at the same time of the year, to distinguish the broods of successive years, or, in other words, the fish of ages differing by one year. At certain lengths there are larger numbers of individuals than at intermediate lengths, these lengths being, of course, those of the *majority* of plaice derived from successive spawning seasons. In

* *Report of the Danish Biological Station*, iv. 1893, published 1894. [An abstract of this Report, prepared by Mr. F. B. Stead, will be found on page 213 of the present number of this Journal.—Ed.]

fact, as the production of new plaice is not constant, but confined to a particular part of the year, the spawning season, it naturally follows that if sufficiently numerous measurements are made, the waves of production ought to be perceptible in the greater abundance of plaice at certain sizes, separated by regular intervals, each group thus distinguished representing the progeny of a single year.

It is better, when possible, to consider only the female sex in applying this method, because the sexes of the same age are of different sizes. The length at which the maximum number of specimens is found, in the sample from off Amrum on December 20th, is 13 in., while in the sample from off Nordeney in November, the corresponding length is between 11 and 12 in. Now we have not samples of all the other plaice in the same region at the same time, but we know that there were smaller, younger plaice nearer shore, and larger further seaward, and may reasonably consider the above to be the mid-size of the plaice which were completing their second year, which would be two years old in the following spawning season, about February. This conclusion is supported by the fact that they were all immature.

I am obliged to confess that I cannot altogether follow Petersen's arguments. He gives in his tables two samples taken in the Limfjord in the beginning of December, the mid-size of one being 14 in., of the other 12 in. to 12½ in. He takes 14 in. as the mid-size of what he calls group 2 from these samples, by which he apparently means that they are at the end of their third year. In my judgment, these fish closely resemble those I have examined from the German Bight, their mid-size is clearly about 13 in., and there is no reason to suppose that they are completing their third year. I consider them to be just at the end of their second year.

Petersen places the mid-size of his 2 group in the Limfjord, in July, at 10 in., of his 1 group at 5½ in., meaning by the former, plaice two years and some months old, by the latter those of one year and some months. I cannot see what reason he has for placing the middle of the 2 group at 10 in., as the largest number of specimens in his sample is at 9 in. With regard, then, to the larger northern race of North Sea plaice, there is a very distinct difference of opinion between myself and Dr. Petersen, which is most clearly exhibited in our conclusions concerning the 0 and 1 groups, that is of fish in their first summer and their second. Dr. Petersen criticises my observations in a note on p. 23 of his memoir, and there entirely ignores the fact that though I have not exhibited my data by the graphic method in tables quite similar to his, yet I have used the principle of the mid-size in separating the groups. It is true that I did not attempt to apply this principle to any extent to the 2 and 3 groups, but

I used it in distinguishing the 0 and 1 groups of plaice before Petersen had published anything concerning the growth of this species. Thus, Petersen says that my specimens in January, April, and May are explained by me as the fry of the year, but that they are the smallest specimens of a group reaching to 2, 3, 4, and 5 inches in length. Now a reference to my data on p. 347, Vol. II. of this Journal, will show that the greatest number of my specimens from the Humber at the end of April were 2 in. in length, while those of 3 and 4 inches were in very small numbers. I find it impossible to believe that these large numbers of plaice at 2 in. were over a year old, while the few of 3 and 4 inches were regarded by me as the smallest of the brood of the previous year. Petersen accepts my identification of the specimens mostly $2\frac{1}{2}$ in. long in June as belonging to the 0 group, though he says they were about $1\frac{1}{2}$ in. long, which is not correct. As to the absence of such specimens in May, which Petersen thinks supports his view, it was merely due to the fact that Mr. Holt did not collect any in that month.

With regard to the 1 group, or specimens in their second summer, Petersen considers that the specimens I assigned to this group, 8 to 12 in. long, from Arlberg (which he quotes as Esbjerg, Arlberg being apparently a misnomer) were over 2 years old. In his tables the 1 group in the Cattegat, in May and June, are only 3 to 5 inches long. The fish in the Cattegat appear to be considerably smaller than in the North Sea, and I certainly still believe my own estimates to be correct for the sizes at which the greatest number of individuals are found. Thus, in March, at the mouth of the Humber, the majority of plaice taken by the shrimp trawls were 7 to 8 in. long, and as far as the evidence goes the number of specimens between this and 2 in. are comparatively fewer. In May and June the mid-size of the fish brought from Schiermonnikoog and the Danish coast to Grimsby, is 9 or $9\frac{1}{2}$ in. If the fish in their second year were mostly 4 or 5 in. long in summer, these fish would necessarily be more numerous than those of 8 or 9 in. long, a supposition which is against all the evidence we have at present.

Petersen states that he marked 1000 specimens of plaice in the Limfjord, 7 to 10 in. long, in March and April, 1893, and they were from 13 to 14 in. long in October and November. They grew, therefore, 4 to 6 in. in length in 6 to 8 months, and yet he believes that at 7 to 10 in. they were 2 years old. It is certain that fish grow slower as they get older, so that it is almost impossible to believe that a plaice which could grow from, say, 8 to 13 in. in 7 months, should require 2 years to reach the length of 8 in.

I think, then, that we have very strong evidence that the smaller fish,

taken in spring and summer, near the German and Danish shores, and from 7 to 10 in. long are year-old fish, and that if we were to search for specimens less than 7 in. long at that time we should find them to be in smaller numbers.

With regard to the plaice from the Brown Ridges, there is considerable difficulty in forming a judgment concerning the age. We know that some flounders, and, doubtless, some plaice, spawn when they are two years old, but only a small proportion. The mid-size in the first sample is 12 in., and it is improbable that so many immature specimens of this size should be three years old, *i.e.* (the date is October), near the end of their third year. I can only suggest that we have groups 1 and 2 here mixed, that is, plaice nearly 2 and nearly 3 years old, as well as a few which are older.

The plaice from the Leman Shoal, and from off Lowestoft, present the same problem—we have evidently the same stages, only from a larger race of fish. We have the fish nearly 2 years old, those nearly 3 years, and some few older. The mature specimens belong to the last two groups.

With regard to turbot and brill, we can scarcely suppose that the former reaches the size of 14 in., and the latter 12 in., in one year. These are the mid-sizes of the immature females taken on the German grounds in June, and are, in all probability, the 2 year old fish. The year old fish, in the case of brill, probably 7 or 8 in., of turbot 9 or 10 in., would be found closer to the shore. Here, again, I differ from Dr. Petersen, who took large numbers of turbot, the mid-size of which was 9½ in., in June and July, at Bornholm, and considers them to be 2 years old. It is true the size of the turbot may be much reduced at this island, which is far within the Baltic, but, on the other hand, Petersen found similar specimens, which he also takes to be 2 years old, in the most northern parts of the Cattegat, and he has no specimens, except one or two at 4 to 6 in., which he can assign to the year-old group. Of brill, Petersen places the 2 year old size at 10 in., the year-old at 5 to 7 in., in the Cattegat.

IV.—Proposed Restrictions on the Landing of Undersized Plaice, in the Light of the New Evidence.

Before the Parliamentary Committee, which conducted an inquiry in 1893, the trawling industry of Lowestoft, as represented by Mr. J. W. Hame, strongly opposed any restrictions being enforced as to the size of fish landed. One of the reasons given was that restriction was unnecessary, because small fish, especially plaice, were not landed at that port. Mr. Hame told the Committee that the day before he gave his

evidence, namely, on May 10th, he turned out two boxes of plaice caught towards the Dutch coast, perhaps from 30 to 40 miles off that coast. He said that one box contained 110 fish, the smallest 12 in. long, and the other contained 90 fish, the smallest 13 in. long. These statements are quite at variance with my observations made at Lowestoft, during September and October this year, and I cannot help thinking that Mr. Hame was mistaken as to the grounds from which the fish came, or else was not sufficiently accurate in his numbers and measurements. The facts show that, on the one hand, a size-limit of 8 in. for plaice, as proposed by the Parliamentary Committee, would make no appreciable difference to the deep-sea trawling industry at Lowestoft, and, on the other hand, that higher limits, such as that which was proposed by Mr. Holt for the protection of the German grounds, would affect that port very seriously.

Mr. Holt's latest proposal was to enforce a limit of 13 in. from March 14th to September 30th, and he supported this proposal by the following contentions: That he had shown the proportion of plaice under 13 in. on the off-shore grounds of the North Sea to be inconsiderable, and that this limit, and no lower limit, would make it unprofitable to trawlers to fish on the Eastern Grounds. Now, it is necessary to see how this limit would work in the southern part of the North Sea, whose conditions I have described, and how it would affect the trawling industry at Lowestoft and Yarmouth. It is clear that the limit would stop the trawling on the Brown Ridges, and all the grounds along the Dutch coast south of the Texel to a distance of about 50 miles from the shore. In the box from the Brown Ridges, examined on October 2nd, no less than 140 out of 176, or over 79 per cent., were less than 13 in. long. In the box from the Dutch coast, received on November 18th, only 18 out of the whole 197, or not quite 8 per cent., were over 13 in. The Yarmouth and Lowestoft trawlers would have to work, therefore, on the English side, from the Outer Dowsing southwards, and, even there, would have to throw overboard a considerable proportion of the plaice now brought to market. In the box from the Leman Shoal, examined on October 4th, 47 out of 115, or 40 per cent. of the plaice, were under 13 in. In the box received on December 23rd, 83 out of 132, or 62 per cent., were under 13 in.

It can easily be inferred from these figures how the establishment of a size-limit of 13 in. for plaice would be received at Lowestoft and Yarmouth. If the regulation were rigidly enforced, it would entail the bankruptcy of probably the greater number of the smack owners, for it is not probable that the increase in the price at which the larger plaice could be sold would be sufficient to compensate for the loss of the smaller.

On the more northern grounds, which are worked by the Grimsby and Hull boats, the proportion of plaice below 13 in. is certainly smaller. Mr. Holt estimated it at 10 per cent., and he was well aware that his proposed limit of 13 in. involved the rejection of this proportion. But the evidence I have collected shows that the proportion is often higher than this. In the sample from the Dogger Bank, of which the measurements are given above, the proportion is 35 per cent., and the samples I described in my paper in the previous number show that a considerable number of plaice of 10, 11, and 12 in. are landed from the Dogger Bank, and, in fact, from all grounds less than 30 fms. in depth in summer.

It is perfectly true, as Mr. Holt pointed out, that the enforcement of a size limit of 13 in. would prevent English trawlers from fishing on the German coast in summer, and so prevent the great destruction of small plaice which they carry on. But with regard to the fishing on these grounds by German boats, I have received from Herr Düge the following important information, which will be of some assistance in forming an opinion concerning the result of keeping English vessels away, supposing the restriction to be put into operation only in Britain.

Sixty-three steam trawlers fish out of Geestemünde, and 600 to 700 sailing boats go there annually, from harbours on the Elbe. The steamers fish the whole year. The grounds worked in the different months are:

January: east and north-west sides of Dogger Bank.
February and March: Great Fisher Bank.
April: Horn Reef.
May: Horn Reef, and grounds twenty miles from East Frisian coasts.
June and July: Horn Reef and Skager Rack.
August and September: Mud-bank to the north of Heligoland, and the east and north-east sides of the Dogger Bank.
October: Mud-bank, Horn Reef, and Sylt ground.
November and December: Horn Reef, Sylt, and Jutland outer ground.

The German steamers seldom go west of 3° east longitude from Greenwich. The grounds off the Horn Reef, and the bank to the north of Heligoland, are much fished, those directly adjoining the coast less.

The sailing boats, on the other hand, fish from March to October almost exclusively within the distance of 3 to 30 miles from the East Frisian and Schleswig-Holstein coasts, and seldom go west of Terschelling, or north of Fanö. The reason of this is that the steamers fish mostly for haddock and cod, while the sailing boats seek for plaice and soles, and take the former to market alive.

There is nothing in this to show what proportion of the smallest fish on these grounds are taken to market, and it is probably true, as Mr. Holt believed, that there is a better market for the smallest plaice at Grimsby, Hull, and London, than in continental ports. At the same time, there can be no doubt that the German steamers, when they are on the small plaice grounds, must destroy as many small plaice as the English vessels, whether they throw them overboard, or take them to market, and with regard to the sailing boats, although they probably throw overboard the smallest plaice without killing them, I cannot believe that they do not take to market the plaice of 10, 11, and 12 inches, which, under the proposed regulation, English vessels would not be allowed to take. In fact, there can be no doubt that the German sailing boats depend for their maintenance and profit chiefly on the same fish as those which were brought to market by the *John Bull*, in the trip on which I was on board of her, namely, on plaice 10 to 13 inches long, soles, and small turbot and brill.

It may be admitted that it would be desirable, if it were possible, to protect and leave alive in the sea the plaice under 13 in. long. It would be desirable for two reasons—firstly, because the fish so preserved would be able to spawn, and secondly, because they would grow to a larger size, and be, therefore, more valuable in the market. According to the evidence I have given in the German Bight, the plaice below this limit are almost all actually immature, both males and females, and even on the Brown Ridges the majority of the females are immature. But we have to consider whether it would be practicable to carry out a prohibition of the landing and sale of plaice under 13 in. I have shown that such a prohibition would mean the closing of the grounds along the Dutch coast to a distance of nearly 50 miles. It must be borne in mind also that my evidence proves that a large proportion of plaice under 13 in., and still more of sexually immature fish, are taken on all grounds less than 30 fathoms in depth, which means a very large portion of the North Sea.

It would not be feasible to have one limit at Grimsby, and another at Lowestoft; the fact that fish from the Humber fleets, and from the Yarmouth fleet, which latter fishes the same grounds as the Lowestoft boats, are alike landed in London, shows how absurd the suggestion is. We have, then, the horns of a dilemma: a 13 in. limit cannot be applied to the grounds between Norfolk and Suffolk, and the Dutch coast, and no lower limit will keep the Humber trawlers from the small plaice grounds of the German Bight. We must then consider whether we are to disapprove of a size limit altogether, or to advocate a lower limit. It is clear that the imposition of an 8 in. limit would do little or no good. It is also certain that plaice of 11 in. and 12 in. form

a large proportion of those landed at Lowestoft. A higher limit than 11 in. does not seem practicable, and the question is, would that limit do any good? The difficulty, of course, is that which has so often been mentioned, that the fish would be usually dead when thrown overboard, and a limit to do good must prevent fishing on grounds where the small plaice abound. In the voyage of the s.s. *John Bull*, on the grounds to the north of Heligoland, plaice below 10 in. actually were thrown overboard, and as I saw myself, mostly dead. Nevertheless, vessels are often tempted to go near shore and fill their holds with such small plaice, when there are not enough larger plaice, soles, and other fish to make a profitable cargo. A limit of 11 in. would, I believe, be of distinct benefit in preventing such a practice. Unfortunately, as I mentioned in the account of my cruise on the *John Bull*, on the Eastern Grounds soles are usually more plentiful, where the plaice are smallest, and I do not see how to prevent vessels fishing for the soles and throwing the plaice overboard. Some of the plaice thrown overboard certainly live to grow larger.

The limit of 11 in. would have certain distinct advantages in addition to the above. It would prevent almost entirely the capture of small plaice below this size, which goes on in English territorial waters by small boats, and where it is not advisable to stop shrimp or inshore trawling altogether, plaice below the limit could be returned to the water alive. In my previous paper I suggested a limit of 10 in., and still believe that even that limit would be of some benefit, but after collecting more extensive evidence and further considering the matter, I have come to the conclusion that a limit of 11 in. would be both practicable and beneficial for the North Sea, and could be applied with equal benefit and no greater difficulty to the South Coast. As a limit of 10 in. is already in force in Denmark, it ought to be possible, in time, for all the nations interested to agree to adopt the same limit of 11 or 10 in. for plaice.

There is probably more chance of soles surviving, if thrown overboard, than of plaice.

The evidence shows that there is no such wholesale destruction of small soles in extra-territorial waters, as of plaice on the German grounds, but a considerable number of a length of 8 in. or less are captured and taken to market in territorial waters, as shown above at Lowestoft. The limit of 8 in. is not sufficiently above the limit of saleability to be of much benefit, while a limit of 12 in. would be unduly high. A limit of 10 in. would be beneficial.

There can be no doubt that the capture of such large numbers of undersized turbot and brill on the German grounds is extremely wasteful, and prejudicial to the general supply of larger fish. Such

undersized and immature fish of these kinds were not found on the Brown Ridges or other grounds worked by Lowestoft trawlers, but doubtless occur near the Dutch coast. There is no evidence that they occur on any grounds at a considerable distance from the shore. The reasonable and practicable limit for brill, in my opinion, is 13 in.; 12 in., as recommended by the Protection Association, would not afford enough protection on the Eastern Grounds, and the 10 in. limit proposed by the Parliamentary Committee would be of very little use.

There can be no doubt that the limit for turbot ought to be higher than that for brill, and the practicable limit, in my opinion, is 15 in. It is certain that there are no mature females below that size, and that limit would not cause any difficulty to the fishermen, except on the Eastern Grounds, or other shallow inshore waters. I have already shown the important contrast in the size of the plaice caught in the two voyages to the Eastern Grounds, described in the previous number. The same contrast presents itself in the size of the turbot and brill. The smallest turbot seen, in the first voyage south of the Horn Reef, was an immature female 13 in. long; the others were seven mature males 14 in. to 22 in., and six mature females 24 in. to 30 in. Of the brill examined three were immature females, 12 in. to 15 in.; the others were eight mature females, 13 in. to 21 in. In the second voyage, on the other hand, when we fished nearer to the land, numbers of brill and turbot under 12 in. were taken.

A Carcinus with a right-handed walking-leg on the left side of the abdomen.

PRELIMINARY NOTE.

By

Albrecht Bethe.

AMONGST a great number of crabs collected in Plymouth Sound for my studies of the central nervous system, one specimen was found with a very interesting abnormality. The thorax of the crab—a female—is normal. The length of the carapace is 47 mm., the breadth 64 mm. The claws and legs are in the right positions, and of normal proportions, with the exception of the fourth leg on the left side, which is smaller than usual. In my opinion, this leg was broken some time before the crab came in, and was not yet quite regenerated. The first four segments of the abdomen are also normal. Each has a couple of *pedes spurii*. To the fifth segment, which in the crab is always legless, a large leg is fastened on the left side. (Fig. 1.)

This leg is, as one can see at a glance, a real walking-leg, and, what may at first sight seem strange, not a left-handed, but a right-handed leg. Comparing it with the other walking-legs, one can see that this additional leg corresponds to the second and third of the thorax. Not only are the positions of the hairs and little pits the same as in those legs, but also the proportions between the single joints and the angles which form the axes of the joints.

Owing to the pressure of the large leg, the left side of the fifth abdominal segment is a little bent on both sides, and the exopodite of the left *pes spurius* of the fourth segment is stunted, so that it is not half as long as the exopodite of the other side. When alive, the leg was motionless, but it was sensitive.

When first I saw the crab, I imagined this surplus leg must be innervated by a nerve coming from a surplus half-ganglion of the right side. And this indeed proved to be the case. A dissection made

from the back showed a big nerve entering the leg, and starting from the right side of the ventral cord. But, strange to say, the nerve does not leave the ventral cord at its side, but in the middle, passing through the middle hole. I cut thick frontal sections of the ventral cord. They show a small surplus half-ganglion on the right side, between the claw-ganglion and the ganglion of the first walking-leg,

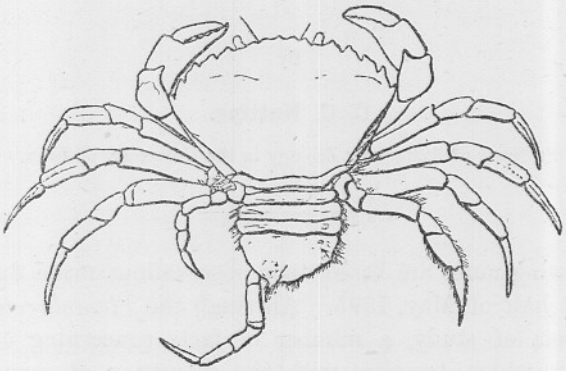

FIG. 1.

and not, as was to be expected, between the first and second or the second and third leg-ganglion.

There is no doubt that in this case we have neither a double-monster nor an atavism, because the ancestors of the Brachyura never had walking-legs on the abdomen.

A second paper on this subject, containing minute descriptions and several illustrations, will soon be published in a German journal, and in that I will endeavour to give a theoretical explanation of this abnormality.

Notes on Plymouth Hydroids.

By

C. C. Nutting.

Professor of Systematic Zoology in the University of Iowa.

THE following notes are based upon observations made during April and the first half of May, 1895. Although the *Plumularidæ* were the special objects of study, a number of facts concerning other forms were noticed, which, together with the discussion of certain matters brought out in the special study of the *Plumularidæ*, were considered by the Director to be of sufficient interest for publication in this Journal. It will be understood that no general discussion of the hydroids at Plymouth is attempted, nor is it my purpose to give a list of the hydroid forms of that exceedingly rich field, no species being mentioned unless some new fact has been observed concerning it.

EUDENDRIUM ALBUM, n. sp.*

Habitat. On stones in shallow water near Millbay Channel. The stones are often covered with a dense growth of this hydroid, which appears to the unaided eye like white cottony tufts or downy patches. The gonophores were abundant in April.

The distinguishing features of this species are the minuteness of the colony and of the individual hydranths, both of which are less than half the height of any other Eudendrium from British waters, and the very striking white colour of the hydranths, a feature not found in any other Eudendrium in that locality. *Eudendrium album* is one of the most abundant hydroids at Plymouth during the spring, where it has heretofore been regarded as *Eudendrium capillare*, Alder. It seemed, however, so different from the descriptions and figures of that species given by Alder, Hincks, and Allman, that specimens were sent to the veteran authority on hydroids—Professor Allman—who regarded it as probably new, and advised the writer to describe it as such.

* This is the species referred to by ALLEN, vol. iv. no. 1, p. 49, of this Journal. A full description, with figures, will shortly be published in *Ann. and Mag. Nat. Hist.*

CLYTEA JOHNSTONI, *Alder.* Medusæ of this species were produced in the aquaria in May.

OBELIA GENICULATA, *Linn.* Numbers of the medusæ of this species were bred in the tanks and bottles of the Laboratory during the latter part of April. They may be readily distinguished from the medusæ of *Obelia dichotoma*, which is very abundant at Plymouth, by the fact that the former have 24 marginal tentacles, while the latter has but 16 at the time of liberation. These small medusæ are readily preserved with the tentacles well expanded by stupefying with cocaine and passing through three or four grades of alcohol.

OBELIA LONGISSIMA, *Pallas?* A specimen brought to the Laboratory early in April is referred with some doubt to this species, which it closely resembled in all respects, except in the fact that the hydrothecæ were marked with regular longitudinal flutings, the ridges between the adjacent hollows terminating in blunt teeth at the margin. This beautiful ornamentation was quite constant in the hydrothecæ, and formed so striking a feature as to suggest a new species. The close agreement, however, of the specimen with Hincks' description and figures of *O. longissima*, taken together with the great delicacy of the hydrothecæ of the latter, render it probable that the form under consideration was *O. longissima*, with the delicate hydrothecæ shrunken so as to be thrown into longitudinal flutings. The gonosome was not present.

Secured in Millbay Channel from a depth of about eighteen fathoms.

CAMPANULARIA NEGLECTA, *Alder.* This very minute Campanularian was found growing on the stems of *Tubularia indivisa.* There were several gonangia present, but the acrocysts were not developed. So far as I can ascertain, *C. neglecta* has not been reported from Plymouth by previous observers, probably having been overlooked on account of its small size. It is only occasionally that the bimucronate ornamentation of the margin can be made out. The stem in its manner of branching and flexuose habit resembles a miniature *C. flexuosa.*

CAMPANULARIA FLEXUOSA, *Hincks.* This beautiful species was found with gonosome well developed, on May 1st. The gonangia differed from Hincks' description in being ornamented with shallow but regular annulations throughout their length. At first glance no indication of this annulation is seen, but with proper treatment of light the markings are plainly made out, and appear to be as symmetrical as those so beautifully shown in the gonangia of *Clytea Johnstoni.*

CAMPANULARIA FRAGILIS, *Hincks.* Not before reported from Plymouth. The single specimen secured from the rocks near Millbay Channel was destitute of gonosome, but showed the characteristic tubular plain-rimmed hydrothecæ of the species. The hydranths have about twenty tentacles, and the proboscis is ovate in outline when

the hydranth is expanded, thus differing from most of the *Campanularidæ*.

GONOTHYRÆA LOVÈNI, *Allman*. This is one of the most abundant species at Plymouth. A number of specimens of the genus that were brought in from time to time during April and May differed so materially from *G. lovèni*, and agreed so closely with the descriptions of *G. hyalina*, Hincks, that I regarded them as belonging to the latter species, and had so labelled them, when another batch of specimens was brought in which showed completely intergrading forms joining the typical *G. lovèni* with almost typical *G. hyalina*. There is a strong probability that these two so-called species are but varieties of one form, which should bear the name of *G. lovèni*, Allman.

OPERCULARELLA LACERATA, *Johnston*. Found growing on young stems of *Tubularia indivisa* from Millbay rocks, on April 26th. Other specimens were creeping over the stems of Eudendrium. This is, I believe, the first recorded occurrence of the species at Plymouth.

OPERCULARELLA HISPIDA, n. sp.*

This species bears some resemblance to *Calycella syringa*, Linn., from which it differs in having a much shorter pedicel, a not strictly tubular hydrotheca, a greater number of segments to the operculum, in the absence of the tubular extension of the operculum, and in a much thinner structure, the hydrothecæ being of glassy transparency in *O. hispida*, but of a decided brownish or yellowish horn colour in *C. syringa*. The most striking feature, however, of the present species is the remarkably hispid appearance of the tentacles, which appear to be made up of series of triangular segments on account of the formidable array of large nematocysts with which they are armed. While examining the expanded tentacles with a $\frac{1}{8}$ objective, I was so fortunate as to see these batteries of projectiles suddenly explode, sending out a perfect maze of barbed threads, which appeared to be larger and longer than those of any hydroid that I have seen, except *Nematophorus grandis*, Clarke.

In the absence of the gonosome, it is impossible to say with any certainty to which genus this interesting little species belongs. The general form of the hydrotheca, the cylindrical hydranth with conical proboscis, together with the convergent teeth, give a facies like that of the genus *Opercularella*, in which it is provisionally placed.

CALYCELLA SYRINGA, *Linn*. Found growing abundantly on young stems of *Tubularia indivisa*. The pedicels are often much longer than one would judge from Hincks' figure. The mass of root-stalks from this species running along in approximately parallel lines on the host, and giving off the peduncled hydrothecæ, afford a good idea of how the

* A detailed description, with figures, will appear in the *Ann. and Mag. Nat. Hist.*

fascicled stems of hydroids may have arisen. In some of the specimens the aggregation of root-stalks would doubtless be sufficiently rigid to support themselves in an erect position after the stem to which they cling had died, and we should then have a loosely put together, fascicled stem, which a little further differentiation would convert into a typical polysiphonic hydrocaulus.

The tubular extension of the hydrothecæ reminds one of similar structures in the genus *Cryptolaria*, which contains several species further related to the one under discussion, in having the operculum composed of convergent segments.

CUSPIDELLA GRANDIS, *Hincks.* In looking over my Plymouth series of hydroids after returning to America, I found specimens of this species growing over the stems of *Halecium tenellum*. A careful examination of the stems of the larger hydroids is frequently repaid by the discovery of one or more species of minute parasitic forms which escape the casual observer, and it is quite likely that a number of new species would reward the patience of any one who would devote himself for a time to a search for these forms on British coasts.

HALECIUM TENELLUM, *Hincks.* A number of colonies with female gonangia were taken from a depth of 18 fathoms on April 19th. These specimens closely resemble in several points miniature colonies of *H. labrosum*, Alder, especially in the shape of the gonangia and the wrinkled appearance of the stems, which, however, are monosiphonic. Indeed, one cannot wonder that Alder mistook *H. tenellum* for the young of *H. labrosum*. Out of a large number of colonies of *H. tenellum* from Plymouth, there are none over half an inch in height, and they very generally show the reduplication of the margins of the hydrophores, which Hincks mentions as a characteristic feature.

PLUMULARIA PINNATA, *Linn.* This is by far the most abundant Plumularian at Plymouth, and afforded an excellent opportunity to study the morphology and reproduction of the group.

The Nematophores. There is a great deal of confusion of terms regarding these structures. The name properly applies to both the sarcodal process and the chitinous receptacle into which it retracts, although it is often used to denote either one of these structures. The terms "sarcostyle," denoting the sarcodal process, and "sarcotheca," denoting the chitinous receptacle, have now come into general use. Hincks' description of *P. pinnata* is incomplete, in that it does not notice the sarcostyles which occur without the investing sarcothecæ. One pair of these naked sarcostyles is found in the usual position of the supracalycine nematophores, and another pair is in the axil of each hydrocladium.

The structure of the nematophores has been the subject of much

discussion, particularly by Hincks, Allman, Reichart, Merejkowsky, Weismann, and Jickeli. With the excellent facilities afforded by the Plymouth laboratory, and the valuable suggestions of its director, I secured a number of fortunate serial sections of the expanded sarcostyles of *P. pinnata*, and have been able to satisfy myself concerning the main points of their structure. The results of this study have corroborated the statements of Merejkowsky up to a certain point, including the following facts—

1. The greater part of the sarcostyle is composed of ectodermal cells.
2. There is a central endoderm core (or cylinder ?) *
3. The cells on one side of this core are very large and quadrangular, while the cells on the other side and of the entire terminal portion of the sarcostyle are of ordinary size.
4. There are pseudopodia-like processes from the free surface of the sarcostyle.

On the other hand, I have been entirely unable to find any trace of the "interstitial protoplasm" described by Merejkowsky, in which he claims that the ectodermal cells are imbedded. Weismann† boldly suggests that this "interstitial protoplasm" is owing to an assumed necessity for free sarcode to explain the pseudopodia-like processes on the free surfaces of the sarcostyles. It seems to me that there is no logical demand for free protoplasm to explain the great extensibility of these organs. The possible tenuity of the walls of ectoderm cells can be appreciated by any one who has made a study of nematocysts, and a careful examination of the sarcostyles, both living and in serial sections, has failed to afford any evidence of free protoplasm, and this negative result is not antagonized by any physical necessity for free protoplasm in organisms which can construct endoderm cell-walls of the marvellous tenuity and extensibility of the nematocysts.

The function of the nematophores is in more doubt than their structure, and is not yet understood. It is practically certain that they are more or less degraded "persons" of the colony which have come to subserve definite functions of great service, judging from the prevalence of these structures throughout the *Plumularidæ*. So far as the species under consideration is concerned, it is safe to say that the sarcostyles are not "fighting persons" or "machopolyps," because they are not armed with any considerable number of nematocysts, the special weapons of hydroids. An examination of the living and active sarcostyles establishes the following facts—

1. The almost incredible extensibility of these organs, which wind

* While at Naples, the writer was able to demonstrate that this structure, in another species, has a central cavity.

† *Die Entstehung der Sexualzellen bei den Hydromedusen*, p. 176.

around the stem, branches, hydrothecæ, and gonangia, in a perfect maze of threads, or even flattened lobate masses.

2. In retraction, the movement is not comparable to the flowing of pseudopodia, but is effected by decided, quick, jerky retraction, giving an idea of definite outlines and cohesion. To use a crude comparison, the sarcostyle contracts much as if it was made of stretched india-rubber and not of a fluid. It it also worthy of note that there is no mechanical entanglement of the various extensions of the sarcostyles, although they appear to be hopelessly intertwined.

3. The sarcostyles are particularly active in the vicinity of mutilated or dead hydranths and gonophores, particularly the latter, and seem to have a definite object in climbing over the sides and into the interior of hydrothecæ and gonangia. There is no evidence that they are able to repair damaged parts.

4. An examination of living sarcostyles, under a high magnification, disclosed certain cells on the distal surface which had the characteristic outlines and movements of amœboid cells, and contained foreign particles.

It would seem from the foregoing observations that the sarcostyles of *P. pinnata* are primarily neither fighting persons, nor persons concerned in the repair of mutilated or diseased parts. It is probable, on the other hand, that they do remove extraneous matter, or dead organic material from the interior of the hydrothecæ* and gonangia, and that they may aid in the capture and ingestion of food for the colony.

Origin of the sex-cells. This species is an excellent one for the demonstration of the cœnosarcal origin of the sex-cells in the *Plumularidæ* as first announced by Weismann.† The gonangia are so excessively numerous that a single series of sections may often be obtained which will show nearly all stages of this interesting process. The course of events in *P. pinnata* agrees very closely with Weismann's description of the origin of the sex-cells in *P. echinulata*, both ova and spermatoblasts, arising in the endoderm of the stem and afterwards migrating into the gonophores, ultimately appearing as ova, or sperm, masses in the matured structures. The ova break through the "stutzlamella" and are fertilized and undergo segmentation between the stutzlamella and the ectoderm. Although the ultimate division of the spermatoblasts may take place in the ectoderm, the primary divisions occur in the endoderm. I have been unable to find any cells recognisable as spermatoblasts in the ectoderm, although very satisfactory serial

* E. METSCHNIKOFF, *Quart. Jour. Micr. Sci.* no. 93.

† See *Die Enstehung der Sexualzellen bei den Hydromedusen*, by Dr. August Weismann. The first announcement was in *Zool. Anzeig.* no. 75, 1880.

sections were made of the male gonophores. It may be, however, that my specimens were too near maturity to furnish conclusive evidence in this matter. In living specimens a division of sperm-cells with partially-developed flagella was observed in the ectoderm.

Asexual multiplication of P. pinnata. On April 23rd several colonies of this species were brought in, which were peculiar in having the ends of a number of hydrocladia greatly elongated, destitute of hydrothecæ and nematophores, and distinctly clavate at the tips. Such specimens were brought in almost daily for some time, whenever the boat went out for collecting. The first colonies found were isolated and kept under observation. They rapidly increased in length, and the terminal turgescence became more prominent. In three or four days it was noticed that these enlarged ends were forking and commencing to branch.

In about a week after the first specimens were noticed, it was found that the side of the jar in which the colonies were confined was marked with closely adhering thread-like filaments, which, on examination, proved to be the greatly produced hydrocladial extensions mentioned above, and they were still connected with the colonies from which they sprung. From these adherent extensions were growing new colonies of *P. pinnata* in various stages of development.

After a time the connection between the parent colonies and the young was severed by atrophy of the connecting hydrocladial extension, rootlets were put forth from the adherent portion or end of the original hydrocladia, and thus young and perfectly independent colonies were produced which grew rapidly during the next few weeks. Another group of colonies showing the hydrocladial extensions was so placed that the extensions could not touch the sides of the bottle in which they were kept. In this case the hydrocladia grew and forked as before, and new colonies arose from the forked ends of the hydrocladia. The parent stalks afterwards died and fell to the bottom, giving the young colonies a chance to attach themselves to the glass.

This process reminds one so forcibly of the sending out of stolons from which new shoots arise, as seen in many plants, that I have proposed the name of stoloniferous reproduction for the asexual multiplication of *P. pinnata* as above described.* It is the first recorded instance of the kind among the Hydroida so far as I can find, although it bears considerable resemblance to the fissiparous formation of frustules as recorded by Allman.†

PLUMULARIA HALECIOIDES, *Alder.* This minute Plumularian was found parasitic on *Antennularia.* The gonosome was not present.

* See *American Naturalist*, November, 1895.

† *Gymnoblastic Hydroids*, p. 152.

PLUMULARIA ALLENI,* n. sp.

Habitat. Found growing on *Antennularia ramosa.* This delicate species bears considerable general resemblance in size, form, and parasitic habit to *P. halecioides.* It differs, however, in having a non-fascicled stem, smaller hydrothecæ, more numerous nematophores, and especially in the gonangia, which are greatly unlike the annulated structure of *P. halecioides.*

AGLAOPHENIA PLUMA, *Linn.* In studying the development of the corbulæ of this species, an interesting fact regarding the sarcostyles was noticed. A young corbula was under examination, the leaves or ribs of which had not yet coalesced, and the sarcostyles of one leaf were seen to stretch across and attach themselves to the next leaf in front, and remain for some time in that position. It appeared as if these sarcostyles served as temporary attachments to hold the edges of the two leaves together, while they were connected by trabiculæ of coenosarc, which rapidly formed a stronger and permanent connection. The perisarc of the edges of the leaves seemed exceedingly thin, and in places appeared to be wanting. A contact having been established between the edges of adjacent leaves, the permanent attachment was soon formed, and the coelomic cavities of the leaves established connections at these points. A little later, currents of water bearing granules were seen to flow in active streams from one leaf to the other. In their incipient stages it is difficult to tell the difference between sarcostyles and gonophores, and they make their appearance at about the same period in the development of the corbulæ.

AGLAOPHENIA HELLERI, *Marktanner-Turneretscher.*† This is the form collected by Mr. Allen from Eddystone Rocks, and mentioned by him on page 49, volume iv., No. 1 of this Journal. This being the first record of *A. helleri* on British shores, the following description is given for the benefit of those who may not have access to the original—

Trophosome. Colony unbranched, attaining a height of three-quarters of an inch. Stem monosiphonic, divided by very deep nodes into short internodes, each bearing a hydrocladium springing from its antero-lateral aspect. Hydrocladia alternate, closely-set, divided into internodes, each bearing a hydrotheca, and partly divided by two imperfect transverse septa. Nodes very distinct. Hydrothecæ obconic, about as deep as the aperture is wide. Marginal teeth nine, unequal in size, the anterior one often being slightly incurved, and rather longer and more pointed than the others; the second and fourth teeth, counting

* Named in honour of the Director of the Plymouth Laboratory, an enthusiastic worker in marine zoology. Detailed description with figures will be published in *Ann. and Mag. Nat. Hist.*

† *Die Hydroiden des K. K. Naturhistorischen Hofmuseums*, Vienna, 1890, p. 271, plate vii.

from behind, are larger than the first and third. There is no apparent intrathecal ridge. Supracalycine nematophores rather small, stout, reaching to the level of the hydrothecal margin; the mesial nematophore springs from just below the margin of the hydrotheca, and projects straight upward and outward, its truncated end reaching to the level of the longest marginal teeth. There are two modified nematophores on each hydrocladium near its base.

Gonosome. (Description from Naples specimen.) Corbula thick and short, with the leaves or ribs more closely soldered together than in other small British species. Ribs six on each side, with a row of nematophores on their distal edges.

Habitat. Found growing on thick roots of marine plants taken from Eddystone Rocks.

Distribution. Naples and Rovigno (Marktanner-Turneretscher), and Plymouth, England.

A List of the Parasitic Copepoda of Fish obtained at Plymouth.

By

P. W. Bassett-Smith, F.Z.S., F.R.M.S., Surgeon, R.N.

THE material from which the present list of Parasitic Copepoda has been compiled was obtained in part by the examination of fish at the Marine Biological Association's Laboratory, but to a still greater extent by daily and diligent search at certain fishmongers' in the town. The following are the most important works consulted :—

1785. Müller, O. F., *Entomostraca seu Insecta testacea, Lipsiæ et Hafniæ.*

1826 and 1831. Otto and Burmeister, *Nova acta Natur Curios.*

1832. Nordmann, A. von, *Mikrographische Beitrage zur Naturgeschichte der wirbellosen Thiere.*

1834–40. Milne Edwards, *Histoire Naturelle des Crustacés.*

1838. Kroyer, H., *Om Snyltekrebsene isaer med Hensyn til den Danske Fauna,* Kroyer's Naturhist Tidsskrift, Bd. 2, pp. 7–52, 131–157.

1850. Baird, W., *Natural History of the British Entomostraca.* Ray Society.

1851. Beneden, P. J. Van, *Note sur un Crustacé parasite nouveau, avec l'enumeration des especes, &c.* Bull. de l'Acad. de Belg. tome xviii. 1, pp. 286–290.

1860. Claus, C., *Zur Morphologie der Copepoden.* Wurzburg naturwiss Zeits. i. pp. 20–36.

1862–68. Hesse, *Observations sur des Crustacés rares ou nouveaux des côtes de France.* 16 papers, Ann. Sci. Nat.

1865. Heller, C., *Crustaceen,* Reise der Fregatte Novara.

1866–79. Gerstäcker, A., *Crustacea,* vol. 5, Bronn. Class. und Ord. des Thierreichs, *Copepoda,* pp. 590–806.

1875. Claus, C., *Ueber die Entwickelung, Organisation und systematische Stellung der Arguliden.* Zeits wiss Zool. vol. xxv. pp. 217–224.

1875. Claus, C., *Neue Beiträge zur kenntniss der parasitischer Copepoden, nebst bemerkungen über das System derselben*, tome cit. pp. 327–360.

1877. Kurz, W., *Studien über die Familie der Lernæopodiden.* Zeit wiss Zool. vol. xxix. pp. 380–428.

1877. Vogt, C., *Recherches Cotières*, Arch. Zool. Exper. vol. vi. pp. 385–456.

The system of classification here adopted is that of Gerstæcker, which is founded largely on the minute anatomy of the animals, and is the most recent.

CALIGIDÆ.

Caligus, *Müller.*

Second and third pair of thoracic legs bifid; each branch with two joints, first and fourth not bifid. Fourth pair with elongated basal joint; cephalothorax not deeply notched in the centre, frontal lobe bearing a sucking disc near the base.

a. Abdomen long.

1. *Caligus rapax, Milne Edwards.* This species was taken in abundance on the surface of the scales of sea trout, *Salmo trutta* (with *Lepeophtheirus stromii*), in the mouth of cod, *Gadus morrhua*, and rarely on the surface of grey mullet, *Mugil capito.* Male generally found accompanying the female, but in smaller numbers.

2. *Caligus diaphanus, Nordmann and Kroyer* (not *Baird*). Found in quantity on the inner surface of the operculum of *Trigla hirundo* and *T. cuculus.* This species is very small, but agrees exactly with Kroyer's description and plate.

3. *Caligus scomberi, n. sp.** I have been unable to place this with any recorded species, and have therefore named it after the fish it is taken from. It is found on the inner surface of the operculum of *Scomber scomber.* It much resembles the last, but the carapace is oval instead of being rounded, and the abdomen is much longer.

4. *Caligus elegans* (?), *Van Beneden.* A doubtful specimen from the mouth of *Gadus morrhuæ.*

5. *Caligus (Sciænophillus) tenuis, Van Beneden.* Found on the inside of the operculum of *Sciæna umbra.* Four specimens were found, on the only fish of the kind examined, and were unmistakeable.

b. Abdomen short.

6. *Caligus minimus, Nordmann.* A number of specimens of both sexes were taken from the gill cavity and mouth of the bass, *Labrax*

* A description, with figures, of this and the other new species mentioned in this paper, at present in manuscript, will be published shortly elsewhere.

lupus, in June and October. The *Hamulus accessorius anterior* is particularly long, and the second maxillipedes in the male are very strong and large.

7. *Caligus Mülleri, Leach*, was found on the surface of the body of poor-cod, but was only seen on a few occasions, a large number of males being taken proportionately to the females. The same *Caligus* was also found on *Trigla gurnardus*.

8. *Caligus curtus, Müller*. This species was taken frequently from the mouth of the cod. Both the description and figure in Müller's work are very indefinite. This species differs from the latter in being rather smaller, the furcula branches longer, and the abdomen rather bigger.

9. *Caligus gurnardi, Kroyer*. One specimen of this species was taken from the gill cavity of *Trigla cuculus* in June.

10. *Caligus brevipedis, n. sp.** Two specimens of this curious form were taken, in August, from the gill cavity of *Motella tricirrata*. It differs from all other described species in the rudimentary condition of the fourth pair of thoracic limbs. The same character was found in both specimens, so that it could not well be an abnormality.

Lepeophtheirus, *Nordmann*.

Frontal lobes without sucking discs; fourth thoracic segment free; genital segment without lobes on the back; abdomen appearing free behind.

a. Abdomen long.

1. *Lepeophtheirus stromii, Baird* (*vesper* of *Milne Edwards*). Specimens of both sexes of this species were found in quantity on the surface of the body of salmon and salmon-trout in June and July.

2. *Lepeophtheirus pollachius, n. sp.** Both sexes taken in quantity from the palate and back of the tongue of *Gadus pollachius*, also from the gills of the ling, *Molva vulgaris*. This species is nearly allied to the last mentioned.

3. *Lepeophtheirus Thompsoni, Baird*. In the gills of turbot and brill, *Rhombus maximus* and *laevis*. The specimens of this species were generally found in great numbers in the gills of the above-mentioned fish; I have taken as many as thirty from one. The specimens described by Kroyer as *L. rhombus* is closely allied in detail, but the carapace as represented by him is very small and round, whereas in this species it is large and distinctly oval, as shown by Baird.

4. *Lepeophtheirus obscurus* (*?*), *Baird*. Found in the gills of *Rhombus laevis* only. This species has outwardly a very close resemblance to

* See former note, p. 156.

the last, but the furcula is distinctly and markedly different, the branches being short, and each branch bifurcating. The male agrees with the description given by Baird of a specimen which I believe he mistook for a female. As this specimen was also taken from the brill, it is likely that they are one and the same species. I have therefore named my specimen accordingly.

b. Abdomen short.

5. *Lepeophtheirus pectoralis, Müller.* This species was very common, taken all round the year, from plaice, flounder, and dab; very frequently attached to the posterior surface of the pectoral fin, but they were often seen moving actively about over the body of newly-caught fish. Especially common on the flounder. Both sexes abundant.

Elytrophora, *Gerstæcker.*

(1) All four pair of legs two-branched, the terminal branch of all provided with long plumose hairs. (2) The number of joints in each branch varying. (3) The outer and inner branch of first pair two-jointed, both branches of second and third with three joints, the inner branch of fourth with two only.

Elytrophora brachyptera, Gerstæcker. From the gills of a large tunny, *Thynnus thynnus,* taken outside Plymouth, I obtained ten specimens of this species, five of each sex, all alive. These I watched for several hours in a bell-glass. They were very active, and the males were seen to attach themselves to the females in the position represented in Dr. Heller's work, firmly fixed by the hook-like posterior antennæ, and second maxillipedes.

Trebius, *Kroyer.*

(1) All four pairs of legs two branched, the terminal joints of all provided with long plumose setae; (2) the outer and inner branch of the first pair with two joints, both branches of second, third, and fourth with three joints.

Trebius caudatus, Kroyer. Specimens were found on the dorsal surface of the head, and in the nasal cavities of the skate, *Raja batis,* but were not common. One was also taken from the skin of a pollack, but possibly may have found its way there during the manipulation of the fish in the boats or on the quay.

Cecrops, *Leach.*

(1) The end joints of the bifid branches of all the true legs, with short hook-like bristles, or having smooth edges; (2) front edge of the cephalothorax deeply cut, two lobed; (3) anterior antennæ covered.

Cecrops Latreillei, Leach. Two specimens were found in the gills of sunfish, *Orthagoriscus mola.*

PANDARUS, *Leach.*

(1) Front edge of cephalothorax, not deeply lobed; (2) anterior antennæ free; (3) cephalothorax broader behind than in front; (4) first pair of maxillepeds cheliform; (5) the outer branch of first true leg single-jointed, the inner with two joints, both branches of second and third pairs two jointed, branches of fourth pair one jointed.

Pandarus bicolor, Leach. A number of specimens of this species were taken from the surface of *Scyllium catulus.*

DICHELESTHINA.

LERNANTHROPUS, *Nordmann.*

(1) Abdomen without dorsal plates; (2) the two posterior pair of limbs changed into lamellar appendages; the two first pair very small.

Lernanthropus Kroyeri, Van Beneden. From only one *Labrax lupus,* in over a dozen examined, did I find any of these curious animals. This was a full-grown fish, and twelve were found, some on the gills of either side. Many of them had the abdomen as a tense bag of bloody fluid, and most had spermatophores attached.

CLAVELLA, *Oken.*

(1) Anterior antennæ single, six-jointed, projecting under the edge of the cephalothorax; (2) posterior antennæ with single hook-like claw; (3) only the anterior pair of limbs formed; (4) genital segment of female, five to six times as long as the anterior part of the body.

Clavella mulli, Van Beneden. A number of specimens of this minute species were taken from the gills of the red mullet, all females. The long straw-coloured ovarian tubes are easily seen projecting beyond the gills.

CYCNUS, *Edwards* (*Congericola, Van Beneden*).

All four pairs of limbs formed, and two branched anterior antennæ, six-jointed.

Cycnus (*Congericola*) *pallida, Van Beneden.* This species was not common. From 14 well-grown conger, I only obtained specimens in two: eleven altogether. They are, however, very difficult to find. The posterior antennæ are very strong and large, compared with the last genus.

and probably move from place to place. The male resembles closely that of *C. cornutus;* in fact, no matter how varied the form of the female in this genus, the males are perfectly distinctive. It was also noticeable that one female would often have more than one male attached, usually to the abdomen. At times as many as five or six would be found fixed on to the various parts of the animal. Occasionally young *Caligidæ* were also present as secondary parasites.

* See former note, p. 156.

LERNÆODEA.

PENELLA, *Oken.*

Thoracic legs close together, found just behind the head, neck without distinct segments, egg sacs thread-like, the hinder part of the body (the genital segment) joined to the neck in a straight line; from the end of the latter projects the abdomen, as a long plumose rod. Head rounded and corrugated, carrying behind it two arm-like projections.

Penella sagitta? Linn. One specimen was obtained from the Laboratory, but from what fish was not known.

LERNÆONEMA, *Milne Edwards.*

Genital segment passing gradually into the neck; head obliquely cut off, or rounded in front; genital opening placed far off from it; thoracic legs with developed oar-like joints.

1. *Lernæonema monillaris, Milne Edwards.* A very perfect specimen of this species was found attached to the sclerotic of a young herring taken in November. There was no malformation of the eyeball.

2. *Lernæonema encrasicola? Van Beneden.* A broken specimen, probably belonging to this species, was taken from a *Clupea alosa.*

LERNEA, *Linn.*

Genital segment dilated, bent in the form of an S, and twisted on its axis; head in front bearing slender forked processes; neck short, simple; all four pairs of thoracic legs unfolded.

1. *Lernea branchialis, Linnæus.* Specimens were taken from the gills of the cod, bass, whiting, haddock.

The body is always full of sanguineous fluid, and the head with its long horns, together with the neck, are deeply buried in the tissues of the gills and head, being surrounded by a laminated clot of blood encysting those parts completely. When once fixed there is apparently no power of movement. The gill cavity of a whiting would appear to be almost filled up with one of these large parasites, and they must materially interfere with the action of the gills.

2. *Lernea lusci, n. sp.** This animal was found only in the gills of whiting-pout, *Gadus luscus,* and was very common, as many as four being found on one fish. The whole head is surrounded by a clot of blood, the elongated horn being buried by the side of the gill bone.

* See former note, p. 156.

CHONDRACANTHINA.

CHONDRACANTHUS, *De la Roche.*

(1) Cephalothorax not separated from the abdomen by a long thin neck. (2) Front end of the body neither thicker nor more slender than the posterior part. (3) Posterior antennæ in the form of hooks. (4). Cephalothorax without processes. (5) Abdomen compressed with concave sides, or with elongated lobes. Behind the second maxillipedes are two pairs of lobed processes, representing the thoracic limbs.

(*a*) Two small horns at the posterior angles of the thorax.

1. *Chondracanthus cornutus, Müller.* A great number of specimens were taken from the gills of the Plaice, *P. platessa*, Flounder, *P. flesus*, and *P. megastoma.* They differed very much in size, being small and especially abundant in the Flounder. The male was almost invariably found fixed on the abdomen of the mature females, by means of its strong, hook-like posterior antennæ.

2. *Chondracanthus soleæ, Kroyer.* Found in the gill cavity of *Solea vulgaris*, but not common; male like the preceding.

3. *Chondracanthus clavatus, n. sp.** Found only on the gills of *P. microcephalus.*

(*b*) A number of supplementary lobes on the sides, none on the middle line.

4. *Chondracanthus triglæ, Blainville* (*C. assellina, Linn*). These were plentifully taken from *Trigla gurnardus, T. cuculus*, and *T. hirundo.* The whole anterior portion of the head, and so-called neck, is buried in a fleshy mass in the substance of the gill, the thoracic portion only showing.

5. *Chondracanthus merluccii, Holten.* Taken from the mouth of *Gadus merluccius*, and is very common; in no fair-sized hake have I ever found it absent. Great numbers are often found together, large areas of mucous membrane being destroyed. The very large hooks of attachment (the second antennæ) being deeply buried, strong muscles are inserted into the bases of these, both for abduction and adduction, so that one would gather that the animal is able to relax its hold, and probably move from place to place. The male resembles closely that of *C. cornutus;* in fact, no matter how varied the form of the female in this genus, the males are perfectly distinctive. It was also noticeable that one female would often have more than one male attached, usually to the abdomen. At times as many as five or six would be found fixed on to the various parts of the animal. Occasionally young *Caligidæ* were also present as secondary parasites.

* See former note, p. 156.

(*c*) Supplementary horns in the median line.

6. *Chondracanthus Zei, De la Roche* (*De la rochiana, Blainville*). Found on the gills of *Zeus faber*. This, too, is very common; one of these being usually found on either side in the anterior angle of the gill cavity. When very small, the horn-like processes are soft and crowded. Male like that of *C. cornutus*.

7. *Chondracanthus lophii, Johnst.* (*Ch. gibbosus. Kroyer*). Found in almost all well-grown angler fish, *Lophius piscatorius*, attached to the gills.

LERNÆOPODIDÆ.

LERNÆOPODA, *Kroyer*.

Cephalothorax short, not attenuated, plainly separated from the body. Maxillipedes of the second pair, long, thin, arm-like, united at their ends; Cephalothorax one-jointed, oval. Body narrow, bag-like, only slightly segmented.

1. *Lernæopoda salmonea, Linn.* (*L. carpionis, Kroyer*). One female specimen found on the gills of *Salmo salar*.

2. *Lernæopoda galei, Kroyer*. Many specimens of this animal were taken from *Mustelus vulgaris, Galeus vulgaris, Acanthias vulgaris*. They were found attached to the soft skin behind the pectoral and anal fins, more particularly in the deep folds by the anal fins of the male fish, and were frequently taken alive.

BRACHIELLA, *Cuvier*.

Cephalothorax markedly thin and elongated, often ringed like a worm. Second maxillipedes are long, arm-like, only united together at their extremity as in the preceding genus, but without articular appendages at their base as in *Tracheliastes*.

1. *Brachiella thynni, Cuv.* From one large Tunny, *Thynnus thynnus*, I obtained four specimens, attached to the soft skin, behind the pectoral fins, two on either side, two being mature and two quite small.

2. *Brachiella insidiosa, Heller*. These were found attached to the gill rays of the hake, *Gadus merluccius*, being fairly common. They agree very closely with that described by Heller (obtained from a species of *Gadus* in the Mediterranean), except that the arms are rather shorter, and the cephalothorax is more acutely bent. Both females and males were found.

3. *Brachiella impudica, Nordmann*. A number of specimens were taken from different species of Gurnards—*Trigla cuculus, T. gurnardus*, and *T. hirundo*. They were generally found attached to the soft skin on the inner side of the operculum near to the border, and were very characteristic. The male was generally found fixed

upon the back of the cephalothorax, and has been described by Milne Edwards.

Var. parva ? Very frequently a smaller animal was also found on the same fish, in like positions, apparently differing only in not having any secondary lobular prolongations on the arms. They had the three pairs of horn-like processes posteriorly, and the males appeared identical; but as they bore egg sacs, they might be specifically different.

4. *Brachiella bispinosa, Nordmann.* Found in quantity from *Trigla cuculus, T. gurnardus, T. lyra.* Attached to the gill rakers of the outer branchiæ; rarely more than two on each fish. The head has the same characteristic organs as in *B. impudica.* The male, which is found at the back of the cephalothorax, has also equal resemblance.

5. *Brachiella triglæ (Anchorella triglæ, Claus).* This species is found attached to the gills of the various Gurnards, *T. cuculus, gurnardus,* and *hirundo,* but was not very common. Although in its outward form the female has most of the characteristics of an *Anchorella,* the male distinctly shows it to belong to this genus.

6. *Brachiella merluccii, n. sp.** These animals are always found attached to the *points of the gill-rakers* of the Hake, *Gadus merluccius,* and never attached to the gill rays themselves, as *B. insidiosa.* Both were frequently found in the same fish, but their positions were never other than that noted.

Anchorella, *Cuvier.*

Second pair of maxillipedes short, united together, ending close to their origin, in a fixing organ. (Male showing no trace of segmentation of the body, which is not elongated, but globular. B.–S.)

1. *Anchorella emarginata, Kroyer.* This species was found attached to the gill-rakers of the outer branchiæ of *Clupea alosa.* The second pair of maxillipedes are *not* completely united at their base.

2. *Anchorella paradoxa, Van Beneden.* Found on the gills of *Scomber scomber,* but rare. The species is, however, very characteristic, and the male is distinctive, but has not yet been described by any author.*

3. *Anchorella uncinata, Müller.* This species is extremely common, being found in the folds of skin around the mouth, and in the gill-cavity of cod, haddock, pollock, whiting, and whiting-pout. The organ of adhesion of this species is a perfect drill.

4. *Anchorella quadrata, n. sp.** A few specimens were obtained of this species from the Dragonet, *Callionymus lyra,* attached to the gill rakers. This species is much like *Anchorella falax,* Heller, in form, except for the great size of the abdomen.

* See former note, p. 156.

Faunistic Notes.

By

E. J. Allen, B.Sc., W. Garstang, M.A., E. T. Browne, B.A., and T. V. Hodgson.

Notes on Dredging and Trawling Work during the latter half of 1895. — During the summer and autumn of the year 1895 it was possible, with the aid of a grant made for the purpose by the Government Grant Committee of the Royal Society, to carry on dredging work with some regularity in deeper water, and at greater distance from Plymouth Sound, than had been possible in previous years. Our efforts were concentrated upon the grounds lying between Start Point and the Eddystone, with a view to compiling a chart showing the nature of the bottom at each spot, and the animals and plants which live there. For this purpose samples were taken, as far as possible, of every species brought up by the dredge and trawl, and preserved for identification, note being made of the relative abundance of each species. With the exception of the Polyzoa and Polychætes, the material collected has now been worked over, and lists of the animals obtained at the different spots drawn up. It would not, however, be advisable to publish the full details at the present stage, as it is our intention to work the same grounds again during the first six months of 1896, at the end of which time the results of the year's work will be combined, and a detailed chart drawn up. Many conclusions, gathered from a study of the rough charts already made out, require to be checked, and others, perhaps, will require modification.

Broadly speaking, the district under investigation can be divided into three principal regions, characterized not only by the nature of the bottom, but also by the animals which live there. The first of these comprises the grounds around the Eddystone, where the bottom is, for the most part, composed of broken shell; the second, a broad stretch of sandy ground, extending from a couple of miles east of the Eddystone to a line drawn about north and south, and

passing through Bolt Tail; and the third includes the off-shore grounds between Bolt Head and the Start, where gravel, broken shell, and soft rock predominate. Each of these three principal regions is, of course, capable of considerable further sub-division, but an account of these, with their inhabitants, must be postponed.

It may be well, however, to give some notes on a few of the rarer animals found, or of those which have not previously been taken by the Marine Biological Association at Plymouth.

Paraphellia expansa, Haddon. Three or four specimens of this interesting anemone were dredged, on August 16th, in about 26 fathoms, at a distance of 3 miles N. W. of the Eddystone. The surface was covered with fine particles of gravel. One of the specimens is still alive in the Laboratory. This species, for which a new genus was formed, was first obtained by Haddon at the mouth of Bantry Bay, in a depth of 40 fathoms, and was described from two specimens—one obtained in 1885, and a second in the following year.* Specimens have since been obtained by Prof. Herdman from near the Isle of Man.†

Sarcodictyon catenata, Forbes. The red variety was common on shelly grounds, both round the Eddystone and off Prawl Point.

Heterocordyle conybearei, Allman. Four colonies of this rare hydroid were dredged near the East Rutts, on August 30th. The species was identified by Mr. E. T. Browne, to whom the following note is due:—Each colony was on a large shell of *Buccinum undatum*, inhabited by the common Hermit Crab, *Eupagurus bernhardus*. The colonies correspond to the description given by Allman. There was no difficulty in identifying the species as the gonophores, each with a single ovum, were present in large numbers upon the blastostyles. This hydroid was first taken by Allman in Glengariff Harbour, Bantry Bay, and afterwards by Hincks at Oban, which are, I believe, the only localities where it has been found.

Of the other Hydroids, *Thuiaria articulata*, Pallas, and *Diphasia tamarisca*, Linn., are worthy of mention.

Ophiactis balli, Thompson, was abundant around the Eddystone, and especially so off Prawl Point. *Ophiura affinis* was also taken at the latter place, and a single specimen of *Echinocardium pennatifidum*, Norman, was dredged from a bottom of broken shell, about 5 miles south of Bolt Head.

Polygordius sp. occurred in numbers in gravel and broken shell dredged off Prawl Point (34 fms.), and a few were also taken from a ground of fine broken shell (20 fms.) south of the Eddystone.

* Haddon, "Revision of British Actiniæ," *Trans. Roy. Dub. Soc.* iv. (Series ii.) p. 321.
† *Brit. Assn. Report*, Ipswich, 1895.

Eupolia curta, Hubrecht. This nemertine was found on three occasions, and was identified by Mr. Riches, who had already taken a specimen in the neighbourhood. It has not previously been recorded for the Atlantic, but occurs in the Mediterranean, at Mauritius, Polynesia, and the West Coast of South America.* We have taken it in the following localities: (1) ½ mile N.W. by ½ N. of Eddystone, August 16th, ground fine broken shell (17–20 fms.); (2) Off Borough Island, August 20th, soft red rock interspersed with gravel (17 fms.); (3) 5 miles S. by E. of Prawl Point, September 17th, shells, broken shell, and gravel (34 fms.).

Dondersia banyulensis, Pruvot. (*Arch. Zool. Exper. et Gen.* ix. 1891, p. 715) = *Myzomenia banyulensis* (Simrot, "Mollusca," *Bronn. Thier-Reichs*, 1893, p. 231.) This interesting neomenian, for the identification of which I am indebted to Mr. Garstang, was taken 3 miles E. by N. of the Eddystone, on the 30th September, in 30 fathoms. Four specimens of the bright red variety were found on the hydroid *Lafoea dumosa*, var. *robusta*, growing on *Pecten* shells. The species has previously been found, also on *Lafoea dumosa*, at Banyul and Roscoff.

Lyonsia norvegica. This lamellibranch was obtained off Prawl Point. A specimen was subsequently taken off Stoke Point.

In addition to the above, which were obtained from deeper water, the following species taken in the ordinary collecting work of the Laboratory may be mentioned.

Tubiclava lucerna, Allman, growing on stones dredged from Millbay Channel (within the Sound), on November 14th. Gonophores were not present. The species is much more slender than *Tubiclava cornucopiæ*, Norman, and the corrugation of the polypary, and its dilatation at the base of the polypite, were very marked. It has previously been taken by Allman, in a rock-pool at Torquay and in Dublin Bay. It does not appear to have been since recorded.

Stylochoplana maculata, Quatrefages, was found in numbers on December 11th, crawling upon zostera dredged in Cawsand Bay. Gamble† gives the following localities for this species: Berwick Bay (Johnston); Firth of Forth (Dalyell); Firman Bay, Guernsey (Lankester); St. Andrews (McIntosh); Jersey (Koehler); St. Malo (Quatrefages); St. Vaaste-la-Hogue (Claparède). It has not been previously recorded for this district.

E. J. ALLEN.

* See BÜRGER. Nemertinen. *Fauna u. Flora d. Golfes v. Neapel.* 1895, where an interesting chart is given showing the distribution of the Genus *Eupolia*.

† *Quart. Jour. Micr. Sci.* xxxiv. 1892–93, p. 498.

On Doris maculata, a new species of Nudibranchiate Mollusk found at Plymouth.—Under the name *Doris maculata*, I describe a small Dorid of striking appearance, which has been several times obtained at Plymouth, and which seems to be quite distinct from any form hitherto described. Pending the appearance of a more complete account of the anatomy and affinities of this interesting form, the present note will enable naturalists to recognise its appearance, and to identify it in the event of additional specimens being found. A brief reference to this animal occurs in my "Faunistic Notes at Plymouth for 1893–94." (*Jour. Mar. Biol. Assoc.* vol. iii. 1894, p. 220.)

The notæum of *Doris maculata* is usually about twice as long as broad, the sides being approximately parallel, and the two extremities equally rounded. The body, however, is flexible, and the actual form of the animal varies accordingly at different times. The largest specimen observed was nearly one inch in length, and proportionately stout and broad; but the usual length of the specimens obtained varies from three-eighths to three-quarters of an inch.

The rhinophores are large, distinctly laminated, and completely retractile. The edge of the rhinophoral cavity is very slightly, if at all, elevated, but is usually provided with a pair of purple tubercles at its sides, one lying on the inner side, the other on the outer side of the cavity.

The circumanal gills are constantly five in number, and are so situated that one gill is anterior and median in position, two others form an antero-lateral pair, and the remaining two a postero-lateral pair, symmetrically disposed with regard to the anus. The gills are simple pinnate plumes, completely retractile within a cavity, and are held out somewhat stiffly in expansion. The peribranchial fossa is bounded by a thin raised lip, which is beset with a number of small tubercles, some of which are pigmented with purple granules.

The foot is broad, and, although concealed beneath the notæum when the animal is at rest, projects slightly behind it during locomotion. The anterior margin of the foot shows a transverse groove, which separates a slender propodial lip from the rest of the foot. The propodium is quite simple, and shews no trace of a division into two lateral halves.

On each side of the oral protuberance is an oral tentacle, whose shape is bluntly conical, or digitiform, according to its state of elongation.

The feature which gives this new *Doris* its most distinctive appearance is the presence, on the back, of a number of conspicuously coloured tubercles, connected with one another by a network of low ridges. These tubercles are of different sizes, and there is a good deal of

irregularity in their arrangement. It is usually possible, however, to recognise two longitudinal rows of particularly large tubercles, three or four on each side, which extend from the rhinophores to the peribranchial fossa. These two rows of large tubercles are situated along a pair of lines which are the sites of tubercular or pigmented modifications in certain other types of *Doridida*, *e.g.* the sub-lateral rows of filaments on the back of *Idalia Leachii*, and the post-rhinophoral rows of pigment-patches in *Doris* (*Jorunna*) *Johnstoni*. In *Doris maculata* there is also an irregular median series of tubercles, as well as a number of smaller lateral tubercles irregularly scattered over the back between the main sub-lateral rows and the margin of the notæum.

The tubercles are of a deep purple colour, due to granular deposits of a purple pigment.

The ridges which connect neighbouring tubercles with one another are often slightly granulated with the same purple pigment.

In specimens in which the serial arrangement of the tubercles is not well defined, the general appearance is that of a central network of ridges, radiating out into irregular lines at the sides. The tubercles arise from the nodes of the network.

Since the general colour of the body is bright yellow, the contrast effected by the purple tubercles and ridges renders this little creature a very striking object in a mass of dredged material; it is, moreover, easily recognised as distinct from any British *Doris* hitherto described.

Doris maculata was first found by me at Plymouth on December 18th, 1893, when two specimens were dredged. It has since been obtained on several occasions, but always from the same locality—the western part of Plymouth Sound, known as the New and Queen's Grounds. The bottom here is clean, and consists largely of hard rock and stones, which graduate into beds of shells to the south. The flora and fauna are characterized by the occurrence of *Delesseria*, *Antennularia*, numerous *Polyzoa*, and *Morchellium argus*.

W. GARSTANG.

On the changes in the Pelagic Fauna of Plymouth during September, 1893 and 1895.—During a visit to the Plymouth Laboratory, in September, 1893, and in September, 1895, for systematic work on medusæ, it was almost a daily occupation to examine with a microscope the contents of the tow-net, for the purpose of obtaining the earliest stages of medusæ. Whilst thus occupied, I noted down not only the medusæ seen, but also other pelagic animals. I propose to give here a few notes to show the change in the pelagic fauna for the same month in different years. This

is not intended for a complete list of all the animals seen, but only a few of the more interesting ones are given, and those which show the changes in quantity.

Noctiluca miliaris.—Bles (1892) states: "The absence of *Noctiluca* is a very extraordinary feature of the year, for 1891 was remarkable for the immense profusion 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." In 1893, I found *Noctiluca* almost daily in the tow-net, the quantity varying day by day. On some days the top of the tow-net jar was covered with a thick layer. In 1895 not a single specimen was seen during September.*

Liriantha appendiculata was exceedingly abundant in 1893, during September and the early part of October. Mr. Garstang sent me an adult male on October 23rd. I never saw a single specimen in 1895.

Amphinema dinema was fairly common during the whole of September, 1893; only a few small specimens seen in 1895, the last on September 20th.

Lar Sabellarum (= *Willia stellata*) was fairly abundant during the whole of September, 1893, especially the early stages; but scarce in 1895, and only medusæ belonging to the first and second stages were seen.

Dipurena halterata, a single specimen taken on 25th September, 1893. None seen in 1895.

Lizzia blondina was not taken during September, 1893; but Garstang obtained specimens during the summer months. During the early part of September, 1895, this medusa was fairly abundant, and disappeared about the middle of the month.

Solmaris and *Octorchis.*—Two early stages of a *Solmaris*, and a specimen of *Octorchis* were taken on 7th September, 1895, about two miles south of the Breakwater. Both genera are new to Plymouth. The *Solmaridae* (Narcomedusæ) inhabit the Mediterranean and the Tropical Seas. *Octorchis* is also a Mediterranean medusa. On 10th September, 1895, a new species of *Dipurena* was taken, and on the 17th September several specimens of *Euchilota*, also new to British seas.

The medusæ were certainly not so abundant in September, 1895, as in September, 1893. This may have been due to the enormous number of *Doliolum* and *Muggiæa* which daily entered the tow-net. In 1893, *Doliolum* was scarce during September, and *Liriantha* exceedingly

* *Noctiluca* did not appear until December, *vide* Hodgson, *infra*, p. 174.—Ed.

abundant. *Obelia lucifera* was exceedingly plentiful during the whole of September, 1893, but in 1895, though a few specimens were taken daily at the beginning of the month, the great crowd did not appear until September 14th, then in the shallow water of Whitsand Bay, but soon swarmed everywhere, along with *Muggiæa and Doliolum*.

Muggiæa atlantica, Cunningham.—Cunningham (1892) has given a description of this species. He first obtained specimens near the Eddystone on September 12th, 1891, "and afterwards it was obtained in great abundance close to the Plymouth Breakwater, and even inside the Sound. It was brought in numbers to the Laboratory almost every day up to about the middle of October, but after the end of that month it was not seen again."

Cunningham (1892), p. 398, gives an earlier history of this siphonophore, and also states that in 1892 it was very abundant at Plymouth, about the middle of September, but decreased considerably towards the end of the month.

In 1893, *Muggiæa* was present during the whole of September, and during the early part of the month fairly abundant. In 1895 it was exceedingly abundant. *

Beroe.—A single specimen taken on 19th September, 1895, about 3 mm. in length.

Echinoderm larvæ.—In 1893, Plutei were abundant during the early part of September, but very scarce towards the end. In 1895 several kinds were seen, some very abundant at the end of the month. The Bipinnariæ, described by Garstang (1894), were first taken at Plymouth in 1893, during August, and apparently disappeared before my arrival, as I saw none during September. But, in 1895, a few specimens were occasionally taken.

Pilidium.—I did not see any larvæ during September, 1893, but frequently saw them in 1895. Fairly abundant on September 7th and 19th.

Terebella.—The larval form in its tube was always present in the tow-net during September, 1893; a sudden increase occurred on September 23rd. In 1895, none seen until September 13th; after this date a few were generally present in the tow-net, but they were never abundant.

Chætopterus.—In 1893, one or two larvæ were usually taken every day. In 1895, a few were seen at the end of August, but none during September.

Polynoe.—In 1893 a few of the early larval stages were taken about the middle of September. In 1895 a few were occasionally seen, but scarce.

* Cf. Hodgson, *infra*, p. 174. It remained this year (1895) until the middle of December.—Ed.

Magelona.—Abundant throughout the whole of September, 1893. On some days I counted the specimens seen—September 21st, 30; 22nd, 20; 23rd, 5; 25th, 50; 26th, 35; 27th, 38. On September 23rd all the Polychaete larvæ were scarce, but medusæ and other animals did not show any visible decrease. In 1895, Magelona was not nearly so abundant; often only a few present, occasionally none seen. On September 13th it was fairly abundant.

Mitraria.—This appears to be a rare animal on the southern coast of England. I only obtained three specimens on 31st August, 1895. Dr. Fowler informs me that some were taken a few years ago at Plymouth, but were not recorded in the journal. Vallentin (1891) records Mitraria for Falmouth in July, 1890.

Actinotrocha.—None seen during September, 1893. Very scarce in 1895; only a few specimens seen; the last taken on September 19th.

Rotifera.—Garstang (1894), p. 235, writes—"Apparently characteristic of this period (September) are the clouds of pelagic Rotifers, which may be occasionally taken." I cannot find any references to Rotifers in my notes for 1893. Certainly none appeared during Sept., 1895, as I kept a special look out for the benefit of a friend.*

Thalia democratica-mucronata.—Garstang (1894) states the nets were crowded with Salps in June, 1893. I saw none during September. In 1895 a few specimens were taken on September 9th only.

Doliolum tritonis.—In 1893 a few specimens were taken at the beginning of September, but soon became scarce. One or two occasionally taken at the end of the month. In 1895, Doliolum was exceedingly abundant at the beginning of September. Often the tow-nets were crowded with specimens. There was a gradual decrease towards the end of the month.

Tornaria.—None seen during September, 1893, but often taken in 1895. Fairly abundant at the beginning of September, and a few were occasionally taken at the end of the month. This is the same species, *Tornaria Krohnii*, which Bourne (1889) found at Plymouth in 1888, during August and September.*

Amphioxus.—A specimen taken in the tow-net on September 3rd, 1895, about 2 mm. in length, and another on September 7th, about 3 mm. in length. None seen during September, 1893.

In some of the species the variation is great, as they are absent in one year and abundant in the other. Little value, however, can be attached to the slight differences in numbers, as a species may be present every year, but owing to its scarcity escape the tow-net, which after all only traverses through a very small portion of the sea, even in

* Cf. Hodgson, *infra*, p. 176-7.—Ed.

the course of a month. I have given these rarer forms to show that they do occur in September, and they may be of use to other naturalists on faunistic work.

The following list is drawn up to show more clearly the variation in the fauna for the two years:

	1893.	1895.
Noctiluca	abundant	absent.
Liriantha	„	„
Chætopterus	few daily	„
Dipurena	one	„
Amphinema	fairly abundant	all show a great decrease.
Lar (*Willia*)	abundant	all show a great decrease.
Magelona	„	all show a great decrease.
Doliolum	few	very abundant.
Pilidium	absent.	fairly abundant.
Tornaria	„	„ „
Lizzia	„	„ „
Actinotrocha	„	few.
Thalia	„	„
Bipinnaria	„	„
Mitraria	„	three.
Amphioxus	„	two.
Beroe	„	one.
Solmaris	——	all new to Plymouth.
Octorchis	——	all new to Plymouth.
Dipurena (*sp.?*)	——	all new to Plymouth.
Euchilota	——	all new to Plymouth.

From this list it is easily seen that more interesting animals were taken during September, 1895, than in 1893. The cause is difficult to account for; it may, perhaps, be due to the weather, which was exceptionally fine during September, 1895. There was scarcely any rain, but plenty of sea mists and fogs; the last week of the month was exceptionally hot. The sea was usually calm; in fact, September was an ideal month for marine work.

The weather during the summer months was very changeable. Mr. Allen informs me that May and June were fine, July was stormy and wet. There was a spell of fine weather at the end of July, and during the first few days of August, then unsettled weather until middle of the month, when the fine weather commenced, which lasted till the end of September.

Garstang (1894) gives a general account of the weather for 1893, which may be of interest to quote for comparison:—

"The year 1893 was one of exceptional interest to the marine zoologist. During the first two months Plymouth experienced a continuous succession of heavy gales, but towards the middle of March the winds became lighter, and the sea, which had been running remarkably high outside the breakwater, subsided. From that time onwards till the middle of September we enjoyed six months of the most delightful weather—a period, with scarcely a break, of calm seas and almost cloudless skies. Under the influence of the great heat the temperature of the Channel waters rose continuously, until, in August, it had attained a point unprecedented for a quarter of a century; and it was of the highest interest to observe the effect of this high temperature, and of the prolonged calmness of the sea, upon the floating population of the neighbouring portion of the Channel. Numbers of semi-oceanic forms which rarely reach our shores arrived in remarkable profusion. In June the tow-nets were crowded with salps, while towards the latter end of August they were almost choked by masses of living Radiolaria." (p. 210.)

On looking up my notes for 1893, I find that the fine weather first broke up on September 6th, with a south-westerly wind with squalls of rain. The sea remained rough until the 11th, then followed a period of fairly calm seas until September 28th, when bad weather again set in till the end of the month. During the latter half of September westerly winds usually prevailed; rain fell nearly every day, and on two occasions showers of hail.

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EDWARD T. BROWNE.

Notes on the Pelagic Fauna at Plymouth. August–December, 1895.—The following notes are by no means exhaustive, or even complete, and merely indicate the more important features of the varied characters of marine life during the period covered by them. In their compilation I have followed the system of a monthly calendar adopted by Garstang (8). If these notes are compared with those of other

observers, certain differences present themselves, some striking, others trivial. That considerable and varied changes in the Floating Fauna do take place is sufficiently obvious, and they are doubtless strongly influenced by conditions of climate and currents. Garstang (**9**) briefly deals with the inter-relations of the Plankton; but very little accurate information on this point is available, and no explanation has yet been given of the periodic appearance and disappearance of certain forms. Thus, *Noctiluca* is recorded by Bles (**1**) as superabundant in 1891, scarce in 1892. Browne (**7**) comments on its abundance in 1893; Garstang (**9**) does not mention it for 1893 or 1894. I have only found a few individuals in December, 1895, a season quite at variance with the notes of other observers. *Muggiœa*, in 1895, appeared about the middle of August, as expected from previous notes; but it remained constantly present, or nearly so, up to the middle of December, two months later than in other years.

As regards Copepods, I have found *Oithona spinirostris* and *Coryceus anglicus* continuously from August to December, both inclusive, the former in diminishing numbers as the winter approached. Bourne (**3**) records both these species as occurring in the spring only; but, in another paper (**4**), refers to them both as being extremely abundant in the open sea in July. The non-appearance of *Paracalanus parvus* (Claus) is noteworthy.

With regard to other forms, Browne (**7**) has dealt in some detail with the more important features of the Plankton for September, and in comparison with a former period, so that there is but little for me to add, nor have I any other definite information of a similar season with which to make comparison.

Some reference is, perhaps, necessary to the observations of Prof. McIntosh, at St. Andrews (**10**). My own scanty notes accord, as far as they go, with his exhaustive record; but certain differences, probably due to locality, are conspicuous. In winter Ctenophores appear to be abundant, and of maximum size, at St. Andrews, but no trace of them exists at Plymouth. This is only one case in point.

The Tow-nettings were taken outside, and usually within a few miles of the Breakwater, at various depths from the surface, to about fifteen fathoms, but without any definite system. In this connection it is interesting to note that certain organisms usually rare, and first found in the open waters of the Channel, in the neighbourhood of the Eddystone, were this year abundant, and found comparatively close in shore. *Tornaria* (Bourne, **2**) was fairly evenly distributed in the inshore and open-sea areas; *Doliolum* penetrated as far as the Sound; while *Muggiœa* was abundant within it.

AUGUST.—This month is perhaps the best in the year, or, maybe, it

divides honours with September. This year, however (1895), the weather was distinctly prejudicial to good work outside the Breakwater, during the earlier part of the month.

Of the Crustacea, *Podon intermedius* (Lillj), and *Evadne Nordmanni* (Lowen), were constantly present, and a large proportion of the females carried ova. The Copepods *Cetochilus septentrionalis* (Goodsir), *Clausia elongata* (Boeck), *Dias longiremis* (Lillj), *Temora longicornis* (Müller), *Centropages typicus* (Kroyer), were invariably taken, the first-named in somewhat limited numbers, the remainder in more or less profusion. *Anomalocera Patersoni* (Templeton) only occurred once, on the 24th, when two individuals were taken. This conspicuous species is stated by Bourne (**3**) to be abundant in the late summer and autumn, though Bles (**1**) and Garstang (**9**) do not mention it.

Oithona spinirostris (Claus), recorded by Bourne (**3**) as an early spring species, was abundant all through the month, and, on the 23rd, females bearing ovisacs were taken. *Coryceus anglicus* (Lubbock), was also taken, though not previously recorded before September (Bles, **1**). Bourne (**3**) describes it as occurring from February to May. Nauplii were extremely abundant, more especially those of Cirripedes. The Zoœa of *Carcinus* appeared about the middle of the month, and soon became abundant, with the larvæ of various other Decapods.

Of Ascidians, *Oikopleura dioica* (Fol), was frequently present, though by no means abundantly. On the 26th, *Doliolum tritonis* (Herdman), appeared for the first time. The Ctenophore *Hormiphora plumosa*, (Agassiz), almost invariably occurred in small numbers. *Muggiœa atlantica* (Cunningham), appeared on the 13th, and from that time forward was constantly present.

From the middle to the end of the month the tow-nettings were taken well within two miles of the Breakwater, and from the 20th onwards the medusoid forms of *Obelia* appeared numerously, but in somewhat fluctuating quantities; and together with them a few other medusæ. Larval forms in abundance made their appearance towards the end of the month. Echinoderms were among the first, with several species of Plutei, and a few Bipinnaria. An occasional Tornaria, *T. Kröhnii*, followed by a variable number of *Trochospheres*, *Pilidia*, &c., and post-larval stages of numerous Polychætes. *Cyphonautes* also appeared in fair numbers. *Spadella bipunctata* occurred somewhat sparingly near the end of the month, and the individuals were of moderate size only. *Ceratium* was taken very sparingly on three occasions, and Diatoms of the genus *Rhizoselenia* were not uncommon.

SEPTEMBER.—The calm and hot weather prevailing almost entirely through this month, if it did not directly increase pelagic life, was decidedly more favourable for its capture. All the Entomostraca

mentioned last month were found, and from the 7th to the 14th were particularly abundant. More especially was this the case with *Cetochilus septentrionalis*. Ova-bearing females of *Clausia elongata* were taken on the 23rd, and females of *Coryceus anglicus* in a similar condition at short intervals throughout the month. *Podon intermedius* diminished considerably in numbers.

On the 13th, Mr. E. T. Browne brought me a fine specimen of the rare *Monstrilla Danæ* (Claus), and I obtained another on the 18th. This species does not appear to have been recorded in this neighbourhood since 1889, when Messrs. Bourne and Norman obtained no less than eight specimens, then its first appearance (**5**). *Nauplii*, of various species and stages, became very abundant, and among the equally numerous Decapod larvæ, the Zoœa of *Porcellana* were conspicuous. *Spadella bipunctata*, of small to moderate size, were fairly abundant, and larval forms of all kinds were more numerous than before. *Tornaria*, fairly numerous at first, was not taken by me later than the 24th. *Plutei*, invariably present, were particularly numerous 7th, 9th, 18th, and 30th. *Trochospheres* and *Pilidia* were plentiful, and the larvæ of Terebella appeared in small numbers, but on the 18th were fairly abundant. *Doliolum tritonis* was more or less abundant throughout the month, and on the 9th a few specimens of *Thalia democratica-mucronata* (Lusk) were taken. *Oikopleura* maintained its numbers as in August. *Muggiœa* was abundant throughout the month, sometimes exceedingly so. *Ceratium* occurred occasionally in small numbers, and Diatoms were fairly plentiful, more particularly so on the last day of the month, when the tow-net was quite choked with them.

October.—The diminution of numerous forms of life, indicated towards the end of September, became very conspicuous during October. *Podon* and *Evadne* disappeared early, and were soon followed by *Centropages typicus*. *Clausia elongata*, *Oithona spinirostris*, and *Coryceus anglicus* alone maintained their numbers, and of the two latter ova-bearing females were frequently found. *Nauplii* and *Decapod* larvæ became scarce. *Doliolum* disappeared on the 13th, but *Oikopleura* appeared more frequently, seldom a tow-netting without it. A fine specimen of *Tomopteris onisciformis* (Eschsch), was taken on the 22nd. *Spadella* increased in numbers and in size. Post-larval stages of many *Polychœtes* were still abundant, and with them *Cyphonautes* maintained itself without perceptible variation. *Muggiœa* was still abundant, and accompanied by its larval form. *Obelia*, with one sudden and conspicuous accession to its numbers, died out, and with it the few Medusæ associated with it. This increased number of Obelia was taken about a mile from the Breakwater. Diatoms, which were inconveniently conspicuous for the first day or two, resumed normal proportions.

NOVEMBER.—*Clausia elongata* became the most conspicuous Copepod. *Coryceus anglicus* also maintained its numbers, but the remainder diminished considerably. The not uncommon *Longipedia coronata* was taken twice, previously only recorded by Bourne (3) in March and April, 1889. *Harpacticus chelifer* was also taken once. This species does not appear to have been recorded at all, though it is fairly common in the littoral and laminarian zones. The Copepods frequenting these regions have been quite neglected.

Two specimens of *Caligus rapax* were taken free swimming. *Nauplii* and *Decapod* larvæ were reduced to a minimum. *Spadella*, at times numerous, was rather small. A single specimen of *Tomopteris* was taken on the 23rd. The post-larval stages of various *Polychætes* were fairly numerous, and, for a time, the larvæ of *Terebella* also. Echinoderm larvæ were rare, one or two *Plutei* being occasionally found. *Cyphonautes* were fairly numerous, and *Muggiæa*, with its larva, was generally present in small numbers. *Obelia* was occasionally represented by a few stragglers.

Diatoms were plentiful, and *Ceratium* was only found occasionally, and in very limited numbers.

DECEMBER.—This month was very similar to the last. *Oithona spinirostris* was only occasionally found. On the 18th, a fine specimen of *Candace pectinata*, Brady, was taken. This species has not hitherto been recorded in this neighbourhood, and, as far as I know, only once for the British Seas, when it was taken by Professor G. S. Brady (6), off the Scilly Isles. *Spadella* still increased both in numbers and in size.

Muggiæa disappeared altogether about the middle of the month. On the 20th, *Ceratium* was taken more numerously than before, and with it was a fair sprinkling of *Radiolaria*. These occurred for the first and only time, but are mentioned by Garstang (9) as frequently abundant in the summer. At the same time a single Rotifer was seen, again the only occasion, and rather a contrast to the frequent clouds of these organisms that Garstang (9) reports as generally occurring in August and September.*

Noctiluca was frequently present, but in extremely limited numbers.

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* *Cf.* BROWNE (7), p. 171.

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T. V. HODGSON.

Nautilograpsus minutus, Milne Edwards.—On September 26th a large three-masted sailing-ship, the *Ballachulish*, of Ardrossan, entered the Sound from a distant port, and enquiry from the Agents showed that she had come direct from Iquique, in Peru, and that for nearly two years previously she had been trading in the Central Pacific.

As the Laboratory boat was passing on the 28th, it was stopped to make a rough examination of the ship's bottom for specimens, and a fine male specimen of *Nautilograpsus minutus*, M. Edw., was taken. This species is a native of the Sargasso Sea, and only a very rare straggler to the British coasts. It is described by Bell* under the name of *Planes linnæana* (Leach), and he states that there are several species of this genus. Stebbing, however, in his *Crustacea*,† reduces the reputed species to one, and substitutes Milne-Edwards' name for that of Bell. The bottom of the ship was covered, in patches, with a number of fine specimens of *Lepas anatifera*, and a single specimen of *Conchoderma aurita* (Spengel) was taken. With these and some green algæ was an enormous quantity of *Tubularia sp.* The latter was in fine condition, and both male and female reproductive organs were well developed. Specimens were taken by Mr. E. T. Browne for identification, and will be described by him. Overrunning both alga and *Tubularia* was a crowd of large *Podocerus falcatus*.

On October 21st a fisherman brought to the Laboratory an enormous bunch of *Lepas anatifera*, fixed to a fragment of some cork structure—thick sheets of cork secured together by wooden pins—found floating in the Channel some two or three miles out. Concealed in this mass was another specimen of *Nautilograpsus minutus*. (M. Edw.) Both specimens were about half an inch across the carapace, and of a reddish colour, but the second specimen had a broad band of white across the anterior portion.

T. V. HODGSON.

* BELL, T.—*History of the British Stalk-eyed Crustacea*, London, 1853.

† STEBBING, T. R. R.—*Crustacea*. Int. Sc. Ser. 1893.

Algological Notes.

By

George Brebner.

THE following list shows the additions made to the marine flora of Plymouth and district, as a result of the dredging, &c., carried on from the 6th September to the 10th December, 1895.

MYXOPHYCEÆ, *Stizenb.* (= CYANOPHYCEÆ, *Sachs*).

Lyngbya Meneghiniana, Gom. (West Hoe).
Phormidium persicinum, Gom. (Duke Rock).
Plectonema terebrans, Born. et Flah. (Cawsand Bay).
Mastigocoleus testarum, Lagerh. (Drake's Island).

CHLOROPHYCEÆ.

Gomontia polyrhiza, Born. et Flah.
Ostreobium Queketti, Born. et Flah.

PHÆOPHYCEÆ.

Desmarestia Dresnayi, Lamx. (Eddystone, &c.).
Ectocarpus velutinus, Kütz. (Rocks at Ladies' Bathing Place, &c.).
„ „ var. *laterifructus*, Batt. in lit. (Rocks at Ladies' Bathing Place, Rum Bay, Firestone Bay, &c.).
Ectocarpus terminalis, Kütz. (Firestone Bay).
Leptonema fasciculatum, Rke. var. *uncinatum*, Rke. (Cawsand Bay).
Ralfsia clavata, Crn. (Drake's Island).
„ *spongiocarpa*, Batt. (Wembury Bay).

FLORIDEÆ.

Those marked * are new to science, † new to Britain.

Conchocelis rosea, Batt. (Cawsand Bay, &c.).
**Colaconema Bonnemaisoniæ*, Batt. in lit. (Eddystone, Mewstone, &c.).
* „ *Chylocladiæ*, Batt. in lit. (Bovisand Bay, &c.).
* „ *reticulatum*, Batt. in lit. (Dredging 34).

Callocolax neglectus, Schmitz (Bovisand Bay, &c.).
Phyllophora Traillii, Batt. (Bovisand Bay, Duke Rock, &c.).
Trailliella intricata, Batt. in lit. (Cawsand Bay).
(= *Spermothamnion Turneri*, var. *intricatum*, Holm. et Batt. Rev. List.)
Rhodochorton membranaceum, Mag.
var. *macrocladum*, Rosenv. (Eddystone).
Rhodochortun minutum, Rke. (Cawsand Bay).
Cruoria adhaerens, Crn. (Queen's Ground).
† „ *rosea*, Crn. (Queen's Ground).
† *Rhododiscus pulcherrimus*, Crn. (Queen's Ground).
Cruoriella Dubyi, Schmitz (Queen's Ground).
Rhododermis parasitica, Batt. (Bovisand Bay).
Melobesia Lejolisii, Rosan. (Cawsand Bay).

Colaconema Bonnemaisoniæ, Batt. in lit., was first recognised in the "fruiting" condition (monospores) in a fragment of *Bonnemaisonia asparagoides*, dredged off the Eddystone Lighthouse on the 9th September. It was made the type of a new genus of endophytic algæ. On the same expedition the interesting *Desmarestia Dresnayi*, Lamx., was obtained, and in the perfect condition, *i.e.* with a main frond, having two smaller lateral fronds near the base, symmetrically placed one on each side. Subsequently, in adjacent waters, 26th September (haul 34), a very fine specimen of the same plant was secured.

Colaconema Chylocladiæ, Batt. in lit., was recognised in fruiting condition (monospores) in a tetrasporogenous specimen of *Chylocladia ovalis*, dredged in Bovisand Bay, 20th September. Well-"fruited" specimens of this species had previously been obtained by Mr. Batters at Torquay, although he had not named, or published, his find.

Colaconema reticulatum, Batt. in lit., was found on a very broad old frond of *Desmarestia Dresnayi*, Lamx.; but as its reproductive organs have not yet been recognised, it is only tentatively placed here in the classification. It had previously been found elsewhere by Mr. Edward Batters.

Trailliella intricata, Batt. in lit., has been made the type of a new genus, on account of the discovery of the tetraspores of the plant. This alga had already found a place in the classification as indicated in the above list. As it was placed from barren specimens, the discovery of the tetraspores, which are unique in position and mode of development for the *Calithamnions*, rendered re-classification necessary. It was named in honour of Mr. G. W. Traill, the well-known Scottish algologist.

Cruoria rosea, Crn., and *Rhododiscus pulcherrimus*, Crn., new to Britain, are interesting members of the Squamariaceæ, and were found by Mr. Batters on shells forwarded to him from the Laboratory.

All the above finds were authenticated by Mr. Batters, to whom the writer's heartiest thanks are due for his invaluable advice and assistance. The writer likewise wishes here to express his great indebtedness to the Director and staff of the Laboratory for the aid rendered in the carrying out of these investigations.

NOTE.—The diagnoses of the new genera, and further information about the more important of the above finds, written by Mr. Edward Batters, will be found in the *Journal of Botany* for January, 1896.

The Protection of Crabs and Lobsters.

By

E. J. Allen, B.Sc.

Director of the Plymouth Laboratory.

"Every legislative restriction means the creation of a new offence. In the case of fishery it means that a simple man of the people, earning a scanty livelihood by hard toil, shall be liable to fine or imprisonment for doing that which he and his fathers before him have, up to that time, been free to do.

"If the general interest clearly requires that this burden should be put upon the fisherman—well and good. But if it does not—if, indeed, there is any doubt about the matter—I think that the man who has made the unnecessary law deserves a heavier punishment than the man who breaks it."—HUXLEY, Inaugural Address, Fisheries Exhibition, 1883.

SEVERAL of the local Sea Fisheries Committees have recently been, or are still engaged in, considering the question of the advisability of adopting restrictive measures for the protection of crabs and lobsters within their respective districts. To Mr. Gregg Wilson, of the Natural History Department of Edinburgh University, I am indebted for copies of two reports on the subject prepared by him for the Northumberland Sea Fisheries' Committee; to Mr. W. H. St. Quintin, chairman of the North-Eastern Committee, for a copy of the evidence taken by their sub-committee from fishermen at various centres in the district; and to the clerk to the Cornwall Sea Fisheries' Committee for a copy of the report of their sub-committee, signed by Mr. E. W. Rashleigh, and a summary of the evidence taken prepared by Mr. Rupert Vallentin. The committee of the Eastern District have, I understand, also had the matter under consideration.

In all cases the suggested restrictions are of two kinds: (1) the establishment of a close-season; and (2), an increase of the present size limit.

With regard to the first of these proposed remedies, it is hardly necessary to point out, that from a scientific standpoint a close-season for any animal can, in the majority of cases, only be justified, when the breeding season of the animal extends over only a limited portion of the year, and when the close-season can be made to correspond with the

breeding season. That any attention should be paid to such arguments as those brought forward by the Looe fishermen in favour of a close time, namely, that the "nets belonging to the drift fishermen become entangled with the floats, which mark the positions of the crab or lobster pots," appears to me to be quite unjustifiable.

The biological question is, in the case under consideration, considerably complicated by the fact that the breeding seasons of the crab and lobster are very different, as well as by the circumstance that both these crustaceans periodically cast their shell, and remain for some time in a soft state, when they are quite unfit for food. It is necessary for us therefore to consider, in the first place, each of the animals independently, and then, bearing in mind that both are caught at the same time and in the same traps, and that in most cases to try to establish a close-season for one and not for the other, would make the fishing during that time quite unprofitable, we must endeavour to ascertain whether, on the whole, one close-season could be justly enforced.

With regard to the reproductive habits of the lobster, we have considerable accurate information. In the last number of this Journal I endeavoured to give a summary of the present state of knowledge on the subject, from which it appeared that most lobsters laid their eggs in August, and that most of these eggs were hatched in the following June, being carried by the female for ten months. During July, the number of females bearing eggs was not large, and of these some carried eggs on the point of hatching, whilst others carried those which had just been laid, the two seasons to some extent overlapping. The evidence given by the fishermen at the different enquiries quite agreed with this statement, for they maintained that they took berried hen lobsters all the year round, and could point to no month in which they were undoubtedly specially numerous. For the lobster alone, therefore, it does not, under these circumstances, appear that any particular period of the year could be legitimately recommended as a close time. A more practical suggestion from the point of view of maintaining the species is that there should be a perpetual close time for berried hens, that is, that the taking of females carrying eggs should be entirely prohibited; and in one locality, at least, in the North Eastern District, a fisherman was found who appeared to be strongly in favour of this extreme step.*

On the other hand, in certain districts it is maintained that such a proceeding would practically close the fishery. Whether or not this would be the case depends on the proportion which the number of berried females bears to the whole catch. The data for determining this proportion are not numerous. From Ehrenbaum's table,† it appears

* *Report*, p. 100. † Reprinted in this Journal, vol. iv. p. 64.

that out of a total of 3,470 lobsters (unsorted catches) counted by him at Heligoland, between November, 1892, and July, 1893, 383 were females carrying eggs, that is, 11 per cent. of the total number taken. Of the lobsters taken by one boat at Plymouth* during May, June, and the first half of July, 1890, about 6½ per cent. were berried females. These numbers represent, therefore, the nearest approximation we can get at the present time as to the amount of loss which the men would immediately suffer, if they were compelled to return all berried females to the sea. In his report to the Northumberland Committee, Mr. Gregg Wilson recommends that there should be a close time for berried hen lobsters only, during the months of June and July, on the ground that more berried females are got during those two months than at other times of the year. I can only say that, according to my experience at Plymouth, it is more difficult to obtain berried lobsters in July than during any other month when the boats are fishing.

With respect to the crab, however, the facts are in many important respects different from what they are in the case of the lobster.

In the first place, the berried crabs are already protected under the Fisheries Act, 1877, it being illegal to buy, sell, or have in one's possession such crabs, and in the second place, these crabs never, or very rarely, enter the pots. When in spawn they migrate to the deeper water, and appear to bury themselves in the sand. At any rate, they are taken in this condition from smooth ground by the trawlers.

As to the spawning time of the crab, Mr. Gregg Wilson gives some interesting information derived from his own observations on the coast of Northumberland, and comes to the conclusion that the spawning period includes November, December, and January. A large proportion of the take of crabs during these months consists of females which are just about to spawn, and Mr. Wilson suggests that these might be protected, and proposes a close time from the 1st of September to the end of January. As an additional argument in favour of this close time he adduces the fact that many crabs during these months are soft, that is, have cast their shell and are quite unfit for food. In November, two out of every three crabs were found to be "casters," and although the men profess to throw these soft crabs back, many of them are so much injured by the rough treatment they receive that there is little chance of their surviving.

"I know of one village," says Mr. Wilson, "where the sorting of the crabs is done, not at the fishing grounds, but on dry land, and where, too, it is done so badly, that as little as a shilling a barrel was got for crabs sent to market in November; and I know another village where the men confess that if the law against the sale of caster-crabs could

* This Journal. Vol. ii. N.S. p. 15.

be strictly enforced, they would have to give up fishing in the late months of the year."

Such, then, are the facts upon which the desirability or otherwise of establishing a close time for crabs and lobsters has to be decided. And it appears to me that, taking these facts as a whole, the Sub-Committee of the Cornwall Sea Fisheries' District adopted the only reasonable course in deciding that no close time could be recommended. For not only do the lobsters carry their spawn equally during at least eleven months of the year, whilst the berried crabs never enter the pots at all, but during the winter months, when it is proposed that the close time should be established, very little fishing takes place, owing to the stormy weather which then prevails. There is, in fact, a natural close time imposed by this cause, which, under any circumstance, would render legislative interference unnecessary.

Passing to the second of the proposed restrictions, viz., an increase of the present size limit, we have first to consider the basis upon which legislation of this kind rests. I cannot do better, in order to make this clear, and to give both sides of the argument, than quote the following from the report of the enquiry held by the Sub-Committee in the North-Eastern Sea Fisheries' District—

"By Mr. Pannett—*

"*Q.* Before asking the next question, I would explain that in considering what should be the size—the smallest size—at which crabs and lobsters should be allowed to be taken, there are two classes of men who each hold different opinions. There are those who are of opinion that crabs and lobsters might fairly be taken as soon as they can be sold, as soon as they are marketable; that is, not to take them wastefully, not to take them for children to play with, not to take them wantonly, not unless they can be sold in the market. These people think the fish should not be allowed to remain in the sea until they get their growth, but that they should be allowed to be taken as soon as they can be sold in the market. Now there is another class of men who say that that is a very improper rule; they say that crabs and lobsters which are not able to reproduce their species, are not able to breed till they reach, on an average, a certain size, although they may be marketable below that size, although they might be sold for money below that size, should not be allowed to be taken till they reach the size at which they have had the chance of breeding once. If so, every she-crab and hen-lobster would, before being killed, have a chance of reproducing one brood to take its place. . . . Would you object to a crab being allowed to grow to the size at which it should breed once before it should be taken, or would you claim that it might be taken as soon as it was saleable?

"*A.* (Fisherman.) As soon as it was saleable."

* *Report*, p. 58.

Again, to another witness.*

"By Mr. Pannett—

"*Q.* If they do not breed till they are much larger than four-and-a-quarter inches, do you not, by killing all the crabs that are under the breeding size, stop the supply of crabs from these fish?

"*A.* (Fisherman.) I don't think so.

"*Q.* How is the supply to be kept up if you kill the crab before sufficient time is allowed for it to spawn once?

"*A.* (Fisherman.) We don't kill them all.

"By Mr. Mally—

"*Q.* With reference to what Mr. Pannett was asking you. Suppose all girls are killed when they are twelve years of age, there would be no young women or young children; that is what we wanted to know. I think you understand that, and if young crabs under the age at which they can spawn be killed, it follows that there can be no crabs from them?

"*A.* (Fisherman.) But crabs breed a deal different to what girls do. Crabs, when they spawn, spawn many a thousand at a time."

There is, of course, also another point of view from which the protection of undersized animals may be advantageous to the fishery, in addition to this matter of allowing each animal to breed once, viz., that if the small crabs or lobsters, which are of little value, be returned immediately to the water, they themselves will grow, and become much more valuable.

Under the Fisheries Act (1877) a limit has already been fixed, below which it is illegal to take either crabs or lobsters. For crabs, the minimum size is $4\frac{1}{4}$ inches, measured across the broadest part of the back, and for lobsters 8 inches, measured from the tip of the beak to the end of the tail. Now both these sizes are considerably below the sizes at which the greater number of the animals begin to breed, so that at the present time large numbers of both crabs and lobsters are sold at very low prices indeed, which have never had an opportunity of breeding, and so helping to maintain the future supply. It appears to be in the direction of raising the limit that legislative interference can with advantage take place. According to Mr. Gregg Wilson's observations, which are, however, not very definite on this head, the majority of female crabs do not spawn until they reach a size of from six to seven inches, whilst the males may be ripe at five inches. In the case of lobsters, although a few females may spawn at eight inches, it does not appear that many do this under ten inches. Hence the limits which would be recommended from purely biological considerations would be, for female crabs at least six inches, for male crabs five inches, for female lobsters ten inches, with possibly a lower limit for the males.

* *Report*, p. 76.

It must not, however, be forgotten that according to the evidence given in the North-Eastern District, the immediate effect of such limits would be, in certain places, at any rate, to entirely stop the fishing, and it would be several years before any very great benefit could follow from the fact that more of the crabs had been allowed to breed. On the other hand, if the limit could be raised gradually, the beneficial effect might be slowly brought about without entailing any sudden hardship upon individuals. This might be done by adopting the recommendation of Mr. Wilson, viz., a limit of five inches for crabs, and by raising the limit for lobsters to, say, nine inches. It is more than probable that if these limits were maintained for a few years, sufficient improvement in size would have taken place to allow of their being raised to the more reasonable standard without serious injury to any individuals.

Report on the Sponge Fishery of Florida and the Artificial culture of Sponges.

(Prepared at the request of the Colonial Office, with a view to the introduction of Sponge Culture in the Bahamas.)

By

E. J. Allen, B.Sc.,

Hon. Secretary of the Marine Biological Association, and Director of the Plymouth Laboratory.

SUMMARY.

I. The Florida Sponge Fishery.—History of the Fishery. Kinds of sponges taken. Relative value of sponges. Methods of procuring sponges. Curing the sponges. Sponge grounds reduced in value through over-fishing.

Sponge Culture Experiments.—Historical.

Experiments of Buccich.—Description of apparatus used, and manner in which the experiments were conducted. Buccich concluded that sponge cuttings would grow to marketable size in seven years.

Experiments in Florida.—Sponge cuttings said to grow more rapidly, increasing to from four to six times their original size in six months, when placed under favourable conditions.

Memorandum by Mr. Benedict, of U.S. National Museum.—Sponge culture experiments do not appear to have been tried to any great extent. Fishermen opposed to anything of the kind as likely to lead to monopoly, and the cutting off their means of subsistence.

Would Sponge-culture by Cuttings be Profitable?—Marenzeller points out that this would depend on whether pieces of a sponge would in a given time together attain a greater weight than the original sponge would have reached if left undisturbed.

Suggested Experiments.—Suggestions by Mr. Bidder (*see below*). Fishing by means of divers, or dredging, should be tried in deeper water.

II. Note on Projects for the Improvement of Sponge-Fisheries. By Mr. George Bidder.

A. There appears no reason yet to suppose that the yield of a sponge-fishery will be increased by planting cuttings, unless these are placed in more advantageous positions than the original sponges. Such advantage may probably be obtained by attaching either cuttings or small sponges to canes or tiles, disposed on iron hurdles standing some feet from the sea-bottom. No certain statement, however, can be made with regard to any project, until there has been effected a series of accurate observations on the natural growth of the sponge of commerce.

B. Sponges could probably be transported alive from the Mediterranean to the Bahamas, but it is not certain that even if they bred freely, their progeny would maintain the superior character of the parents.

C. There is no special breeding season for sponges.

APPENDIX.—Rate of Growth of Sponges.

THE FLORIDA SPONGE FISHERY.*—It was not until the year 1850 that the attention of American sponge merchants was directed to the fact that the reefs of South Florida possessed an abundant growth of sponges. Previous to that time, all sponges sold in America had been obtained from the Mediterranean or the Bahamas. When, however, the true value of the Florida sponges was once realised, an important industry grew rapidly, the island of West Key and the town of Apalachicola being at the present time chiefly interested in the promotion of the fishery.

In Florida, as in the Bahamas, five principal grades of sponges are recognised. The most valuable of these is the *sheepswool* sponge, which is regarded by naturalists as a variety of *Hippospongia equina*, the horse-sponge and Venetian bath sponge of the Mediterranean. The representative in America waters of *Euspongia officinalis*, the Levant toilet sponge and the Turkey cup sponge, the most valuable kinds found in the East, is the *glove* sponge, which is, however, the least valuable of the American grades. The grades intermediate in value between the *sheepswool* and the *glove* sponges are the *velvet*, another variety of *Hippospongia equina*, the *yellow*, and *hard-head sponges*, which may belong to the same species as the Mediterranean Zimocca sponge (*Euspongia zimocca*), and the grass sponge (*Spongia graminea*, possibly a variety of *Euspongia officinalis*), a grade of little value.

By far the most costly sponges in the market are those from the Mediterranean, the sheepswool sponges of the Bahamas and Florida being regarded as the next in quality. Of the latter, the Florida sponges are said to be superior to those sent from the Bahamas, being supposed to possess a somewhat finer texture, and a more regular and compact mode of growth. The irregularity of shape of the Bahama sponges is stated to be due to the irregular nature of the bottom on which they grow.†

The method by which the sponges are procured in Florida is similar to that practised in the Bahamas, but differs essentially from the usual

* The following account has been compiled, for the most part, from an article by Rathbun in "The Fishery Industries of the United States" (Section V. vol. 2, p. 819), published by the U.S. Commission of Fish and Fisheries, Washington, 1887. The discussion of the question by Dr. Juan Vilaro [*Esponjicultura cubana*, Revista de Pesca Maritima VII. Madrid, 1891], was also consulted; it is compiled chiefly from the American Reports.

† The method of preparation of Bahama sponges is also stated to be inferior to that practised in Florida.

Mediterranean mode of fishing. In the latter case the sponges are generally obtained by divers from depths of from 15 to 20 fathoms, the men working without a diving dress, using large stones, which they hold at arm's length in front of them, to carry them to the bottom. They usually remain under water about two minutes. In America, on the other hand, sponges are taken in water of from 3 to 6 fathoms, or even shallower, by means of a three-pronged hook fixed at the end of a pole, men working the poles from small boats. The sponges are seen from the surface with the aid of a "sponge-glass," which is generally a wooden bucket painted a dark colour inside, and with the bottom replaced by a sheet of glass. When the glass is plunged below the surface of the water, the effect of the surface ripples is removed, and by looking through the bucket a clear view of the sea-bottom can be obtained even at considerable depths. As soon as a sponge is seen it is taken by means of the hooks. At the end of a day's fishing, the small boats, each of which is usually occupied by two men, return with their catches to the sponging vessel, which has been lying near all day, and the sponges are placed on board. Some of these vessels remain on the fishing grounds for from one to three months, whilst others return to port at the end of a week or fortnight only. It is generally usual, however, for the vessels to take their catch every week to the "crawls"—enclosures of stakes 8 or 10 feet square, situated in water 2 to 3 feet deep—in which the sponges are cured. The process of curing consists in allowing the animal portion of the sponge to rot, and then clearing it away by squeezing and beating. As much of the water as possible is pressed out, and the sponges then strung on rope yarns, and hung up to bleach and dry. The only other processes to which they are subjected before being placed upon the market are "liming" and trimming, but both of these are carried out after they have passed out of the hands of the fishermen into those of the dealers. The "liming" consists in dipping the sponges in a weak solution of lime in sea-water, and subsequently drying them, a treatment which adds to their value by giving them a bright yellow colour. This process requires to be very carefully performed, as too much lime is liable to injure the tissue of the sponge.

When sponge-fishing was first practised on a large scale in Florida, only the larger sponges were taken, but in consequence of the amount of fishing which was carried on, the number of large sponges became insufficient to supply the demand, and the smaller ones were gathered to make up the requisite quantity. It became evident, however, that the value of the grounds would soon become considerably reduced, and those interested in the matter began to consider the possibility of increasing the number of sponges by attempting their artificial

cultivation. Unfortunately, however, up to the present time, the matter does not appear to have been carried beyond a very elementary experimental stage.

SPONGE CULTURE EXPERIMENTS.—The statement that detached sponges were capable of fixing themselves and continuing their growth, was first recorded in 1785 by Filippo Cavolini, his account being based upon experiments carried out in the Bay of Naples. It was not, however, until the year 1862 that attention was drawn by Professor Oscar Schmidt to the fact that portions of a sponge would also fix and grow, and the possibility of its application to the production of sponges on a commercial scale pointed out.

EXPERIMENTS OF BUCCICH.—In consequence of the opinion expressed by Professor Schmidt, "that if a perfectly fresh sponge is cut in suitable pieces, and if these pieces, properly protected, are again placed in the sea, they will grow and finally develop into complete sponges," a number of experiments were made during 1863-1872, at a station established on the bay of Socolizza, at the north-eastern point of the island of Lesina. This establishment was closed in 1872, on account of the hostility of the native fishermen, who continually interfered with the growing sponges. An account of these experiments has been given by Dr. Emil von Marenzeller,* from the original notes of Signor Gregor Buccich, who was in charge of the establishment. The experiments seem to show that for European sponges cuttings, if carefully treated, can be reared successfully until they become of marketable size. From the account given, it appears that for making sponge-cuttings the most favourable time is during the winter months, as in cool weather there is less tendency for the sponges to suffer from detachment and exposure to air. The best localities are sheltered bays, with pure sea-water as free as possible from mud. The sponges from which the cuttings are to be made require very careful treatment, and the method finally adopted by Buccich was as follows: The sponges having been obtained either with tongs or a drag-net, and the injured portions, as far as possible, removed, they are fixed by means of wooden pegs to the inner side of a sort of fish-box, which is towed behind the boat. It is better, especially in warm weather, to leave the sponges for a little time in this box, in order to see whether or not putrefaction is likely to take place. When it has been ascertained that all the sponges are healthy, the cutting and planting are proceeded with. The cutting is done upon a small board, moistened with sea-water, with a knife having a saw-edge, and the pieces are made so as to measure about an inch each way.

* Die Aufzucht des Badeschwammes aus Theilstücken. Verhandl. der k.k. Zoologisch-botanischen Gesellschaft in Wien. Vienna, 1878. Translated in U.S. Fish Commission Report, 1879; p. 771.

Each piece should have as large an area as possible of intact outer skin. Various methods of planting the cuttings were tried. The pieces, especially those with only one cut surface, very soon attach themselves to a suitable base either of stone or wood, if brought into close contact with it. They must, however, in general be fastened in some way to prevent them from being moved about by waves and currents. Amongst other methods tried by Buccich was that of fixing the pieces by means of wooden pegs upon flagstones, in which holes were bored. But in this case the mud and sand on the bottom, and possibly also the excess of light, proved injurious. The apparatus finally adopted consisted of two boards, about 25 inches long and 16 inches broad, kept in a parallel position one above the other by two props placed at a distance apart of about $4\frac{1}{2}$ inches, and having their opposite ends fixed to the boards. Between the props stones could be put as ballast. Twenty-four holes, at distances of $4\frac{3}{4}$ inches from each other, were bored in each board, into which the two ends of as many bamboo rods could be fastened, thus forming a kind of vertical grating. Before, however, the bamboo rods were placed in position, the pieces of sponge were fixed to them in the following way: Three holes were made in each rod, at equal distances apart, and each piece of sponge was perforated with a hole sufficiently large for it to be able to slide on the rod. Three pieces of sponge were put on each rod, and supported on wooden pegs placed through the holes in the latter. In order to perforate the sponge-cuttings without injuring them, a trepan about a quarter of an inch wide, kept in rapid motion by a fly-wheel, was used. When the pieces of sponge had been fixed on the rods as described, and the rods placed in position in the frame, the whole was sunk to the bottom and allowed to remain. All wood used in the apparatus was well tarred, in order to prevent the destructive action of boring molluscs, and for this purpose it would be advisable, in any future experiments, to construct the apparatus of iron. It was found that if due care had been taken, 90 per cent. of the cuttings developed successfully, and Buccich states that they were found to grow two or three times their original size during the first year. He was of opinion that although some pieces will grow to a considerable size in five years, it would require seven years to raise completely matured sponges fit for the market.

Experiments in Florida.—It has been maintained, however, that for Florida sponges the rate of growth is considerably quicker than that indicated by these experiments, and the only account yet given of any attempt there made to grow sponges from cuttings appears to confirm this view. This is given by Rathbun,* as follows—

* *Loc. cit.* p. 832.

"The first trials were made at Key West, by the agent of Messrs. McKesson and Robbins, sponge dealers, of New York, who have recently contributed to the U. S. National Museum four specimens of the sheepswool variety, showing the first-fruit of this important work. We have not been able to obtain a detailed report of these experiments, but from a letter written at Key West, and kindly furnished by Messrs. McKesson and Robbins, the following brief account has been prepared—

"The sponges were all raised from cuttings; the localities in which they were planted were not the most favourable for sponge development, and their growth was, therefore, less rapid and perfect than might otherwise have been the case. They were fastened to the bottom, in a depth of about 2½ feet of water, by means of wires or sticks running through them. The four specimens sent to Washington were allowed to remain down a period of about six months before they were removed. Fully four months elapsed before they recovered from the injury done them in the cutting, which removes the outer 'skin' along the edges of the section, and the actual growth exhibited was for about two months only. The original height of each of the cuttings was about 2½ inches. One was planted in a cove or bight, where there was little or no current, and its increase in size was very slight. The other specimens were placed in tide-ways, and have grown to from four to six times their former bulk. Two hundred and sixteen specimens in all were planted at the same date, and at the last accounts those that remained were doing finely.

"The chief obstacle to the artificial cultivation of sponges at Key West arises from the fact that the sponge fishermen infest every part of the region where sponges are likely to grow, and there is no legal protection for the would-be culturist against intruders. The enactment of judicious laws bearing upon this subject by the State of Florida, or the granting of special privileges conferring the right to occupy certain prescribed areas for sponge propagation, would undoubtedly tend to increase the annual production of this important fishery."

Unfortunately, these experiments do not appear to have been carried further in Florida, and no reference to their continuation is made in subsequent reports of the U. S. Fish Commission.

MEMORANDUM BY MR. BENEDICT.—Through the kindness of Professor Brown Goode, it is possible in this connection to add the following memorandum by Mr. James E. Benedict, Assistant Curator of the Department of Marine Invertebrates at the United States National Museum—

"While in Florida several years ago, I inquired particularly into sponge culture. Many people denied that the experiment had ever been successfully tried, showing that it had not been tried to any great extent. I was informed, however, that by raising a sponge nearly to the surface, without lifting it out of the water, and dividing it up, and fastening the pieces to some anchor, and placing them in favourable localities, they grew rapidly. The sponge fisher-

men, however, are very much opposed to experimenting in this direction, as they believe it can only be successfully carried on when the grounds are parcelled out, which they think would result in monopoly, and cutting off their means of subsistence.

(Signed) "JAMES E. BENEDICT,

"*Assistant Curator, Department of Marine Invertebrates.*

"November 14*th*, 1895."

WOULD SPONGE-CULTURE BY CUTTINGS BE PROFITABLE?—To what extent the culture of sponges, after the manner suggested by Schmidt, would be a profitable undertaking, depends largely upon the rate of growth of the cuttings as compared with the rate of growth of uncut sponges. As Dr. von Marenzeller points out, it is questionable "whether it is profitable to cut to pieces a sponge, which uncut would have quicker reached the same size and weight than all the cuttings together in seven years. Under such circumstances, sponge-culture had better be confined to the transformation of flat and, therefore, worthless sponges into round ones, which, though small, would find a ready market. Possibly several, especially misshaped, pieces might be made to grow together, and form larger and better ones."

SUGGESTED EXPERIMENTS.—Mr. George Bidder, a member of the Marine Biological Association who has been engaged for some years in studying the anatomy and physiology of sponges, and is a recognised authority on these subjects, has kindly furnished some valuable notes upon this point, in addition to a number of suggestions as to various methods for endeavouring to improve sponge fisheries, which are appended to this report.

In addition to the practical proposals made by Mr. Bidder as to the most suitable lines upon which experiments might be carried on, with a view to the improvement of the Bahama sponge industry, it may be suggested also that, in case this has not already been tried, an attempt should be made to obtain sponges in the Bahamas from deeper water, either by the use of the dredge, or with the aid of divers. In the Mediterranean, the sponges found in shallow waters, such as those from which they are obtained in America, are stated to be much coarser and less valuable than those taken from depths of from 15–20 fathoms. According to Hyatt, sponges probably occur in American seas down to a depth of about 30 fathoms, and it is quite possible that an attempt to obtain some of those living at greater depths than the 3–6 fathoms, to which the fishing is at present confined, might yield more valuable material. This could be easily ascertained, when one of H.M. ships, with divers on board, visited the Bahamas, or experiments might be made with the dredge. Sponges obtained by these methods would also be less injured than those taken with the hooks.

Note on Projects for the Improvement of Sponge-Fisheries.

By

George Bidder.

For Summary see under title of preceding article.

A. *Sponge-cultivation.*

In considering the experiments of Buccich (**6**) on propagation of sponges by cuttings, two main questions present themselves:—

(1) If a sponge be divided into many fragments, will the total increase of such fragments and their progeny be greater than the increase of the intact sponge and its progeny would have been in the same time; the conditions of water, &c., being identical?

(2) Are sponges, grown as recommended by Buccich, more or less favourably situated than those on the sea-bottom?

(1) The first of these questions I should, according to our present knowledge, answer in the negative. We have no evidence whatever as to the rate of growth of the sponge of commerce at Lesina, under natural conditions. So far as I am aware, there is no observation in the literature of the subject which throws any light whatever on the probable age of sponges of given size, their probable future rate of increase, or the dimensions at which increase stops.*

When, therefore, Buccich records that his cuttings grew to two or three times their size in the first year, we have no reason for supposing that an equal increase would not have taken place had they remained intact in the surface of the parent sponge. *A priori*, I should suppose that a greater increase would have taken place. For the life of a sponge depends on a most interesting system of hydraulic canals, on the mechanical perfection of which depends the quantity of its food. Each cutting contains only the fragment of such a system, broken into, with direction of currents confused or inverted, and pressure-chambers

* A discussion of the question of growth will be found in the Appendix.

opened. Until growth has repaired these injuries, the cut fragment must necessarily be at a disadvantage, as compared with a complete sponge of its own size,* and I am of opinion that the complete small individual is at a disadvantage as compared with the equal portion of a large and powerful sponge.

We have no knowledge of any causes to check the growth of a sponge, though it may be assumed (without positive proof) that they are subject to senile decay. But we have no knowledge that the tissues of a senile sponge undergo rejuvenescence when they are divided into fragments; and the observations of Buccich—that certain cuttings never grew at all, and that the growth was unequal—indicate slightly the more probable hypothesis that the fragment of an effete sponge is itself effete.

It is urged that misshapen sponges may thus be utilized. But it must be pointed out that misshapen sponges can still breed, and that there is no evidence how far the reproductive function is interfered with by the cutting process; I should myself expect such interference to be important. Buccich found 90 per cent. of his cuttings attain "marketable size" in seven years. Whether this is advantageous depends on the length of time taken by a self-sown sponge to attain "marketable size." If this be seven years also, then the method is profitable for misformed sponges; if it be only one year, then the quantity produced by natural reproduction would be greater than by the method of cuttings.

I know of no observations which favour the former hypothesis; and some siliceous sponges have been observed to grow to an equal size in a single season.

In view of the commercial importance of this question, it appears highly desirable that observations should be made as to the rate of growth of self-sown sponges. Until such are made, I cannot see that we have any reason to suppose that propagation by cuttings is in itself likely to increase the value of a sponge field.

(2) The above conclusion coincides nearly with that of Dr. von Marenzeller, in 1878. But the second question appears to have escaped his notice.

Briefly, I consider that the method of Buccich may possibly be made useful as a means of inducing sponges to grow on a more extended surface than the sea-bottom, and under more advantageous conditions.

It has been recognised among certain littoral sponges that gigantic specimens are generally found hanging from the under surface of

* In the Florida experiments it is recorded that this was the case.

a rock, or floating body.* This has been observed for calcareous sponges on the floating frameworks set for oyster-spat in Holland (9), on the bottoms of ships in Naples harbour (9), on the under surface of a buoy at the Isle of Man (13), and may be verified to some extent even on the shore-rocks near the Plymouth Laboratory.

I am aware of no direct observations on this point with regard to any greater depth. But the same advantage, probably, there also attends an elevated position. Thus, Hyatt (5) says that "The sponges near Nassau lie . . . . always in currents, sometimes running three or four miles an hour. . . . . Both of these conditions are essential to sponge growth, namely, a continuous renewal of aërated water, and a plentiful supply of food." And Rathbun (11) says of cuttings in Florida: "One was placed in a cave or bight, where there was little or no current, and its increase in size was very slight. The other specimens were placed in tide-ways, and have grown from four to six times their former bulk."

Now, where a current of water is flowing over a solid surface, a very slight increase in height from the surface means great increase in velocity of current. Buccich's method placed the cuttings from four to twelve inches above the sea bottom, and with their centres four inches apart, disposed on four parallel gratings separated from each other by the same distance. He appears to have dealt only with the small, fine, toilet sponge (7); but even so, I think the system capable of improvement. I consider great advantage might be obtained by inducing sponges to grow on hurdles rising some feet above the sea-bottom, and allowing a distance between the centres of four inches for cuttings, and twelve inches or more for grown sponges, with a distance between every two hurdles equal to their own height. I should experiment by ballasting and sinking a hurdle such as is used for a deer fence, preferably of enamelled iron; with *(a)* canes tied across it parallel to the bars, and *(b)* vertical tiles, hung in pairs on the bars. To these cuttings, or small sponges, might be attached; and I should try making the attachment with a needle and thread, using the method of Buccich as a control experiment. The cuttings on the canes would grow round them to form perforated spheres. These Marenzeller states to be of less value in the market, owing to the perforation, but I should imagine they would soon acquire a value of their own, as they would have no torn surface. These, also, as being exposed on all sides, would probably grow most rapidly. The cuttings on the tiles should become of the ordinary hemispherical type. It might be found that young sponges

* Cf., especially VOSMAER (9), where he points out the advantages to the sponge of a position where water flows freely round it. This was to some extent recognised, long ago by Grant *fide* Johnston (1).

would sow themselves naturally on the tiles, rendering cuttings unnecessary.

It would be better if the hurdles were sunk rather in deeper water than that from which the sponges are taken, lest the cuttings should suffer from excess of light. I should cut the sponges in a wooden trough, holding enough water to cover the sponge. The advantages expected by the method would be :—

(1) Increase of the bearing area of the field.
(2) Removal of the sponges without injury, and with careful selection.
(3) Increase in the rate of growth, and in the maximum size.
(4) Improvement in shape of the sponges.

There is also a proposition given by Dr. von Marenzeller which deserves attention. Larger sponges are naturally of greater value, in proportion to their weight, than smaller sponges; and he points out that if two or three be attached closely together (misshapen specimens could be thus utilized) they will grow into one sponge.

In this case, also, I should suggest the use of the needle and thread to effect the attachment; and, from the biological point of view, there is little doubt of effectual union. But the possible existence of biological disadvantage, in total ultimate weight, cannot be estimated until we have some knowledge of the laws of growth in sponges; and the commercial advantage depends not only on this, but on market details, as to which I cannot find information. Probably the increase in value with size of Nassau sponges is far less than with those of the Adriatic.

It must be understood that these recommendations are based principally on general reasoning from what is known of the conditions of life in sponges. The direct experimental evidence bearing on the questions involved is slight, imperfect, and uncertain; the work done by Professor O. Schmidt (6) was brilliant; but it has remained incomplete, as he left it, for twenty-three years.

To avoid needless waste of capital, it is desirable to make a series of exact observations on the sponge of commerce with regard to the following points :—

(1) Rate of growth, and length of life, of sponges growing naturally on the sea-bottom.
(2) Do. do. of sponges attached with their natural bases to artificial trestles or hurdles.
(3) Do. do. of sponges raised from cuttings in either position.
(4) The size at which, in self-sown sponges and in cuttings, breeding commences.

It must be remarked that it is difficult to see how any process of culture can be possible, unless private property in areas of sponge-fishery can be recognised and protected. [*Cf.* (1) (6)].

I see that Mr. Allen properly suggests the possibility that the deeper waters of the Bahamas may with advantage be exploited. If this be done, as in the Mediterranean, by divers without diving dresses, I would suggest encouraging them to try the use of water-spectacles. I am not aware that these have been ever used either for pearl-fishing or sponge-fishing; but, while every student knows that the imperfection of the submerged human eye can be corrected by convex lenses, there is a wide gulf of ignorance separating the student from the pearl-diver of the Indian Ocean. Probably any wholesale optician would supply spectacles of the required formula at the price of a few pence. The experiment might be worth instituting at Ceylon.

B. *Transport of Sponges from the Mediterranean to the Bahamas.*

If it were desired to transport European sponges alive to the Bahamas, I believe that this could be done. The sponge of commerce lives well in the Naples Aquarium, and I see no reason why it should not live in a suitably constructed tank on board a ship. In this way a number of individuals might be transported, and deposited in a space cleared from other sponges at a spot where the fishery is good, there to breed as they successively ripened. If it were practical from the nautical point of view, I should suggest the use of a closed wooden tank, with perforated sides, flat bottom, and pointed ends, to be towed behind the ship; just floating enough to keep a flagstaff out of water in case of accident. The sponges should be gathered with the pieces of rock to which they adhere, and these stones fixed firmly in the bottom of the tank. Before employing this method, it might be prudent to make aquarium experiments as to how far the high surface temperature of the seas traversed may prove deleterious to the sponges. Were such temperatures proved to be fatal, it would be necessary to use an aquarium inside the ship, artificially cooled.*

* Since the text was in type, I have been able to consult Lamiral's original account (3) of his unsuccessful attempt, in 1862, to acclimatise Syrian sponges on the French coast. He placed 150 sponges in six cubical boxes of 2 ft. 7 in. each way, six similar boxes being used for reservoirs to maintain a circulation (cooled with such ice as he could obtain), and the whole carried on the deck of a crowded packet-boat. This apparatus was quite inadequate; and his description leaves little room for doubt that the tanks were lined with bacterium slime from the very beginning of the voyage, and that the sponges hopefully planted on the French shore were in various stages of putrescence.

He records the bottom temperature at Tripoli in May as 19° C. in ten fathoms of water; his reservoirs on the journey rose to 23° C. and 25° C. An interesting account of the Syrian divers is given; besides useful details as to qualities of sponges, &c.

* "On ignore quelle est au juste la durée de la vie des Eponges et la vitesse de leur accroissement; cependant, dès la troisième année, on peut revenir pêcher dans les lieux où elles avaient été précédement presque épuisées."—LAMIRAL, *loc. cit.* vol. viii. p. 329.

† Probably based on Schmidt's own statement: "Man sucht in der schon beschriebenen Weise dieselben Standorte Jahr für Jahr ab. . . . nicht nur die ausgewachsenen, sondern auch die kleineren Exemplare genommen werden." (Supplement der Spongien der Adriatischen Meeres, 1864, p. 25.) At the time of writing the text I could not refer to Schmidt's original papers; there is nothing to be added from them to the later account of his experiments given by Marenzeller.

But if the transport were successful, and the sponges bred, it is very doubtful if any advantage would be gained. It must be regarded purely as an experiment in the dark; and I can see no means of forecasting its result, or testing it in any way, but by its completion. If the difference between the sponges is a true racial difference, then the race from the Mediterranean might possibly prove stronger than the race of the Bahamas, and supplant it, though the fact that the climates are different is against considering this as probable. There is, however, grave doubt whether the difference be due to deep-seated heredity. The sponges of America are considered no more than varieties of the Mediterranean species; and Professor Hyatt is of opinion (5) that the difference in quality between American and European sponges is due to the higher temperature of the American water, and to the coral sand. My own experience in calcareous sponges points to most remarkable plasticity in response to changes of environment, and it must be considered possible that, even if the imported sponges bred, their offspring would be indistinguishable from those always existing in the locality.

C. *Close time for Sponges.*

It is so common and so natural a tendency to consider the well-being of any fishery capable of improvement by the imposition of a close season, that it may be worth while recording simply that, according to F. E. Schulze (7), the toilet-sponge at Lesina breeds quite indifferently all through the year.

Professor Schulze is the leader of all modern work on sponges, and his observations were made on a plentiful series of sponges supplied by Signor Buccich.

APPENDIX.

Rate of Growth in Sponges.—According to T. Lee (12), the fishermen of Nassau say that the young sponge reaches marketable size three months after its attachment. Lamiral (3), in his scheme for acclimatisation on the French coast, stated that exhausted fisheries are regenerated in three years.* O. Schmidt (6) "inclined to the opinion" that the growth of a self-sown sponge was no faster than that of one of his cuttings, which were found to take seven years to reach marketable size;—it is noticeable that before the experiment he had expected quicker growth (*l.c.* p. 776). The Florida fishermen—*v.* Rathbun (11)—contend that "the Florida sponges grow much more rapidly, and reach a fair size within a comparatively short period." The Florida cuttings increased "to from four to six times their bulk" in six months, but this growth was actually effected in two months, as "fully four months elapsed before they recovered from the injury done them in the cutting."

If this last be accurate, then a cutting of $2\frac{1}{2}$ cubic inches, growing to five times its bulk in two months, attained a volume equal to a hemisphere over $3\frac{1}{2}$ inches in diameter. Were it to proceed for the next two months at the same rate, we should have a hemisphere over 6 inches in diameter, which is more than marketable. Had the original $2\frac{1}{2}$ cubic inches been produced at the same geometric rate, then a hemisphere of $1\frac{1}{4}$ inches in diameter would have produced the six-inch sponge in six months.

We have no right to assume this constant geometric ratio, nor to reason elaborately from inexact statements about amputated fragments; but putting these observations with the assertions of the Nassau and Florida fishermen, there seems a balance of evidence against assuming in these localities a period much greater than a year before the self-sown sponge becomes marketable. The Levant variety, discussed by M. Lamiral, lives where the atlas shows a mean annual temperature of about 7° F. below that of Florida, and the Adriatic variety, investigated by Professor Schmidt, at a mean temperature of about 7° F. lower still; we have no right to assume that the rates of growth are identical. But since in the Adriatic the same grounds are said (8) to be fished mercilessly, mature and immature, year after year,† there seems to be great presumption against Schmidt's estimate; and this estimate was calculated from Buccich's cuttings, which I believe to have been unnecessarily

* "On ignore quelle est au juste la durée de la vie des Eponges et la vitesse de leur accroissement; cependant, dès la troisième année, on peut revenir pêcher dans les lieux où elles avaient été précédement presque épuisées."—LAMIRAL, *loc. cit.* vol. viii. p. 329.

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injured by exposure to air, by the trepanned perforation, and by too close planting so as to choke each other.

The much-needed observations on the natural growth of commercial sponges could probably be best made by observing the seedlings on a small marked area, artificially cleared. Single sponges fixed on stones could also have labels attached with silver wire, and be examined periodically.

That the rapid period of growth suggested by the fishermen is not impossible, is shown by a few observations which have been made on calcareous and siliceous sponges. Vosmaer (**9**) calculated the giant *Sycon* on the oyster-frames to grow 1 to $2\frac{1}{2}$ inches in length in a fortnight, and (**10**) found the bud of a *Tethya* in a month as large as its mother, $\frac{4}{5}$ inch in diameter. Bowerbank (**4**) quotes H. Lee, that in the Brighton Aquarium *Hymeniacidon* formed in five months a crust 1 foot in diameter. Of this sponge and of *Halichondria* numerous large crusts may be observed in spring on the rocks near Plymouth Laboratory; they appear rarely to survive the summer, and Johnston (**1**) states that many allied species are annual. Carter (**2**) found *Spongilla*, at Bombay, grow over a surface two or three feet in circumference in nine months; and states that specimens growing on straw in the water reached a thickness of half-an-inch in a few days, before the straw in the water had changed colour.

The growth of horny sponges may easily be much slower than in these instances, but as yet I know of no reason to assume so.

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It will be seen from this list how greatly I have been aided in compiling these notes by the most valuable publications of the United States Commission of Fish and Fisheries.

Recent Reports of Fishery Authorities.

The Scottish, Newfoundland, and United States Reports.

By

J. T. Cunningham, M.A.

(1) Thirteenth Annual Report of the Fishery Board for Scotland, being for the year 1894. Edinburgh, 1895.

(2) Annual Report of the Newfoundland Department of Fisheries for the year 1894. St. Johns, N.F., 1895.

(3) Report of the United States Commissioner of Fish and Fisheries for the year ending June 30th, 1893. Washington, 1895.

ARTIFICIAL HATCHING OF FISH EGGS.—The Scottish Report, whose title is given above, is stated to refer to the year 1894; but as a matter of fact, a great deal of the work recorded in it was carried out during the earlier portion of 1895. This is the case with the operations of the Dunbar Hatchery, described by Mr. Harald Dannevig, the Manager of that establishment. We find that 44,085,000 eggs of plaice were collected last spring, and from these 38,615,000 fry were obtained, and liberated in the sea. This shows a loss of only 12 per cent. in the process of hatching. But large as the numbers appear, it should not be forgotten that the above number of eggs represents the produce of only 220 female fish, reckoning 200,000 eggs to each, which is a low estimate, for it has been proved by Dr. Fulton that the larger female plaice produce each from 300,000 to 500,000 eggs in one season.

It is, I think, interesting to consider, from various points of view, the proportion borne by the artificial hatching operations to the natural propagation of the fish in the sea. We have not at present ascertained approximately the number of females which spawn in the sea in one season, but we have some data concerning the number of mature females taken out of the North Sea, in one year, by the fishermen. According to Mr. Holt's statistics, which were very carefully collected, the number of mature plaice, over 17 in. in length, landed at Grimsby

alone in one year is more than 7,000,000; and as there are three females to two males, we may reckon that over 4,000,000 of these are females. We take, then, 4,000,000 of mature female plaice from the North Sea at Grimsby alone, not to speak of the numerous other trawling ports on the east coast of Britain, and in return we hatch the eggs of 220. The proportion here is one spawner in the hatchery for every 19,090 spawners killed at Grimsby. But next we have to take into consideration the superiority of the artificial process. We do not know what is the mortality of the eggs and fry in the period between fertilisation and the absorption of the yolk, under natural conditions. As we have seen, in the hatchery the mortality is only 12 per cent. Let us assume, for the purposes of calculation, that the loss is only 10 per cent. in the hatchery, and is 90 per cent. in the sea. Then we obtain nine times as many fry in the hatchery as in the sea from the same number of fish. It comes to the same thing if we say that one female spawner in the hatchery is equal to nine spawners shedding their eggs, without assistance, in the sea. We may say, therefore, that the work of the hatchery is equivalent to saving 9 females out of every 19,090 landed at Grimsby, or one out of every 2,121, or, in round numbers, one out of every 2,000. The disproportion would be very much greater if we took the total number of female plaice landed on the east coast of Britain. It seems to me beyond question, that if we regard the whole North Sea plaice fishery in this way, not taking the numbers caught by foreign fishermen into account, the results produced by the operations at Dunbar will be quite imperceptible. To diminish the destruction of mature fish even by one in every 2,000 in each year, could not make any appreciable difference in the general abundance of plaice in the North Sea.

It must not be supposed that I have any prejudice against artificial hatching, or that I am unable to appreciate the skill and efficiency with which the Dunbar establishment has been organised and operated. On the contrary, I think that Dr. Fulton and Mr. Harald Dannevig deserve great credit for the energy and ability they have exhibited in the working of the first British hatchery for sea-fish, and for the success they have obtained. No harm, but only good, can result from an honest and strictly accurate calculation of the possible results. The evidence available from other enterprises of the same kind tends to show that quite obvious local results have been produced by the liberation of large numbers of fish-larvæ in the sea, and although, as the above calculations show, we cannot expect to perceive any increase in the general plaice production in the North Sea, in consequence of the work at Dunbar, it may be quite possible to recognise on particular local grounds an increased abundance of marketable plaice, derived,

with reasonable probability, from the fry liberated from the hatchery. We cannot, however, admit the correctness of certain calculations contained in the official general statement of this Report. These are, that if one in a hundred of the fry distributed from the hatchery survived, and were worth sixpence each, the resulting value to the fisheries would be about £18,000, and that it would require the survival of only one in a thousand, in value one penny each, to cover the expenses of the work. Fish in the sea have clearly no value, and we cannot hope to catch all of them. It is difficult to say whether a quarter, a half, three-quarters, or what proportion would be caught; but even when they were caught and sold, their value could not be all applied to defray the cost of hatching, because the greater part of it, as usual, would go to defray the cost of catching and marketing. Such calculations would only be applicable to fish that were reared entirely in confinement, like chickens or pigs.

The importance of the working of a marine hatchery at the present time, and on the comparatively small scale of that at Dunbar, may be reasonably held to be, not in the immediate utilitarian result to be derived from it, but in its value as a sufficiently extensive experiment in the open. We have reached a certain point in laboratory research and experimentation. We have discovered enough concerning the life-histories of food fishes, and their place in nature, to obtain glimpses of the possibility of a more scientific and more profitable exploitation of the products of the sea than that which is now practised. To convert these glimpses into comprehensive perception, we require more investigation and experimentation under the open sky, and on a scale commensurate with the extent of the regions to be exploited. Thus the managers of a hatchery ought not be content with proclaiming the millions of fry they have liberated, but should ascertain what ratio these numbers bear to the number of fry naturally present in the region where they are placed, and should make every endeavour to trace their future history. In this Report Dr. Fulton gives the result of some very valuable experiments he has made, as to the effect of the currents on the east coast of Scotland, on bottles floating level with the surface. These results show that buoyant objects at the surface are carried southward and eastward to the neighbouring shore. One or two of these bottles were found ultimately on the German coast, near Heligoland. The fry from the hatchery were liberated at the mouth of the Firth of Forth, and in St. Andrew's Bay, and according to the direction of the drift, ascertained by the experiments just mentioned, the survivors should be found chiefly on the southern shores of the Firth, and further south-east towards Berwick. It will probably turn out, therefore, that the

influence of a hatchery is confined for the most part to a comparatively limited neighbourhood, and it ought to be possible, if the necessary data are accurately observed, to ascertain the magnitude of its influence within these limits. Comparisons should be made between the natural propagation of the fish, and the artificial propagation within the limits thus set by natural conditions. Hitherto they have not been made, and the necessary observations have not been carried out. The results would doubtless be more favourable than those of the comparison above made between the operations of one hatchery and the Grimsby fishery.

In the Newfoundland Report for 1894 it is stated that the number of cod eggs treated at the hatchery, on Dildo Island, Trinity Bay, in that year, was 346 millions, from which 221½ million fry were obtained and liberated. This is a survival of 64 per cent., or a loss of 36 per cent. The number of cod fry liberated was, therefore, nearly six times as great as that of the plaice-fry produced at Dunbar. But it must be remembered that the cod normally produces a much larger number of eggs than the plaice. According to Dr. Fulton's calculations, the number in the cod varies roughly between three and six millions. If we take four millions as a moderate average, the above number of eggs is the produce of only eighty-six female cod, so that from this point of view the work of the Dunbar Hatchery on the plaice was really of greater magnitude than that of the Newfoundland Hatchery on the cod. The efficiency of the treatment was considerably greater at Dunbar, that is to say, the loss or mortality during the treatment was much less in the Scottish establishment. But at Dildo Island the number of eggs collected was so large that there was not room for all of them in the hatching apparatus, and the excess was utilised by being placed in linen bags, suspended in wells, in the wharves outside the hatchery. This may to some extent account for the greater percentage of loss.

As evidence of the successful results of the hatching operations in Newfoundland, it is stated that in the beginning of the summer of 1894 there was a great abundance of cod of various sizes and ages in Trinity Bay, and none in the neighbouring Bonavista and Conception Bays, where the season's fishery turned out very poorly. The liberation of fry has been carried out annually since 1890 in Trinity Bay only, and it is maintained that the cod found in large numbers in that bay in 1894 were derived from the fry deposited. It is stated that the cod one year old were most abundant, next to these in numbers were cod of two years, and then the three-year-old fish, with a fair proportion of still older and larger fish. This is in accordance with the continual increase in the number of fry liberated each season since 1890.

In the Newfoundland Report for 1892 it is pointed out by Mr.

Nielsen, who conducts the hatching operations, that the idea that if the fish were not artificially treated they would propagate in the natural way, is a mistake. All the spawners are caught in the neighbourhood of the hatchery, and if there was no artificial hatching just as many fish would be taken, and no living fry would be returned to the sea from them. We here come upon the same question which was indicated above, in reference to the Dunbar Hatchery, namely, what proportion exists between the number of spawners artificially treated, and that of those which spawn naturally in the same district. Evidently Mr. Nielsen's view is that the capture of adult fish is so great that very few are left to shed their spawn, or, at any rate, such a small number that the number of the fry derived from them is small in proportion to the number of fry liberated from the hatchery. We cannot deny that the evidence given of the great increase in the number of adult cod, following directly upon the liberation of millions of fry from the hatchery, gives strong support to Mr. Nielsen's contention. But in this, as in other cases, we ought to be supplied with other important evidence, perhaps the most important being a direct determination of the number of cod eggs actually present in Trinity Bay, during the spawning season of the cod, in order that we may compare this with the number of eggs treated artificially in the hatchery. In Newfoundland, as in Norway, it has been observed that an increase in the supply of cod has followed upon artificial hatching. But in regard to all such evidence the vastness of the numbers put forward, and the absence of accurately observed data for comparison, tempt one strongly to adapt a well-known phrase and say, "c'est magnifique, mais ce n'est pas la science." The operation which is stated to produce such successful results, is that of placing so many million living fry in the sea at the stage at which the yolk has just been all exhausted. Surely it is not impossible, or even difficult, to ascertain how many such fry were in the sea already, without the operation. Until this or similar facts have been ascertained, it cannot be said that the process of artificial propagation has been put on a practical basis.

However, notwithstanding this criticism, it must be admitted that local benefit from artificial propagation appears to have been produced. This leads to some further interesting considerations. It is well-known that the Scottish Fishery Board have closed certain inshore areas to beam-trawling. In these areas there appears to be no kind of fishing carried on which involves the destruction of young plaice or the young of other flat fishes on a large scale. The abundance of the flat fishes in these closed areas has been examined annually since 1886, with great statistical accuracy, by means of experimental trawlings carried out by the Board's steamer *Garland*. Notwithstanding the protection,

the number of plaice and other flat fishes has not increased: it has fluctuated from year to year, but never maintained a steady increase. The number per haul of the trawl has also not increased in the open area. * It seems reasonable to infer that the reduction of the number of spawners on the open grounds, by the great extension of the trawling industry, is so great that protection of the young fish is not sufficient to compensate for it. With food-fishes, as with oysters, we are apt to attach so much importance to the number of ova produced by each female, that we overlook the importance of the number of females. It is of course true that if we could save a larger proportion of the progeny of a few parents, we should obtain a large number of fish or oysters. But, on the other hand, it may be, and experience indicates that it would be, more practicable to obtain our object by preserving a larger number of parents. In the case of oysters more success has been secured, as Mr. Bashford Dean has pointed out, by maintaining a very large reserve of parents, than by trying to preserve a larger proportion of the progeny. One method of doing this with sea-fishes would be to create reserved and protected spawning grounds. But there are objections to this method: there is the difficulty of protection, and also the fact that the fish will wander away, and be caught on other grounds. Now it is possible to regard the hatchery, as at present worked, as simply a reserve of spawners. No matter how many spawners may be taken from the sea, those in the hatchery are safe, and will supply their annual quantum of eggs or fry. But to carry out this principle effectively it would be necessary to keep in confinement, not hundreds but thousands or millions of spawners. We should have to maintain a number bearing some significant proportion to the number which now survive to spawn in the sea. It is conceivable that if spawning fish were maintained in confinement all along the coast in sufficient numbers, we might depend for our fish supply almost entirely on the eggs and fry derived from those. It may be that this will be the ultimate solution of the problem of replenishing our exhausted fishing grounds. In the meantime, although it seems wonderful to read of hundreds of millions of fry placed in the sea, as a matter of fact we are dealing, as I have shown, with only a few hundred spawners, while thousands upon thousands are being annually captured.

* The following are the average numbers of fish taken per shot of the trawl, in two periods of four years:—

	Closed Area.		Open Area.	
	Flat fish.	Round fish.	Flat fish.	Round fish.
1886–89 . .	178·5 ...	77·8	91·2 ...	86·4
1891–94 . .	120·9 ...	89·9	77·6 ...	102·5

In the American Commissioner's Report (p. 72), we find a section devoted to the description of "Some Results of Acclimatisation." The most important of these results is the successful introduction of the Atlantic shad (*Clupea sapidissima*) to the waters of the Pacific coast of North America. The supply of shad on that coast, we are told, continues to increase, and is now so great that the retail price of the fish there is actually less than on the Atlantic coast. The shad has within a few years not merely been successfully introduced, but has permanently established itself, and become one of the cheapest fish of the region. It must be noticed, however, that this is not, properly speaking, a success to be placed to the credit of the system of artificial propagation. It is true that the introduction was effected by the transportation of artificially hatched fry from hatcheries on the Atlantic seaboard, and their liberation in Pacific waters. But the abundance of the fish in the Pacific States is due to its own natural multiplication in its new habitat, not to its continued artificial propagation there, and the same success might possibly have been obtained if a sufficient number of adult fish had been placed alive, and in healthy condition, in the rivers of the Pacific slope. The transportation of the minute fry may have been easier than that of the adult fish; perhaps, indeed, the latter operation would not have been possible at all. But even if this were so, the artificial hatching of the fry, in the first instance, was only a detail in the process of transportation and introduction, and artificial propagation has not been carried on subsequently in the new habitat, and therefore has had nothing to do with the subsequent increase in the supply, any more than artificial breeding has had to do with the troublesome multiplication of European rabbits in Australia.

The introduction of shad fry to the rivers of the Pacific States was first attempted in 1871, 24 years ago, when 12,000 of them were liberated in the Sacramento River. From that year until 1886, 609,000 fry were liberated in the Sacramento, 600,000 in the Williamette River, 300,000 in the Columbia River, and 10,000 in Snake River. Nothing is said of any planting of fry after the year 1886. The catch of the fish in 1892 was estimated at 700,000 lbs., having a value to the fishermen of £4000. But, probably in consequence of thinness of the population, the demand for shad in the west seems very slight, the price in 1892 being 4 cents. or 2d. a lb., and the fish being only incidentally taken in nets operated for salmon, or other fish. This fact has, doubtless, an important bearing on the increase in the abundance of the shad. The remarks I have made show how completely illogical, in my opinion, is the argument contained in the following sentence, quoted from the Report under review: "If these far-reaching and no doubt permanent results attend the planting on few

occasions of small numbers of fry, in waters to which the fish are not indigenous, is it not permissible to assume that much more striking consequences must follow the planting of enormous quantities of fry year after year, in native waters?"

The history of the introduction of the striped bass (*Roccus lineatus*) to the same region adds strong support to my argument, for this introduction was altogether independent of artificial propagation. In 1879 about 150 specimens, a few inches long, taken in Shrewsbury River, New Jersey, were carried across the Continent and liberated at the mouth of Sacramento River; in 1882, another lot of 300 fish was transported to the same region. As a result of these two small deposits the species became distributed along the entire coast of California, and the catch in 1892 was about 43,000 lbs., for which the fishermen received somewhat more than £1,000.

The operations of the U.S. Commission for the year, in the propagation and distribution of fish, are recorded in the Report in great detail, but only a few points need be mentioned here. The discussion of results is not attempted in this section of the Report. The propagation of marine fishes is still conducted on a rather small scale. At Gloucester Station, Mass., 49 million cod eggs were obtained, and 20 million fry produced and liberated. At Woods Hole cold killed the spawners, and only 2,883,000 cod eggs were obtained, from which 850,500 fry were produced. Lobster eggs were also hatched; and mackerel, sea-bass, and flat fish on a very limited scale. Of shad 31 million fry were hatched at Battery Island Station on the Chesapeake, about 7 million on the Delaware, 5½ million at the Central Station, a total of 43½ millions. Thus, the number of fry obtained was only a little greater than that of the plaice hatched at Dunbar, and little more than one-fifth of the number of cod-fry hatched in Newfoundland. But, on the other hand, the number of eggs per female shad is given as 45,000, and the number of eggs obtained was 74,150,000, so that 1,647 females were stripped, and from this point of view the propagation of shad in the United States, is on a larger scale than that of plaice or cod in Scotland or Newfoundland.

Investigations.—As usual, a considerable amount of research is described in the Scotch Report. Dr. Fulton has added another series of experiments to those which have been carried out on the *Garland*, by his instructions. In this case he has had an equal number of hooks of different sizes fitted on one long line, and the line has been shot, in order to see whether the larger hooks caught fewer small and immature fish. The fish caught in largest numbers were of course haddock, and although the proportion of mature to immature fish was

greater with the larger hooks, still this advantage was not sufficient to compensate for the great general reduction in the number of fish caught. Small hooks catch a large proportion of large fish, and large hooks a considerable proportion of small.

Of Prof. McIntosh's additional contributions to the knowledge of eggs and larvæ, perhaps the most interesting is that concerning the turbot. The material in this case was derived from the mature living turbot, collected at the Dunbar Hatchery. In the summer of 1894, these turbot, although gravid, did not spawn. On the 7th September a specimen was examined, and in the centre of the enlarged ovary was a large space filled with mucus and the remains of ripe, but dead, ova. The fish were evidently, it is stated, getting rid of the eggs of the season which had been retained in the ovary, and died there. This is exactly what I described years ago, in this Journal, concerning the sole in the Plymouth tanks. Prof. McIntosh thinks that the egg-bound condition, *i.e.* the refusal to shed the spawn in a normal manner, is voluntary, and that it would soon disappear when the fish grew accustomed to confinement. It is quite probable that the turbot would shed its spawn in confinement after a time, but in the Plymouth Aquarium the soles did not spawn till after five or six years, and the turbot has not spawned there yet. At Dunbar, the soles and turbot collected in 1894 were unfortunately lost from overcrowding, in consequence of the limited capacity of the ponds; and in 1895 the fertilised eggs from other turbot which were obtained, were artificially stripped from the fish.

Mr. Arthur T. Masterman has two papers in the Scottish Report, one on the rate of growth of plaice, and one on hermaphroditism in the cod. The former paper consists largely of comments on Petersen's work and my own; those on the former being complimentary, those on the latter very much the reverse. As he bases his comments largely on theoretical assumptions, I do not think it necessary specially to defend my own work. Mr. Masterman's own contribution to the evidence concerning the growth of plaice consists in the application of Petersen's method of graphic curves to the measurements of plaice taken on the east coast of Scotland by the *Garland*. The curves obtained, especially those of plaice taken in St. Andrew's Bay in 1891, do give successive maxima in the number of individuals at certain sizes, but that these maxima correspond to the broods of successive years seems to me more than doubtful. Thus, according to Masterman, the mid-size of the year old fish in July is 6 in., of the two year old 8½ in., while in November the mid-size of the year old fish is 9½ in., and even in October is 9 in. That is to say, the majority of the year old fish grow 3 in. in length in the three months, July to October, but only

2½ in. in twelve months. Another objection is that, according to Masterman, the plaice of 13 in. mid-size are in July in their fourth year; although it is known that plaice on the east coast of Scotland are at that size, with few exceptions, immature, while three-year-old plaice are nearly all mature. It is true that Masterman only urges that by the method, with a proper series of observations, valuable results *might* be obtained; and if we could explain away the cusp of the curve for July at 6 in., the two cusps at 8½ and 13 in. would represent the plaice in their second and third years, a result which would agree with my own conclusions. In his second paper Mr. Masterman describes two hermaphrodite specimens of the cod, and discusses their condition in relation to hermaphroditism in general. In the course of his remarks he refers to "Nansen's observation of the protandric hermaphrodite condition of *Myxine*," apparently in ignorance of the fact that Nansen's description of that condition was a confirmation of my previous discovery. This is the second time that my discovery of the hermaphroditism of *Myxine* has been attributed in a Report of the Scottish Fishery Board to Nansen. On the former occasion the error was corrected, not by myself, in the columns of *Nature*. If Mr. Masterman had consulted my paper he would have found that the habits of the hag-fish were more definitely known than he seems to suppose.

It should be mentioned that the Report of the United States Commissioner, whose title is given at the head of this article, is merely the report proper, without the appendices, which were issued previously, and which contain detailed accounts of many of the investigations mentioned in the general report. This general report consists of four parts—the Commissioner's own statement, and three divisional reports, one on the division of investigations by Richard Rathbun, one on the division of statistics and methods, and the third on artificial propagation and distribution. Reference to interesting points in the last two divisions has been made, and it remains to mention the character of the investigations carried on by the Commission in the year 1892–93. In 1892 the *Albatross* was employed by the United States Government in investigations of the seal and seal fisheries of the Behring Sea. From August, 1892, till April, 1893, she was under repair at San Francisco, after which, by direction of the President, she joined the fleet which was employed in patrolling the North Pacific and Behring Sea. The naturalists belonging to the ship remained with her, except when she was under repair, and carried on observations concerning the seals, and the fishes of the places visited, as opportunities occurred.

On December 6th, 1892, an agreement was concluded between the

Governments of Great Britain and the United States, which provided for the appointment of a joint commission of two experts, one on behalf of each Government, to report upon the fisheries in the territorial and contiguous waters of the United States and Canada. The reports were to be presented within two years, and the object in view was the recommendation of practical and administrative measures to be adopted by both authorities. The two Commissioners appointed were Mr. Richard Rathbun and Dr. William Wakeham, and their investigations during the time covered by this report were confined to the mackerel fishery.

Various other investigations, such as the survey of oyster beds in Chesapeake Bay and Galveston Bay, the study of the lobster by Professor Herrick, at Wood's Hole, the discovery that the tile-fish had returned to the Continental slope, south of New England, with the return of warm water to that region in consequence of a change in the interaction of the currents, are mentioned, but the full description of them is to be found in special papers.

The Fourth Report of the Danish Biological Station.

By

F. B. Stead, B.A.

THE PLAICE IN DANISH WATERS. — The Fourth Report of the Danish Biological Station consists of a lengthy paper by Dr. C. G. J. Petersen "on the Biology of our Flat-fishes and on the Decrease of our Flat-fish Fisheries," which was awarded a prize by *Det Kongelige danske Videnskabernes Selskab*, and which certainly deserves the careful attention of all who are interested in fishery questions. The first chapter gives a fairly complete account of some of the main features in the life history of the plaice in the Danish seas, together with shorter notes on other flat-fishes; the second and third are occupied by a discussion of the reasons for the deterioration of the fisheries, and of the remedial measures by which this evil may in the future be prevented. The paper is supplemented by five appendices, one of which, on the post-larval stages of flat-fishes, is of particular interest. For the full English translation with which we are provided English naturalists can but express their gratitude to the author.

The first question to which our attention is drawn in this paper is that of the variations in size, which plaice from different localities

are found to exhibit.* These differences are seen on comparing the average sizes of plaice which have just arrived at maturity, and also the average sizes of mature (grown-up) plaice (*i.e.*, three years old and over) from different localities. Thus while in the Baltic the average size of mature plaice is about 10 inches, it is 11 inches in the Lesser Belt, and 12–13 inches in the Cattegat. Whether this gradual decrease in the average size of the mature fish, as we pass from the Cattegat to the Baltic, is due to a corresponding gradual change in the conditions favourable to growth, or whether it implies a migration of the larger plaice from the Baltic towards the Cattegat, is not certain, but there are reasons for thinking that the plaice of the Baltic do not enter that sea in any numbers till they are one year old, so that to speak of a race of plaice peculiar to the Baltic would be erroneous.

Further, as we pass from the German Ocean to the Baltic, there is a gradual decrease of the size at which plaice become ripe for the first time. If to these differences others (*e.g.*, in the number of fin rays) be added, the existence of separate races is still unproved. For seeing that the eggs and fry of all the plaice are pelagic, and must in consequence all be mixed together, the appearance of one form of plaice in the Baltic and another in the Cattegat, must be due either to the fact that the eggs of one form cannot live when carried into the territory of the other, or that the differences between the two forms are wholly ontogenetic. Of these two alternatives our author is inclined to accept the second.

Perhaps the most interesting part of Petersen's paper is that in which he describes his method of determining the rate of growth of plaice. By fishing at any given time of year in a number of different places, at different depths, and with nets of various kinds, and measuring all the fish caught, Petersen found that the fish were grouped about certain maxima corresponding to the most common lengths of the fishes born in successive years. These groups he calls the "0 group," consisting of fish less than one year old, the "1 group" between one and two years old, the "2 group" between two and three years old, and the "3 group" consists of fish three years old and over.

Leaving for a moment the question of how far this method of determining the rate of growth of the fish, and the probable age of any particular individual, is a sound one, we may pass on to a brief resumé of the life history of the plaice in Danish seas as traced by Petersen. The spawning season lasts from November to April, with a maximum in January and February. The larvæ, so long as they retain their yolk sac, are 6–7 mm. long. "When the yolk sac is absorbed, and the fish have become unsymmetrical and compressed, with their left eye sitting

* Cf. CUNNINGHAM. "North Sea Investigations"—this Journal, vol. iv. nos. 1 and 2; especially no. 1, pp. 23–25, and no. 2, pp. 97–108.

nearly on the edge of the brow, but while they are still transparent pelagic fish, they are 10 to 12 mm. long." The length at which the metamorphosis is complete, appears to vary from 10 mm. to 13 mm. Petersen was unable to find the young plaice of 12 mm. before the month of May, and concludes that the larvæ hatched in November take six months to pass through their pelagic stage. The same does not hold, however, for the turbot, the brill, the flounder, and the sole, in all of which the spawning season begins later than in the case of the plaice.

Further, the young plaice of 12 mm. in length are always found close in on the shores, and never in water of two fathoms and over. From this fact Petersen draws the conclusion that of the pelagic fry in the sea only those which happen to be near the shore at the time when metamorphosis takes place can survive. It is the physical conditions then, and not the presence of enemies, which causes that enormous destruction of larvæ which undoubtedly takes place.

The young fish belonging to the "0 group," which have all reached the length of 12 mm. by the month of May, grow to a length of 2–4 inches by the following autumn. In the succeeding winter they cannot easily be found on the shores, and it is suggested that they bore down deep into the sand where the seine cannot reach them. By the end of their first year the young fish migrate into deeper water, and this migration probably begins in the winter months. An investigation made at Aalbek in July, 1893, showed that the plaice were larger the deeper the water examined. Summarising the results of this investigation it was seen that besides the "0 group," which were found in water of less than 2 fathoms, there was a "1 group" from $2\frac{1}{2}$–2 inches at 5 fathoms, and a "2 group" from $6\frac{1}{4}$–10 inches, which began to appear in water of 8 fathoms.

The different groups are not, however, found in all the seas. On the contrary, while as we have already seen, the "0 group" is entirely absent from the Baltic, the plaice in their second and third years are present in considerable numbers. The largest specimens (14 in.) found in the Baltic, probably represent the 3 group, and the size at which the 2 group meets the 3 group, is set down at 8 to 9 inches. On the other hand, fish of 3 years old and over are not found in the Northern Cattegat in any numbers "without much searching"; and it seems clear that owing to persistent over-fishing there has been in recent years a decrease in the size of the plaice caught in the Cattegat. As Petersen remarks in pathetic italics, "*they do not get time in the Cattegat*"—cut off, as it were, by ruthless fishermen before they attain their prime! The fact that the "3 group," which is almost absent from the Cattegat, and but poorly represented in the Baltic, is found in the

intervening seas, has suggested the view that an emigration of three-year-old plaice takes place from the Baltic.

Turning now to the question of the accuracy of the method employed for determining the rate of growth of fish, it seems clear that while the existence of the natural groups, each varying about a most common length, correspond to the average size of fish of that age is clearly shown; a reference to Petersen's tables leaves the impression that considerable uncertainty exists as to where one group ends and another begins, and as to the exact position of the most common length for each group. And this is practically admitted, when the remark is made that "besides distinguishing the sexes, we ought also properly . . . . to fish the same number of specimens of each annual series, in order not to efface the boundary lines between them." How can we be sure that this is done?* In cases where fish of all the different ages can be fished "in one draught" the difficulty is no longer present.

It was mentioned above that plaice less than 1 year old were not found in the Baltic. Hensen has, however, shown that the eggs of the plaice are found there; and the absence of the young fish is accounted for by the peculiar hydrographical conditions which obtain in that sea. For experiments made by Petersen, in Copenhagen, on living plaice eggs, proved that the highest specific gravity at which all the eggs sank was 1·0120 10° C., corresponding to a salinity of 1·44 per cent.; and Hensen's investigations prove that "*almost every month* there occurs such a low salinity that the eggs *must sink to the bottom.*" If, as is probable, the eggs, on sinking to the bottom, are killed, the absence of the young fish is clearly accounted for.

The same does not, however, hold for the turbot, the brill, or the flounder. The fry of these fish are sometimes met with in multitudes on the shores of the Baltic, while in the Cattegat young flounders are found in company with young plaice. With regard to the turbot and the brill the explanation given is that the pelagic fry of these fish are more hardy than those of the plaice, and so can live in water of a lower salinity.

With regard to the *food* of plaice of different ages a short summary of the main facts is given by our author. Thus, during the pelagic stages the food consists chiefly of copepods; and even when the fish have grown to $1\frac{1}{4}$ to $1\frac{3}{4}$ inches, "*Copepoda, Cladocera, Ostracoda,* and *the larvæ of bivalves*" may form their food.

At a length of 2 in. to 3 in., however, the diet has changed, and now consists of *Idothea, Gammaridæ,* smaller *Annelida,* and the *fry of bivalves.*" When the fish have grown to a length of 3 to 5 in., "they

[* Cf. for a more detailed criticism of Petersen's results CUNNINGHAM's paper in this number of the Journal pp. 136–138.]

take in the main the same sort of food as the older plaice," and after the end of their first year there is no change in the character of the food of the plaice.

We may now pass on to our author's discussion of the economic question: how may the plaice fishery be prevented from further deterioration? We may say at once that Petersen is in favour of the imposition of a size limit, but for reasons somewhat different from these commonly given in support of this proposition. He points out that the object to be kept in view is to make the fishery yield as large a profit as possible. It is necessary, therefore, to allow the fish to grow to such a size, that the largest possible weight of fish involving the highest selling price can be obtained.

Now, a plaice of 10 in. weighs less than ½ lb., and one of 14 in. more than twice as much: it follows that, unless in the time that it takes 10 in. plaice to grow to 14 in., the mortality is such as to reduce the population of these plaice to less than half its original number, the total weight of the plaice at 14 in. will be greater than at 10 in. It is not likely that the death-rate is as high as this, because the plaice does in fact grow to a much larger size than 14 in.; further, it would seem that disease is almost unknown among these fish: and their enemies are apparently few. Hence, by allowing the 10 in. plaice to grow to a larger size before capturing them a greater profit will be obtained. There will of course be a limit of size beyond which it will not be profitable to allow the fish to grow, and this limit will depend on the death-rate at each size.

Our author contrasts his view, which he calls the "growth theory," with the "propagation theory" of other writers. Those who hold this latter view insist on the necessity of increasing the *number of individuals*, and, in recommending a size limit, are happy if they can secure that the fish shall be allowed a chance of spawning. Petersen, on the other hand, thinks it of more importance to allow the fish to grow to the size at which they will yield a maximum profit, and holds that ample provision is made in nature for keeping up the numbers. As his point of view is an important one, and as it is stated with great clearness, I do not hesitate to quote him on this point *in extenso*. "It has always been hard for me to believe that there should be any want of eggs of plaice in our seas, partly because Hensen's excellent investigations have shown what immense quantities there are of them, partly because I myself see our seas filled with such eggs. Nor have I ever been able to believe in any want of young plaice. . . . Nay, everything seems to me to indicate that it is not in the *beginning*, but *in the middle and end of the life of the plaice* that we must look for the injury; for it is here that man interferes as a troublesome

factor."* And again, "If we fish the plaice while they are small, we do not get so great a profit from them as we might and ought to have. *In this only, so far as I can see, the 'destruction' consists.*" †

It is of interest to notice that the view here set forth appears also in the discussion on the desirability of a close time for crabs and lobsters.‡ And if it is assumed for any species—(1) that the provision made in nature for keeping up the numbers of individuals is more than sufficient, and (2) that owing to *natural* influences, the number of surviving *grown-up* individuals is fixed and relatively small, then it will follow that the continual destruction caused by man must of necessity lead to a decrease in the number of large individuals, and that this decrease cannot be met either by artificial propagation, or by the imposition of a *small* size limit. These two assumptions appear to me to underlie the view which our author puts forward as the "growth theory"; and the first of them implies that there is, under natural conditions, an excessive wasteful production of young fish.

Our author further points out that, in respect of the plaice, both theories will lead to a similar practical conclusion—the imposition of a size limit; though the effective size limit, from the point of view of the "growth theory," will be higher than that which is required by the "propagation theory." This, however, does not hold good in all cases. The eel-fishery, for instance, consists wholly in the capture of eels which have never spawned. "The propagation theory would be obliged to require a size limit of at least 20 inches, in order to protect the stock of eels satisfactorily; *but then the males could not be caught at all.*"§ The growth theory, on the other hand, would be content with a lower limit.

It will be seen that the questions raised by the discussion of these different theories are of great practical importance. They are among the scientific problems which call for settlement, before sure guidance can be given to the legislator.

* *Loc. cit.* pp. 61, 62. (*In all quotations the italics are Petersen's.*)

† *Loc. cit.* p. 57.

‡ *Cf.* p. 186, this number of Journal, answers of fisherman to cross-examination by Messrs. Pannett and Mally.

§ *Loc. cit.* p. 82, footnote.

Director's Report.

THE investigations into matters connected with economic fishery questions have been carried on with considerable success, during the summer and autumn months. Mr. J. T. Cunningham has visited various fishing centres on the East Coast, and has been able to supplement the observations made by Mr. Holt and himself at Grimsby, in some important respects, by thus extending the field of investigation. As will appear from the full report published by Mr. Cunningham in this number of the Journal, he has, amongst other things, shown that two distinct races of plaice occur in the North Sea. It had already been ascertained that the plaice of the English Channel formed a smaller race than those generally landed at Grimsby from the North Sea. The evidence now obtained from Lowestoft proves that the plaice brought to that port from the Dutch coast, south of the Texel, are no larger than those of the English Channel, so that the high size limit proposed to be applied to the plaice landed at Grimsby would be quite inapplicable to those landed at Lowestoft.

Mr. F. B. Stead has commenced an investigation of the fish which inhabit the bays on the South Coast of Devon, at present closed to trawlers. The results of this investigation promise to be of great interest. From the facts at present ascertained, it appears that during October and December, the only fish which are taken in these bays in sufficient numbers to be of importance, from a practical point of view, are plaice and dabs. Of these two species, the plaice only are valuable, and the large number of competing dabs must probably be regarded as a positive hindrance to their well-being. Any controversy that may be raised, therefore, as to the advisability or otherwise of keeping these bays closed to trawlers, should be solely occupied with the consideration of the question whether such closure is necessary or desirable for the protection of plaice. It has further been shown that the bays differ markedly from one another in respect of the sizes of the fish they contain, for whilst half the plaice in Start Bay were found to be over $12\frac{1}{2}$ inches in length, in Teignmouth Bay half the plaice captured were under $10\frac{1}{2}$ inches.

I have given, in another part of the present number of the Journal, a brief account of the investigation which is being carried on into the

fauna and flora of the outlying grounds between the Eddystone and Start Point. It is proposed, during the next six months, to dredge over the same grounds again, in order to confirm the results already arrived at, and to fill in the many gaps which at present exist in the rough charts that have been made.

The naturalists who have occupied tables at the Laboratory, since the publication of the list in my last Report, are :—

E. T. Browne, B.A., August 19th to September 30th *(Medusæ)*.
G. Brebner, September 5th *(Marine Algæ)*.
S. D. Scott, B.A., September 16th to October 5th *(General Zoology)*.
A. H. Church, B.A., December 17th to December 25th *(Marine Algæ)*.
E. H. Chapman, December 28th to January 20th *(General Zoology)*.
T. H. Taylor, M.A., January 6th to 10th *(Polyzoa)*.

Of the gentlemen whose names appeared in the previous list, Dr. Bethe remained until the middle of October, and Messrs. Riches and Bidder until December, so that the number of workers at the Laboratory during the later months of the year has been somewhat larger than usual.

It will be noticed that two naturalists have been engaged in the study of marine algæ. It is some time since botanists have taken advantage of the facilities afforded at the Laboratory for this kind of work, but it is hoped that for the future this want of support may not be continued. If those interested in marine botany could obtain the necessary funds for the purpose, it would be an excellent thing to have a botanist permanently stationed at Plymouth.

The following papers, which have recently been published elsewhere than in the Journal of the Association, contain the results of investigations carried on at the Laboratory :—

Barthels, P.—"Notiz über die Excretion der Holothurien," *Zool. Anzeiger*, No. 492, 1895.

Bidder, George.—"The Collar-cells of Heterocoela," *Quart. Journ. Micr. Sci.* xxxviii. p. 9.

Browne, E. T.—"On the Variation of Haliclystus octoradiatus," *Quart. Journ. Micr. Sci.* xxxviii. p. 1.

Garstang, W.—"Budding in Tunicata," *Science Progress*, iii. Mar., 1895.

Garstang, W.—"Outlines of a new Classification of the Tunicata, British Association, Ipswich, 1895.

Hickson, S. J.—"The Anatomy of Alcyonium digitatum," *Quart. Journ. Micr. Sci.* xxxvii. p. 343.

MacBride, E. W.—"The Development of Asterina gibbosa" (*in part*). *Quart. Journ. Micr. Sci.* xxxviii. p. 339.

Nutting, C. C.—"Notes on the Reproduction of Plumularian Hydroids," *Amer. Naturalist*, Nov. 1895, p. 966.

Arrangements have been made by which Mr. Garstang will conduct courses of study in Marine Biology, at the Laboratory, during the Easter Vacation. A special room will be fitted up for the accommodation of students joining this class, and it is hoped that a sufficient number will take advantage of the arrangement, to encourage the formation of such classes in the future. Mr. A. H. Church, of Jesus College, Oxford, is also prepared to conduct a similar class in marine botany.

Before closing this report, I should like to take the opportunity of drawing attention to some facts regarding the general position of the Association, and its work at the present time. As any further development of our activity depends so largely upon questions of finance, it will be well if these are considered first, and in doing this it is necessary to distinguish between the maintenance of the Plymouth Laboratory, and the work carried on there, and the expenses of the investigations into the North Sea Fisheries, which have been so successfully prosecuted on the east coast. The latter have been supported almost entirely by special donations, given from time to time by Mr. J. P. Thomasson, and by the Drapers' and Fishmongers' Companies, and although there is no immediate prospect of funds being forthcoming for their continuation, it is to be hoped that they may not be allowed to lapse for that reason.

Leaving these special investigations out of consideration, the annual income of the Association from all sources, amounts to £1,950, and the estimated expenditure for the general conduct of business, and the maintenance of the Plymouth Laboratory on its present footing, is £1,800, which leaves a balance of £150.

The want at Plymouth, which must be put before all others, is that of a suitable boat. Experience goes more and more to show that the amount of energy wasted, and the limitation put upon our investigations through this want, is exceedingly great. I do not hesitate to say that the effective work of the Association could be increased by, at least, fifty per cent., if a suitable small steamer were in our possession. Instead of confining our collecting to within five or six miles of Plymouth Sound, the whole western half of the English Channel, including the Channel Islands, would become our field of operations; whilst the fishery investigations, which we are attempting, could be done more completely, and with far less expenditure of time and serious inconvenience, and others, which are now quite beyond our power, could be undertaken by the present staff. Our income would be sufficient to maintain a boat large enough for our purpose, if only the funds were available to procure her.

When this question has once been satisfactorily settled, we may, I

believe, consider that the Association possesses a well-equipped laboratory, capable of turning out a large amount of valuable scientific and economic work, without any considerable increase of the income at present at our command. It must not be forgotten, however, that the above estimate only allows for one naturalist on the staff of the Association, who can devote any considerable proportion of his time to carrying on research. Further development must then be sought for in the direction of obtaining funds for the appointment of additional naturalists on the staff, for the resources of the Laboratory will be sufficient to keep several investigators constantly employed, without much additional expense beyond their salaries.

Efforts should also be made in all possible directions to induce public bodies to offer scholarships for biological research, which might be held at Plymouth. A number of scholarships are already given to enable the holders to prosecute technical researches in Chemistry and Physics, and if biologists take the matter up, there seems no reason why some of these should not be obtained for fishery investigations. With regard to scholarships for purely scientific work, it is remarkable that whilst the facilities offered to able men, to pursue scientific study up to the examination standard, are by no means limited, opportunities for carrying their work to a legitimate conclusion appear to be granted to but few. Year after year numbers of men turn aside directly they reach the point where their real scientific training may be said to commence. These are the men, whose services in the interests of the Association, or, which is saying the same thing, in the interests of Biology in this country, we should endeavour to retain.

E. J. ALLEN.

January, 1896.

POSTSCRIPT.

SINCE the above report was in the press an opportunity of securing a small steam fishing yacht, upon advantageous terms, has presented itself, and as the vessel appeared to be exactly suited to the work of the Association, the Council decided that it would be advisable to purchase without delay. The yacht, the *Busy Bee*, of Fowey, is now in our possession, and it is hoped that the confidence of the Council that the supporters of the Association, by subscribing the necessary funds, will recognise the wisdom of the course they have pursued, may not prove to be misplaced.

I am glad to announce that Mr. J. P. Thomasson has already been kind enough to make a donation of £100 towards the purchase money. A sum of £600 is required, and subscriptions may be sent either to the Hon. Treasurer, or to myself.

E. J. A.

February 13th, 1896.

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.

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

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

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

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

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

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

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