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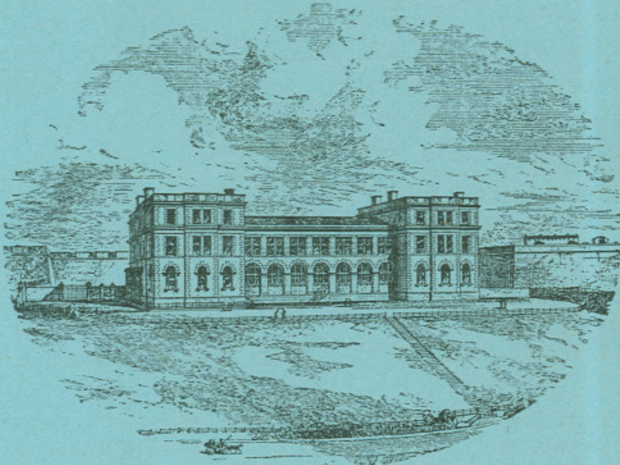

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On the Peculiarities of Plaice from Different Fishing Grounds.

By

J. T. Cunningham, M.A.

The investigation here described may be regarded as the natural sequel of the observations by which I showed that the plaice of the Brown Ridges, as well as those from the Plymouth grounds, were smaller when they attained to sexual maturity than those of the northern part of the North Sea. Mr. Holt, in 1894, published in this Journal some observations on the dwarfed and ciliated or spinulated plaice of the Baltic; and Dr. Heincke, now Director of the German Biological Station at Heligoland, had suggested as a probability that the plaice of the Heligoland region were a smaller geographical race, distinguishable by special characters from those of other regions. I referred to this subject at the end of my paper on the Physical and Biological Conditions in the North Sea, in the preceding number of this Journal, and mentioned the paper in which Georg Duncker * has recorded and discussed the results of an examination of samples of plaice and flounder from various localities. Among these localities was the Heligoland region; but Duncker had not compared the plaice of Heligoland with those of other parts of the North Sea. I have not had time to make as extensive an investigation of the matter as would be desirable. I commenced my observations at Lowestoft in September last, and continued them until the beginning of December, when I quitted the service of the Marine Biological Association. I have examined samples of plaice from the Brown Ridges, from the grounds off the Norfolk coast, from a position north-east of the Dogger Bank, and from the neighbourhood of the Eddystone Lighthouse. I have also endeavoured to acquaint myself with the complete geographical distribution of the plaice and the species most nearly allied to it, and for this purpose devoted several days to the examination of specimens in the National Collection. I have to thank Mr. G. A. Boulenger, F.R.S.,

* *Wiss Meeresuntersuch.*, Neue Folge, Bd. I., Heft. 2, 1896.

for his kindness and courtesy in providing me with facilities for carrying out this part of the work in the Natural History Museum at South Kensington. I will describe first the characters of the samples of plaice from the North Sea and the South-west coast.

I. The Variations Observed in Plaice from different parts of the North Sea and Channel.

The method I have employed is not exactly the same as that adopted by Duncker, who followed the example set by Heincke in his papers on the varieties of herrings, in the publications of the Commission zur Untersuchung der Deutschen Meere. The first step in either method is the actual observation by measurement and counting of the principal characters in each individual fish. The characters selected by Duncker were the following:—

1. The number of vertebræ in the caudal peduncle.
2. The number of vertebræ between the abdomen and the caudal peduncle.
3. The number of abdominal vertebræ.
4. The total number of vertebræ.
5. The number of gill-rakers on the first branchial arch.
6. The number of dorsal fin-rays.
7. The number of ventral fin-rays.
8. The length of the caudal peduncle.
9. The mean height of the same.
10. The greatest height of the body without the marginal, or dorsal and ventral, fins.
11. The greatest length of the head, on the upper side.
12. The extent of spinulation in the males.

In accordance with Heincke's method Duncker divided the variations observed in each of these characters into stages, which he denoted by symbols. The object of this is, firstly, to eliminate small errors of observation; secondly, to allow the differences to become more distinct; and thirdly, to show the relations between different variations; that is, to exhibit what is known as correlation. The character of each fish is thus represented by a formula consisting of a number of symbols, and a difference between local races may be demonstrated by the fact that the most frequent formulæ are different in the two cases.

I decided to neglect the examination of the number of vertebræ altogether. The variations in these were too small to be likely to exhibit any differences between the different samples I was investigating, and so far as they existed would be sufficiently represented by the variations in the number of fin-rays and length of the caudal peduncle.

The exposure and enumeration of the vertebræ are operations that take some time, and by omitting them I was able to examine a larger number of specimens. I omitted also the mean height of the caudal peduncle, the determination of which did not appear to be susceptible of great accuracy, and I did not follow Duncker in combining together head-length and height of body. I added the examination of another character, namely, the number of the tubercles, whose prominence or flatness I also noted.

The characters I have examined are therefore the following:—

1. Maximum height of body without fins.
2. The length of the head, from the apex of the lower jaw to the end of the opercular bone, on the upper side.
3. The length of the caudal peduncle, from a line joining the ends of the marginal fins to the middle of the line of articulation of the caudal fin-rays.
4. The length of the caudal fin, from the latter point to the end of the middle rays.
5. The number of the tubercles on the head behind the eyes.
6. The number of the gill-rakers on the first branchial arch, upper side.
7. The number of the dorsal rays.
8. The number of the ventral rays.
9. The number of ciliated rays in the dorsal and ventral fins.
10. The ciliated (spinulated) scales on the head and body.
11. The maturity or immaturity of each specimen.

The measurements of lengths were made with a millimetre scale and a pair of dividers, and they were only taken to the nearest millimetre. It did not appear that greater accuracy was possible. The body of a plaice is not rigid like that of a crustacean, but any part of it may be stretched or compressed a fraction of a millimetre, so that any greater accuracy of measurement would have been apparent and not real. No such qualification applies to the enumerations of numerical characters, which are absolute, and were made with the greatest care. The lengths of parts after measurement were calculated as hundredths of the total body-length, which was measured from the apex of the lower jaw to the end of the tail. To obtain this length the fish was laid upon the measuring-rod, and the lower jaw was pushed into contact with the vertical surface of a piece of wood placed upright at one of the lines of the measure, the length at the end of the tail being then read off directly. The measure was always taken with the lower jaw just closed and not pressed. As the lengths were only taken to millimetres it seemed useless to calculate the proportions to higher fractions than hundredths of the body-length. The fish varied from about 200 to

500 mm. in length, so that ·01 of the total length varied from 2 mm. to 5 mm., but ·001 would have implied accuracy to from ·2 to ·5 mm., which was greater than the accuracy of direct measurement. Considering the great variations in the proportions with age and condition of the individual, differences between local races not exhibited in hundredths of the total length may be regarded as quite unimportant.

The direct results of the examination of the specimens and calculation of percentages are recorded in Tables A appended to this paper. The sexes are recorded separately, and the specimens given in order of total length, in order to show what variations depend upon sex or increase in size.

The comparison between the samples from different localities, in Tables B, has been made by placing side by side the actual numbers of individuals observed to have each degree of variation which was distinguished. Duncker has given tables of frequency, but they differ from mine in two respects; firstly, that he takes the larger stages of variation mentioned above, and secondly, that he has given the *percentage* of individuals, not the actual number. As the number of individuals was in my investigation rather small, and as the object was only to ascertain and compare the distribution of the variations, no advantage appeared to be gained by comparing the percentages of individuals instead of the actual numbers.

The largest number of individuals have been examined in the case of the Brown Ridges and the Norfolk coast, these being the two principal distinct regions where the sailing trawlers of Lowestoft work. From the other two regions, namely, the Eddystone grounds and the ground to the north-east of the Dogger Bank, a smaller number were obtained. All those from the Brown Ridges were examined at Lowestoft, and also the greater number of those from off the Norfolk coast: the latter include samples taken outside the Dowsing Bank, off Cromer, and off the Well Bank. An additional sample, taken fourteen miles from Cromer, was sent to me in London from Lowestoft. The Plymouth samples were sent from the Plymouth Laboratory. The remaining sample was a box sent from Billingsgate, and stated by the sender to have been caught 220 miles from Smith's Knoll, just to the north of the tail of the Dogger Bank, at a depth of 25 fathoms.

I will proceed now to the comparison of the various characters in the samples.

According to the statistical enquiries of Mr. Francis Galton and Professor Weldon the magnitude of a character which occurs with the greatest frequency nearly coincides with the arithmetical mean of all the observed magnitudes, and the frequencies of the other magnitudes are symmetrically disposed about the maximum frequency.

In my results in the majority of cases an approximation to this condition is visible; but I have not calculated the actual mean, or attempted to determine the probable error or mean error of the deviations. The question I have proposed to investigate is merely whether there are between the samples differences in the characters examined, which are sufficient to be definitely demonstrated by comparing the frequencies with which the variations occur.

The most frequent height of body in the plaice of Brown Ridges is 39, both in the males and females. In the females from the Norfolk coast it is the same, while in the males it is 38. But we cannot say therefore that the Norfolk males are narrower, for among the Brown Ridges specimens there are 16 having a body-height less than 38 per cent., and among the Norfolk coast males only 10. On the contrary, the number of specimens having heights of 40, 41, and 42, is greater in the Norfolk coast males than in those of the Brown Ridges, and this does not appear to be due to a difference of age or stage of growth. Duncker found that a considerable decrease in breadth took place between 15 cm. and 20 cm. in length, and an increase after 30 cm. But where two local races are known to differ in absolute size, like those we are now comparing, the question is whether we are comparing samples of corresponding stages and ages. Now there are rather more specimens between 20 cm. and 25 cm. in the Norfolk coast sample than in the other, and therefore more young specimens, and these should be rather narrower than the old specimens; but we have no reason to suppose that the largest specimens in the Norfolk coast sample are older than those from the Brown Ridges. On the whole, then, we must conclude that the male plaice from the Norfolk coast are broader than those from the Brown Ridges. The single male at 45 was only 20·7 cm. long. The females of the Norfolk coast are also slightly broader than those from the Brown Ridges.

It will be seen that the difference between the sexes in height of body is very slight, but what superiority there is, is on the side of the females, and this is in agreement with Duncker's results.

In the Plymouth females the body-height 38 per cent. is the most frequent, while the males appear to be broader, the maximum being at 39. On the other hand, in the plaice from north of the Dogger Bank, although there is no maximum frequency, the number of individuals being small, the much greater breadth of body is sufficiently obvious. A comparison of the lists of specimens from the Norfolk coast, and from the more northern ground which I have given, will show that the greater breadth of the more northern specimens does not depend entirely on age or size. A similar great height of body was found by Duncker in the Cattegat plaice, which exceed in this respect the plaice of the Baltic. The latter are stated to be mostly from 38 to 39 per cent. in height, like my specimens from Brown Ridges and the Norfolk coast. Now the largest specimens from the Cattegat examined by Duncker were between 39 and 40 cm. in total length; but Petersen, in the *Report of the Danish Biological Station*, 1893, records specimens up to nearly 22 inches, or 55 cm. Thus the Cattegat plaice do not appear to be very much smaller on the whole than those of the northern part of the North Sea, and we may conclude that they are similar to these. Whether they agree with them in other characters will be seen in the course of this paper.

In the last two columns I have added the figures of Plymouth and Brown Ridges to represent a southern race, and the figures of the other two localities to represent a northern, and it will be seen that though the maximum frequency still remains in both sexes of both races at 39, yet the northern race is distinctly broader.

In the second set of tables are seen the frequencies obtained by taking all individuals regardless of sex, and here also the greater breadth of the Norfolk coast specimens, and of those from north-east of the Dogger Bank, is evident.

Length of Head. The most conspicuous fact that appears from the figures referring to this character is that in all four cases the females are distinctly longer in the head than the males. This agrees with Duncker's results. Duncker also found that the length of the head decreased during the growth of the fish. Such decrease is evident in my list of the males from the Brown Ridges, where the length 20 occurs seven times among the 15 largest specimens, and only greater lengths occur among the 37 smaller. The length 19 per cent. occurs only once, and that is in the largest male from beyond the Dogger Bank. But a similar decrease is not perceptible in the females. In the Norfolk coast females the length 24 per cent. occurs eight times, twice in the largest specimens, three times in specimens between 30 and 40 cm., and three times in specimens between 20 cm. and 30 cm. The greater length of head, then, in the females of the Norfolk coast is not due to a greater proportion of young specimens in this sample.

In the samples from the Brown Ridges and the Norfolk coast the maximum frequency is in both sexes at 22, but in the case of the Norfolk coast the greater lengths are more frequent, and the shorter less frequent than in the case of the Brown Ridges. It is not, however, so obvious that the specimens from north-east of the Dogger Bank have longer heads than those of the Norfolk coast, or even than those of the Brown Ridges. If we take into consideration the small number of specimens we see that there is a slight superiority over the latter. The Plymouth specimens again, as far as we can judge from so small a sample, appear to be a little shorter in the head than those of the Brown Ridges; in the males of these only the most frequent head-length is 21, while in all the other cases the maximum is at 22. In treating the samples in two sections only, southern and northern, we see that the former are shorter in the head. When the numbers of the two sexes are combined, the Norfolk coast sample appears to have the longest head on account of the large number of females in this sample. The greater length of head in the northern plaice is evident when all the figures are combined into two columns.

Caudal Peduncle. In this character a constant difference between the sexes is not evident, but again a slight superiority in the northern samples is indicated.

Length of Caudal Fin. The caudal fin appears to be distinctly longer in the sample from the Norfolk coast than in that from the Brown Ridges, the most frequent length being 19 per cent. in the former, 18 per cent. in the latter. The Plymouth specimens, however, have rather longer tails, at least in the males, than those of the Brown Ridges, and those of the north-east of the Dogger Bank rather shorter than those of the Norfolk coast. I am inclined to think that a reduction in the relative length of the caudal fin takes place as the limit of increase in size is reached; in other words, that the fin is shortest in the oldest specimens, the caudal fin growing less than the body in adult specimens, especially when the size reached is great. Thus two of the three specimens of the Norfolk coast, in which the caudal fin is only 16 per cent. of the total length, are the two largest, 56·8 cm. and 63·0 cm. respectively. The Norfolk coast samples certainly include more young specimens than any of the others, as well as absolutely the smallest specimens examined, as is natural from the fact that the district is nearest to the shore; and in this sample the greater lengths of caudal fin are most frequent.

Number of Tubercles. This is a character which is not considered by Duncker. Numerical characters are not usually subject to change with growth in the individual, but this character may possibly change to some extent. When one or more tubercles are so flat as to be virtually obsolete, I have counted only those which were distinct, while in other cases some of the five usually present are represented by two or more separate points. The flatness or prominence of the tubercles must be considered, and it is not fully represented in the tables.

In all cases the normal number 5 is most frequent. A reduction occurs most commonly in the sample from the Norfolk coast; it does not occur in the specimens from the Brown Ridges, but is more common in the Plymouth specimens than in those from north-east of the Dogger Bank.

The description "flat," however, in reference to the tubercles, occurs frequently among the notes of examination of the specimens from beyond the Dogger Bank, and least frequently in connection with the Brown Ridges specimens. The reduction of the tubercles, which makes some of them virtually obsolete and the rest less prominent, was particularly noticed in the largest females from the Norfolk coast, especially in a sample sent me in November, and caught fourteen miles off Cromer. In many of these I thought the condition suggested that the tubercles had actually been subject to mechanical friction. In the same specimens the edges of the marginal fins were thickened and contracted, evidently in consequence of frequent abrasion and healing. We know that the ground off the Norfolk coast is very rough and stony, and that the plaice is in the habit of burying itself in the ground it lives on. The fish also must doubtless push its head under stones and into the ground to obtain its prey; so that I think it very probable that the tubercles, as well as the edges of the fins, are worn away in the plaice of this district. The ground on the Brown Ridges, on the other hand, is composed of exceedingly fine smooth sand; that beyond the Dogger Bank is rather smooth; and on the Plymouth grounds both rough and smooth occur.

Gill-rakers. In all cases the most frequent number of the anterior processes on the first branchial arch is 10, and there is not much difference in this character between the sexes or the samples from different localities. But there is seen in the females of the Norfolk coast a slight indication of an increase in the number; the numbers above 10 occur more frequently in proportion. Considering the large number of female specimens from the locality which were examined (91), this result is, I think, significant, and it is confirmed by a similar indication in the females of the most northern locality. We may infer that the number of gill-rakers increases as we proceed towards the north.

Fin-rays. The variation in the number of fin-rays is considerable, and the frequencies of the different variations are not very symmetrically distributed. The largest sample is that of the females of the Norfolk coast, and here the most frequent number in the dorsal fin is 72; but the middle frequency, which is almost as great, is 73. The most frequent number in the males is 74; but, nevertheless, it will be seen that on the whole the number of fin-rays is greater in the females than in the males in all the samples; that is to say, in the former the higher numbers occur more frequently, and the lower numbers less frequently. In the females from the Brown Ridges there are two maxima for the dorsal rays: one at 70, the other at 76. Whether this indicates a true dimorphism, like that found by Professor Weldon in the shore crabs of Naples with regard to their frontal breadth, I am not prepared to say, the number of individuals being too small. But it is clear that the females of the Brown Ridges have on the whole a slightly greater number of fin-rays than those of the Norfolk coast, and the same is true of the males. As in other cases, the Plymouth specimens seem to resemble those of the Brown Ridges; those from beyond the Dogger Bank to resemble those of the Norfolk coast, in this character. The most frequent number of anal rays in the Norfolk coast and Brown Ridges samples is 55, except in the males of the former, where it is 53 or 54. As in the case of the dorsal rays, the figures show a slight superiority in number of anal rays of the southern samples over the northern, although the difference is not in either case very important.

Spinulation of the Scales, or Ciliation. In the tables of frequencies I have employed almost the same degrees of spinulation as Duncker, but have distinguished two degrees in the spinulation of the head instead of one. The degrees are (1) on the middle rays of the dorsal and ventral fins only; (2) also on the head in front of the preopercular bone; (3) also on the operculum; (4) also on the skin of the body near the edges, in the region over the interspinous bones; (5) spinulation extended over other areas of the body. In examining the specimens I counted and recorded the number of dorsal and anal fin-rays on which spinulated scales occurred, and in the first set of tables in which the characters of each specimen are given I have added the numbers together, and given for each specimen the total number of spinulated rays. One object of this was to ascertain whether the spinulation of the scales extended on to additional rays in proportion to the degree in which it extended to other parts of the body. The result is to show that there is no exact proportion between the number of fin-rays which are spinulated and the extension of the character on other parts of the body. The fact is that scales are also present along the middle rays of the dorsal and anal fins in the females and in the young males, although, like the scales on the other parts of the body, in these cases they are not furnished with spines on their outer edges. In a female 30·7 cm. long from Plymouth I found that there were rudimentary scales on 24 of the dorsal rays and 21 of the ventral. The spinulation develops at about the time when the male becomes mature, and evidently develops very quickly, although it possibly increases with age. I obtained some male specimens of the Norfolk coast plaice from 20 cm. to 25 cm. in length on purpose to study the development of the spinulation on the scales. In a specimen 20·7 cm. long, and another of 23·8 cm., there was no trace of spines on the scales of the fin-rays, while in another 25·8 cm. long they were just developing. In most cases there are not more than two spines on each scale, and on many scales only one spine. The spine commences as a deposit of calcareous matter in the shape of a short cone, and is formed not as an outgrowth from the scale, but as a separate deposit, of which the base afterwards becomes united to the scale. The position and shape of the growing spine are shown in Fig. 1.

In the table of the frequencies of the degrees of spinulation I have omitted those specimens from the males of Norfolk coast and the Brown Ridges which were below 26 cm. in length. In the former case there were eight of these, leaving 41 to be considered; in the latter there were only two omitted, leaving 50. It will be seen that in both cases the second degree of spinulation is the most frequent, but it is equally evident

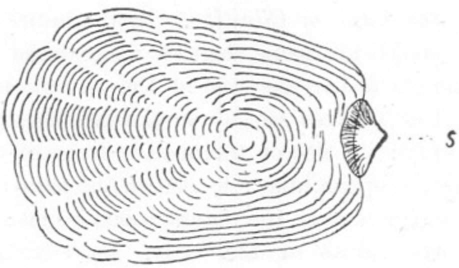

Fig. 1.

Scale of dorsal fin-ray of a plaice from the Norfolk coast, 25·8 cm. long, magnified. *S* the incipient spine at the outer edge of the scale.

that the higher degrees are somewhat more frequent in the specimens from the Norfolk coast. Now among the latter the smaller specimens must be younger and more immature than those of the same size from the Brown Ridges, and therefore the lower degrees of spinulation ought to be more frequent in the specimens from the Norfolk coast, if we consider only those which do not exceed the maximum length of those from the Brown Ridges. One specimen, however, of the three from the Norfolk coast which had no spinulation was actually mature—it was 36·5 cm. long; the other two were apparently immature, and were smaller. This shows that the development of spinulation does not always correspond exactly to the attainment of maturity, although it does so usually. In the Norfolk coast sample there are 12 specimens exceeding in size the largest of the Brown Ridges plaice; the largest of these 12 is 48·9 cm. long, the next largest is 43·2 cm. Putting aside the largest, we cannot consider the other 11 to be older than any of the specimens from the Brown Ridges, because the difference is not greater than that which I have shown to exist in the length of the smallest mature in the two cases. The largest specimen from the Norfolk coast has the fourth degree of spinulation. Taking all these facts into consideration, I conclude that on the whole the spinulation is slightly but distinctly greater in the plaice from the Norfolk coast than in those from the Brown Ridges.

In the females also there is a slightly more frequent spinulation among the specimens from the Norfolk coast than in those from the Brown Ridges. It is rare to find any trace of the condition in the females, but it is by no means exclusively confined to the oldest or largest specimens. One of the three spinulated females from the Norfolk coast was only 27·0 cm. long, and apparently immature.

The much greater development of spinulation in the plaice from beyond the Dogger Bank is very evident from the figures. But we must consider how far this may be due to the greater age of the specimens, since the locality where they were captured is in greater depth of water and much farther from the coast than the district off the Norfolk coast, or even the Brown Ridges. Now in the males of the deep-water sample there are eight specimens over 40 cm. in length, the largest being 47·3 cm. long; of these, in the smallest specimen, the degree of spinulation is 2, in the largest 5, and in the other six 4. Of the males from the Norfolk coast, six are over 40 cm. in length, and the largest is 48·9 cm. long; of these three have degree 2, one degree 3, and two only have degree 4. We have no reason to suppose that the northern specimens are older, although not larger; the presumption is the contrary. Therefore we have sufficient proof that the plaice from the more northern locality are considerably more spinulated at the same age than the Norfolk coast specimens, and *a fortiori* than those of the Brown Ridges. There is evidence that the development of spinulation increases with age; but enough evidence has been here produced to show that the difference between my samples from different localities is not due to differences of age.

It may be pointed out as worthy of note that in the two females in which spinulation occurs among the specimens from beyond the Dogger Bank, it is present on the cheek, and almost entirely absent from the fins.

The males from Plymouth appear to be rather more spinulated than those from the Brown Ridges; but it may be mentioned that in the specimen which is recorded as having degree 4, the spinulation of the interspinous regions was only just perceptible.

Recapitulation. The investigation shows that although the number of individuals examined is not so large as it should be, yet there are distinct differences in structural characters between the samples, especially between those of the Norfolk coast and the Brown Ridges, which would almost certainly be confirmed by examination of a larger number of specimens.

Omitting the tubercles and the length of the caudal peduncle, in which the indications are not very distinct, I find distinct differences in the following characters: Height of body, length of head, length of caudal fin, spinulation of scales, number of gill-rakers, number of fin-rays. The length of the caudal fin decreases apparently with age, and it is not very evident that it is a permanent characteristic of the different local forms. We have then left three characters of proportion and two of number. The first three characters all vary with age, the latter two do not change in the individual.

The change in the height of the body with age does not appear to be very constant or important in my samples; the height is distinctly greater in the northern samples than in the southern. The difference between the sexes is slight.

The length of head is a marked sexual character, being greater in the females; it decreases as age advances, but within the limits of size of my specimens the decrease is not obvious in the females, and not very important in the males. The length of head is a little greater in the northern samples.

The spinulation of the scales is a character, with few exceptions, confined to mature males, and forms the most conspicuous local peculiarity. There is no important difference in this character between the plaice of Plymouth and those of the Brown Ridges; but on the Norfolk coast, and still more beyond the Dogger Bank, it is much more developed than on the Brown Ridges.

The number of fin-rays is slightly greater in the females, and is somewhat less in the northern samples than in the southern.

The gill-rakers, on the contrary, are slightly increased in the northern samples as compared with the southern.

II. Comparison of the Local Forms Examined with those of other Regions.

Duncker examined 35 males and 45 females caught in the neighbourhood of Heligoland. The males were from 13·4 cm. to 28·9 cm. in length, the females from 19·3 cm. to 32·6 cm. Now I have shown in a previous paper that no plaice from this district were mature below 11 in., or very nearly 28 cm., in two samples which I examined, containing together 307 specimens. It is not surprising, therefore, that in Duncker's specimens the degree of spinulation was much lower than in the samples described above from the Norfolk coast, and even from the Brown Ridges. Duncker's male specimens from Heligoland must have been all, or nearly all, immature. It will be seen from my list of Norfolk coast specimens that spinulation often commences on the fin-rays before maturity, and this accounts for the fact that the first stage of the character occurs in a considerable proportion of Duncker's specimens. The smallest in which it occurs is 20·6 cm. long; the largest in which there is no spinulation at all is 26·6 cm. long. In my Norfolk coast samples the smallest specimen in which spinulation occurs is 23·5 cm. long, and only one smaller than this was examined, while the largest in which it was absent is 36·5 cm. long. Degree 2 occurs in Duncker's specimens, in one specimen 24·5 cm. long, and one 26·7 cm. long, while in the Norfolk coast specimens the smallest in which this degree occurs is 27·3 cm. long. It is not possible then to conclude from Duncker's specimens whether in the race to which they belong spinulation is much developed or little. There is nothing to contradict the probability that they belong to a race as strongly spinulated in the adult males as the Norfolk coast form or that from beyond the Dogger, and we certainly have no evidence at present that they are less spinulated than those of the Brown Ridges. Duncker unfortunately overlooked the question of the age and maturity of his samples.

Duncker divides the height of the body into only two degrees, and combines it in his formulæ with the length of the head, and I can therefore only attempt to make a comparison from his descriptive remarks. He says that the height exceeds 38 per cent. in the Heligoland plaice but seldom, and it would seem from this that these plaice are rather narrower than those from the Norfolk coast of the same size, and perhaps than those of the Brown Ridges; but the comparison, under the circumstances, is not worth much. Seventy-two per cent. of the Heligoland specimens have a length of head over 24 per cent., and this would seem to show that these plaice were much longer in the head than any of my North Sea samples. But with regard to both these characters it must be remembered that the proportion of smaller specimens is much higher than in my samples, even when I consider only those of my specimens which are below the maxima sizes of Duncker's; and I conclude, therefore, that the head is much longer in the younger specimens. Indeed Duncker himself mentions the fact, stating that the 21 smaller females from Heligoland have a mean head-length of 24·9 per cent., and the 24 larger, above 23·6 cm. in length, a mean of only 23·7 per cent.

No comparison then is possible except in the characters which do not vary with age, namely, the numbers of fin-rays and gill rakers;

and here Duncker does not give details, but simply states that the anal rays are mostly 51 to 55, the dorsal 66 to 80, and the gill-rakers mostly 10 or 11.

In describing some specimens from the Baltic in this Journal* Mr. Holt referred to two spinulated specimens of the plaice, one from the south coast of Iceland, and one from the Great Fisher Bank in the North Sea. These specimens were among the collections left by Mr. Holt at Cleethorpes which came under my charge. I have examined them, and recorded their characters in the tabular lists appended to this paper. They are both males of large size, and except in the greater size of the Iceland specimen do not differ much from the largest of the males I have examined from beyond the Dogger Bank. In both specimens, as often occurs in the higher degrees of spinulation, this character is developed slightly on the head and body on the lower side. It never occurs on the fin-rays of the lower side, because there the scales are virtually obsolete. In the Iceland specimen the scales are spinulated all over the upper side of the body except below the pectoral fin, and also very slightly on the head and interspinous regions on the lower side. In the Fisher Bank specimen the spinulation extends all over both sides, also with the same exception, but is much weaker on the lower side than on the upper.

We have next to consider the plaice of the Baltic, samples of which are described by Duncker. Some of the specimens mentioned by Holt in the paper above cited came into my hands, and their characters are detailed in the tabular lists. The plaice of the Cattegat occupy geographically a somewhat intermediate position, and we may examine their characteristics before referring to the fish of the Baltic proper. Duncker remarks of the Cattegat plaice that they resemble those of Heligoland in all other respects, but differ in their enormous height of body and the shortness of the head. This is exactly what might be expected when we know that Duncker's sample from Heligoland consisted chiefly of very young and small specimens of a large-sized race. The males of Duncker's Cattegat sample were from 29·5 to 39·4 cm. in total length, and 10 in number; of females there were 30 specimens 28·0 to 38·6 cm. in length. They were thus nearly all larger than the largest of the Heligoland specimens. Four of the 10 males had no spinulation, two had degree 2, and the rest degree 1. One of the specimens without spinulation was 39·4 cm. long, one 35·0 cm., one 34·1 cm., and one 29·5 cm. According to Petersen's records† some male plaice are immature in the Cattegat at 32·5 cm., if not even at a larger size. But in none of my samples is a male specimen so large as 39·4 cm. entirely without spinulation. I find it difficult to believe

* Vol. iii. p. 198. † *Report of the Danish Biological Station*, iv., for 1893.

that plaice in the Cattegat are less spinulated when mature than those of the northern part of the North Sea, and think it probable that if a larger number of mature specimens from the former locality were examined they would be found to exhibit as great a development of spinulation. My specimens from beyond the Dogger Bank, being taken in deep water far from land, would naturally include few immature specimens, and male specimens in that condition even 35 cm. in length might occur nearer shore. It must be pointed out that in my specimens from beyond the Dogger Bank degree 4 of spinulation only occurs in specimens over 40 cm. in length, and we know from Petersen that male specimens above that length occur in the Cattegat, although Duncker did not obtain any. There is nothing in the results of Duncker concerning the numerical characters to distinguish the Cattegat plaice from those of the northern part of the North Sea examined by me.

Duncker examined 34 males and 48 females from the Western Baltic, taken in the neighbourhood of Niendorf and Kiel. The males were from 22·6 to 29·7 cm. long, the females from 22·3 to 31·2 cm. long (from 9 in. to little over 12 in.). We know from Holt's evidence that plaice of the Western Baltic at these sizes are all, or nearly all, sexually mature. The spinulation varies from degrees 2 to 5 according to my notation, and it is certain that it is more strongly developed than in the most spinulated of my samples, degree 1 occurring not infrequently in the females.

The height of the body, on the average 38 to 39 per cent. according to Duncker, seems to be no greater than in the Norfolk coast plaice, and scarcely so great as in the specimens from beyond the Dogger Bank. The length of the head is a little greater than in the northern part of the North Sea.

In the numerical characters there is a marked reduction: the dorsal rays rarely exceed 70, though instances up to 75 and one of 78 occur. The ventral have a maximum of 60, but are mostly from 46 to 55. In this respect the form approximates to the character of the flounder. The number of the gill-rakers, however, is not greater than in North Sea plaice, but is on the contrary rather less, the number 12 not being exceeded, while in the Cattegat plaice the range of variation extends to 13, as in my specimens from the North Sea.

The caudal peduncle, reaching sometimes 9 per cent., seems to be rather larger than in the North Sea.

Duncker describes four males and seven females from Greifswald, a place on the coast opposite the island of Rügen, and little more than 100 miles east of Kiel. On the evidence of these few specimens he concludes that the Greifswald plaice are on the whole different from those of the neighbourhood of Kiel, and approximate in several characters more to those of the North Sea, although it might be expected that, the locality being farther inwards in the Baltic, they would be more different from the plaice of the North Sea. I fail, however, to find in Duncker's description any differences to which such importance can be attributed, especially when the small number of specimens is considered. The four males are all small and young, 19·6 to 22·6 cm., and this would partly account for the slightly lower height of body and greater length of head which Duncker mentions. The number of gill-rakers reaches 13, but I fail to see any difference in the number of fin-rays. The degree of ciliation was 2 in all four male specimens, which is in accordance with their small size.

We see then that as far as the small amount of evidence at our disposal goes, the Baltic plaice are modified in the same direction as northern forms in the North Sea with regard to reduction of fin-rays and increase of spinulation, and to a much greater degree, while with regard to other characters, branchial rays, height of body and length of head, no very distinct differences are exhibited. In accordance with the reduction of the dorsal and ventral fins, the caudal peduncle is a little longer in the Baltic. It is interesting to notice that as we proceed northwards in the North Sea and Atlantic these modifications are associated with a great increase in total size, while in the Baltic there is an equally conspicuous decrease in size. This proves that the modifications are independent of the rate of growth, and therefore presumably of the amount of available food.

III. The Relations between Local Variations and Specific Characters in the Plaice and Allied Species.

The plaice and flounder are certainly very closely allied, and there is a third form which also differs but slightly from them. This third form is the *Pleuronectes glacialis* of Pallas. To study the relations of these three forms to one another we must take a general survey of all that is known concerning their whole distribution, and their variations in different parts of their habitats. The question has previously been discussed by Professor Smitt in his edition of the *Scandinavian Fishes* of Fries and Ekström, 1893, and by Duncker in the paper frequently cited above; but I have endeavoured, by examining additional evidence, to carry the investigation somewhat further.

Pleuronectes platessa. Southwards on the European coast the plaice seems to extend into the Mediterranean, although I have not been able to discover any very definite or detailed account of specimens from that sea. Smitt mentions its existence there, and Jordan and

Goss * state that in the Museum of Comparative Zoology at Cambridge, Mass., there are a number of specimens from Trieste. Northwards the species extends to the White Sea. The evidence of this is that Smitt (*loc. cit.* p. 395) mentions a young plaice from Archangel which agrees with the form described by Pallas from Alaska and Kamtchatka under the name *Pl. quadrituberculatus,* and by Steindachner under the name *Pl. Pallasii.* Smitt regards these names as synonyms of *Pl. platessa.* I do not admit the synonymy, and shall discuss the matter presently; but we may take it that the plaice extends to the White Sea. We have seen that it is abundant on the south coast of Iceland, and extends into the Baltic as far as Greifswald. But the plaice is not mentioned as occurring on the coast of Greenland, and is certainly absent from the east coast of North America. In the Pacific, however, forms which must be regarded as local varieties of the plaice, or very closely similar to it, reappear, and I will here give the history of these forms so far as it is known. The following is a list of the names under which the specimens have been described or mentioned :—

Pleuronectes quadrituberculatus, Pallas, Zoogr. Rosso-Asiat. iii. 423, 1811. Bean, Proc. U.S. Nat. Mus. 1881. Jordan and Gilbert, Synopsis Fish. N.A. 1882.

Parophrys quadrituberculatus, Günther, Cat. Fish. Brit. Mus. iv. p. 456 (copied).

Pleuronectes Pallasii, Steindachner, Ichth. Beitr., S.B., k. Akad. d. Wiss. Wien, lxxx. 1880.

Platessa quadrituberculata, Jordan and Goss, Flounders and Soles of Am. and Eur. Rep. U.S. Fish. Com. for 1886, pub. 1889.

The original description of *quadrituberculatus* by Pallas is as follows :—

Longitudo (11″ 4‴) fere pedalis, latitudo summa cum pinnis 5″ 11‴ sine pinnis 4″. Forma Flesi. Caput a latere oculato, fusco nigricante, tuberculis quatuor osseis, conicis obtusis prominentissimis, serie lineae laterali continua, quorum duo approximata anterius, tertium orbitae superioris postico margini contiguum, quartum maximum sinui branchiali adsidet. Linea lateralis in utroque latere a sinu branchiali levissime descendens, dehinc media rectissima speciem catenulae referens. Corpus glaberrimum, squamis subdistinctis obsoletissimis, cauda evidentius squamosa usque in radiorum intervalla. Opercula angulata. Pinnae pectorales rad. 11 subacutae ; ventrales falcatae, rad. 6. P. dorsi ab orbitis incipiens rad. 70. P. ani pollicari a ventralibus distantia, rad. 51. Spina subcutanea ad anum. P. caudae rotundata, radiis 18 robustis bifidis.

* "Flounders and Soles of America and Europe." *Report of U.S. Fish Commission for* 1886.

Now there is one point in this description which shows that the fish described was not a plaice at all. The four tubercles are not all behind the eyes, but only the third and fourth. Jordan and Goss describe their specimen as having about five tubercles above the operculum, and D. 68, A. 50. Bean gives no description, but states that his specimen was obtained at Kodiak; Jordan and Goss' specimen was also collected at Kodiak, and it is not clear whether it was the same specimen or whether there were two. Kodiak is a large island off the south coast of Alaska.

In the British Museum collection there is a single specimen identified as the *quadrituberculatus* of Pallas, and collected by the U.S. Fish Com. steamer *Albatross*. The identification is evidently that of the American naturalists, and the specimen leaves no doubt as to what were the characters of the fish so identified. The specimen was taken at Herendeen Bay, a bay on the north side of the Alaska Peninsula in 56° north latitude and 161° west longitude. The characters of the specimen are given in the tables below, and it will be seen that they are similar to those of a plaice. The body is rather broad and the head long, but in these respects the fish does not differ from the plaice of the North Sea to any important extent, and it must be remembered that we can make no very minute comparison between spirit specimens and fresh specimens. The tubercles on the head are, however, peculiar, and have a character which has not been observed in any Atlantic plaice; they are remarkably prominent, regularly conical, and uniform in size. In number and position they are like the tubercles of the plaice. The scales are like those of the plaice, cycloid and reduced so that they do not overlap. The lateral line is slightly elevated above the pectoral fin, but otherwise straight as in the plaice. The specimen is male, and the scales on the fin-rays are spinulated as in the majority of male plaice. The teeth seem to be rather smaller than in the North Sea plaice.

We find then that in the North Pacific, about the shores of Kodiak and the Alaska Peninsula, there is a local variety of the plaice, of which only a few specimens have been obtained, and that this form has been erroneously identified with the *Pl. quadrituberculatus* of Pallas. The depth of water at which it was taken is not stated.

The only other record we have of a plaice-like fish in the North Pacific is Steindachner's account of *Pl. Pallasii*. The specimens so named came from Kamtchatka. The characters described are five depressed bony tubercles with blunt outer edges in a horizontal row between the eye and the lateral line. Dorsal rays, 63–68; anal, 48–53; all the fin-rays scaleless; scales small, rounded. A figure is given showing the tubercles more rounded and less prominent than in the British Museum specimen.

South of Alaska and Kamtchatka we have no evidence that the

Pacific form of the plaice exists. The flat-fishes of California and the west coast of America generally have been attentively studied by American zoologists, and are captured regularly for the market; but no specimens of this form have been noticed except the above, nor have any been discovered in Japan. The plaice-like form again is not known at present to extend further north than Herendeen Bay. Flat-fish have been collected at more northern places on the west coast of Alaska, but specimens of this form were not among them. It appears, therefore, that the species in the Pacific does not extend so far north or so far southwards as in the Atlantic; but, on the other hand, it is found on the west shores as well as on the east, whereas on the west side of the Atlantic it is absent.

Pleuronectes glacialis. Now to the northward, where the plaice disappears, the northern species, *glacialis*, is found in its stead, and this species occurs along all the northern coasts of Europe and America, and on the east coast of America. It presents local variations, and has been described under various names, but there is no doubt that it constitutes a single species, which in many respects is closely allied to the plaice. The following are the principal synonyms and references :—

Pleuronectes glacialis, Pallas, Zoogr. Rosso-Asiatica, iii. p. 424.

Pleuronectes cicatricosus, Pallas, *ibid.*

Pl. glacialis, Richardson, Voy. *H.M.S. Herald*, p. 166 (1852). Bean, Proc. U.S. Nat. Mus. 1881, p. 241 (Kotzebue Sound, Northern Alaska). Jordan and Gilbert, Synopsis Fish. N.A. Smitt, Scandinavian Fishes, 1893.

Platessa dvinensis, Lilljeborg, Svensk Vet. Akad. Handl, 1850.

Platessa glabra, Storer, Proc. Boston Soc. Nat. Hist. 1843, p. 130.

Liopsetta glabra, Gill, Proc. Acad. Nat. Sci. Philad. 1864.

Euchalarodus Putnami, Gill, Proc. Acad. Nat. Sci. Phil. 1864, p. 216.

Pleuronectes glaber, Goode and Bean, Proc. U.S. Nat. Mus. 1878, p. 347. Bean, *ibid*, p. 345.

Pleuronectes Franklinii, Günther, Cat. Fish. Brit. Mus. iv. 1862, p. 442.

Pallas first described *P. glacialis* in 1773, in his account of his journeys through various provinces of Russia; and in his larger work, published in 1811, repeated the description with but little modification. His specimens were taken in the Kara Sea and at the mouth of the river Obi. The chief characters given are the absence of spiny tubercles like those of the flounder; the ridge behind the eyes rough, but not divided into tubercles; the middle rays of the fins on the coloured side roughened with very minute spines; dorsal rays, 56; anal, 39. The upper side is also *squamulis asperis granulatum,* which probably means that the upper side was spinulated all over.

According to Pallas' description *P. cicatricosus* differs but little from *glacialis.* The specimens were collected in the sea between Kamtchatka and America. It is said to be more oblong, the length being three times the breadth without the fins. There is a rough osseous ridge behind the eyes. On the upper side the scales are far apart and scarcely projecting, except that every third or fifth over all the body and operculum has projecting setae on its margin; the middle fin-rays are also roughened with slight projecting points. Length of the specimen was $8\frac{7}{12}$ inches, the breadth $2\frac{10}{12}$ inches; the number of dorsal rays 59, anal 36. It is clear that the two forms thus described belong to the same species, and it is difficult to decide which was the more spinulated of the two.

Richardson states that he identified as the *P. glacialis* of Pallas a flounder taken in Bathurst's Inlet, which is on the north coast of North America. He afterwards obtained two specimens from the same region from Dr. Rae. They had all the characters described by Pallas, except the roughness of the middle rays of the dorsal and ventral fins. Richardson suggests for the first time that this may be a sexual peculiarity. He states that the parietal and suprascapular space—in other words, the post-ocular ridge—is divided into elevated granular surfaces; the scales are small and without spinules, except along the bases of the dorsal and ventral fins on the upper side. The length was 7·5 inches; the dorsal rays 58, the ventral 43.

In the British Museum collection there are two specimens identified with Richardson's species, which Dr. Günther named *Franklinii*, considering it distinct from *glacialis.* One of these is 22·8 cm. long (9 inches), and according to the label came from Dr. Rae's collection. It has evidently been dried, and is moth-eaten; but the spinulated scales could be felt both on the fin-rays and on the body. The other specimen has also been dried, and was too hard and stiff for detailed examination; but this also has some spinulated scales on the fin-rays and the edge of the body. This specimen was labelled, "From the Haslar collection." Probably one of these specimens, or both, were those examined by Richardson, whose description of the spinulation in such case was incorrect. They are certainly of the same species as the *glacialis* and *cicatricosus* of Pallas.

The first description of specimens of the same species on the east coast of North America is that of Storer, in 1843, who gives it the name *Platessa glabra.* He says the body is perfectly smooth, and mentions no spinulated scales on the fins. But the number of the fin-rays (D. 54, A. 39), and the character of the post-ocular ridge (naked and rough, continued back to the superior angle of the operculum, where it is much larger, and terminates in an obtuse point), show that the fish in question resembled *glacialis.* The specimens were taken in Boston harbour.

In 1864 Gill gave the name *Liopsetta glabra* to Storer's species, and described a new species under the name *Euchalarodus Putnami.* The description summarised is as follows: D. 55–58, A. 39–40. Two specimens examined, obtained at Salem, Mass. Scales minute, distinct, immersed, each one on the coloured side with several slender teeth behind, directed outwards; on the light side of the body smooth or uniciliate. Lateral line straight. Head with an osseous ridge continued backwards, where it is expanded and separated from an oblique bony tubercle on the scapula. The name was given from the teeth, which were in a single series and movable.

In 1878 Tarleton H. Bean pointed out that the movable teeth and certain other minute characters, described by Gill in *Euchalarodus,* occurred also in *P. glabra,* and in the plaice, the teeth being movable in mature specimens in the breeding season; and that *Euchalarodus Putnami* was in fact the male of *Liopsetta glabra,* differing from it only in having more of the scales ciliated. The largest female in the gravid condition was 13½ inches long. In the *Review of Flounders and Soles,* 1889, Jordan and Goss confirm Bean's conclusions, and state that they see no difference by which *Liopsetta glabra* can be separated from *P. glacialis.* Specimens have been taken from Providence, Rhode Island, to Labrador, so that the southern limit of the species is 41° north latitude.

Specimens identified as the *P. glacialis* or *cicatricosus* of Pallas have been taken in recent years by the U.S. Fishery steamer *Albatross,* on the west coast of Alaska, north of the Alaska Peninsula. The species is recorded by Bean as taken in Kotzebue Sound, but he gives no description; the same specimens, however, are briefly described by Jordan and Gilbert in their *Synopsis of the Fishes of North America.* It is there stated that the dorsal rays are 56, the anal 42 in number; that the scales are minute, imbedded, ctenoid in the males, smooth in the females. Now, the specimen in Bean's catalogue is numbered 27,947, and this very specimen, bearing the same number and labelled from Kotzebue Sound, is now in the British Museum, received from the Smithsonian Institution. I examined it myself, and have recorded its characters in the lists below. It is a female, and yet is strongly ciliated on the fins and all over the body on the upper side, and only a little less on the lower side. On the coast of Alaska then the females are not without spinulation. In Jordan and Goss' *Flounders and Soles* a female of the same form from Kotzebue Sound is figured, and appears to be the same specimen which I have examined; but the number is quoted as 27,497, probably a mere clerical error.

There are two other specimens from Alaska in the British Museum, collected by the *Albatross* in the Nushagak River, and obtained from the U.S. Fish Commission. These also I have examined, and have recorded their characters below. Both are females, and immature; the smaller is ciliated on the fins, head, and central region of the upper side, but not on the interspinous regions; on the lower side it is also ciliated in the central region. The larger is ciliated all over the upper side, except the region covered by the pectoral, but not on the lower side.

Lilljeborg's specimens came from the mouth of the river Dwina, at Archangel, from which place Smitt also obtained specimens. Smitt considers Lilljeborg's species identical with Pallas' *cicatricosus*, but thinks that there are important differences between this and *glacialis*. He says that Pallas based his distinction on the deeper form of the body, and greater closeness of the scales in *glacialis*. The difference reappears, though modified by age and sex, between the specimens brought by Nordenskiöld from the north coast of Siberia, east of the Kara Sea, and the specimens brought from the White Sea. The specimens of the east coast of the United States, according to Smitt, also belong to *cicatricosus*. The narrower form, with fewer or smaller scales, therefore, according to Smitt, occurs in the White Sea, on the east coast of America, and in the Behring Sea; while the broader form extends along the Arctic shores of America and of Siberia; the *glacialis* is a purely Arctic form, while *cicatricosus* lives in a milder climate.

The evidence I have been able to examine does not enable me to test Smitt's conclusions with regard to the breadth of body or length of head very completely. I can only point out that the three specimens from the coast of Alaska, one of which at 18·3 cm. was mature, agree fairly closely with the proportions given by Smitt for *cicatricosus*, and at the same time are not markedly narrower or longer in the head than many of the female plaice from the northern part of the North Sea. The male *glacialis* examined by Smitt were longer than the *cicatricosus*, all females, which he examined, and may have been older, which would to some extent account for their greater breadth and shorter heads. Smitt does not discuss the spinulation of the scales, and does not even mention that this is on the east coast of America a sexual character. In the two specimens from the north coast of North America which I have examined, as far as can be judged from their unsatisfactory condition, the spinulation is not greater than in male plaice from the North Sea, but their sex is unknown. The three specimens from the coast of Alaska are all females, and more spinulated than most of the male plaice from beyond the Dogger Bank.

In these specimens of *glacialis*, therefore, spinulation is undoubtedly more developed than in the most spinulated plaice, even than in those of the Baltic. On the other hand, the descriptions of the American naturalists do not tend to show that the forms named by them *Liopsetta Putnami* and *glabra* are more spinulated than the plaice of the Baltic. It is clear, however, that all the local forms of *glacialis* differ very distinctly from the plaice in the smaller number of fin-rays and the character of the post-ocular ridge, which is granulated, terminating posteriorly in a pear-shaped elevation of the skull-bone, succeeded by a slight elevation of the post-temporal bone. These two elevations correspond to the two posterior tubercles of the plaice, but are not prominent enough to be called tubercles.

We have seen that in the White Sea both plaice and *glacialis* occur; but this is the limit of the plaice eastwards and of *glacialis* westwards. The two species similarly succeed one another on the coast of Alaska, the northern limit of the plaice being the northern shore of the Alaskan Peninsula, which also forms the southern limit of *glacialis*. *Glacialis* therefore is strictly a geographical representative of the plaice. So far as we know it is, like the plaice, a marine form, not ascending rivers higher than their mouths. There are remarkable and interesting differences in the limits between the two species in different parts of the world, which are found on examination to correspond very closely to differences of temperature depending on ocean currents. In a map of the world by John Bartholomew the seas closed by ice in winter in the north are distinguished, and the distribution of the species *glacialis* corresponds almost exactly to the area of these seas. Owing to the north-eastern trend of the coast of Scandinavia the Gulf Stream, or north-easterly warm current in the Atlantic, travels far to the north and east, producing an ice-free sea as far as the entrance of the White Sea. Thus the plaice extends on the east side of the Atlantic beyond the North Cape, latitude about 72°, while on the east side of the Pacific its northern limit is about 56°. The westward projection of Alaska stops the north-easterly progress of the warm current in the Pacific, so that Behring Sea is closed by ice in winter, and here we have the form *glacialis*. Again, the open warmer sea in the Atlantic embraces the south coast of Iceland, where the plaice is not only abundant, but reaches its maximum size; while the glacial sea extends along the coasts of Greenland, down the west coast of America to Nova Scotia. The southerly cold current, known as the Labrador current, passes down from the north along the coast of Labrador and the east coast of North America, and this fact corresponds to the southerly extension of the *glacialis* form to Cape Cod, and the entire absence of the plaice. It appears that *glacialis* is taken on the coast of the United States chiefly, if not exclusively, in winter; and we may conclude that the low temperature of the water in winter excludes the plaice, while the high summer temperature prevents the extension of *glacialis* further to the south.

Pleuronectes flesus. We have next to consider the flounder, which is distinguished from the other two species most conspicuously by the character of the scales, many of which are more reduced than in the plaice, while others on particular parts of the body have taken on a peculiar development, and have been enlarged into prominent thorny tubercles. These tubercles are most constantly present in a single row along the bases of the dorsal and ventral fins, and are also usually present on the head and about the lateral line, while in certain forms they are developed over nearly the whole of the skin of the upper side.

The species occurs on the east side of the Atlantic all along the coasts of Europe—from the White Sea on the north to the Black Sea at the extremity of the Mediterranean. At different regions within these limits it exhibits local variations. Duncker examined samples from various parts of the Baltic and from the North Sea. In criticising his results we must take into account the fact that the flounder is essentially an estuarine fish, often ascending rivers into fresh water, and only descending to the sea in order to spawn.

In the Baltic the flounder extends much further than the plaice, and generally exhibits a much greater development of tubercles than on the coasts of the North Sea. Duncker examined samples from Königsberg, Greifswald, Niendorf, and Kiel. From Königsberg he had 20 males and 8 females; the males from 19·0 cm. to 28·2 cm. in length, the females from 23·3 to 28·2 cm. They were remarkable for their very rough squamation, great height of body, very short heads, and conspicuous red spots, approximating to the coloration of the plaice. There were crowded small tubercles over the whole of the upper side, on the blind side at least along the lateral line, on the abdomen, and on the interspinous region. The average height of body was 39·9 per cent. in the males, 41·1 per cent. in the females. The length of head was 22·3 per cent., and also less in the males. The number of fin-rays was higher than in other Baltic samples, the mean of the dorsal being 58·1, of the ventral 40·7. The number of gill-rakers was 11–18.

The Greifswald sample consisted of 14 males, 15 females; the males in length 16·5 cm. to 26·0 cm., the females 15·8 cm. to 34·6 cm. In these the squamation was less rough; the height of body less, 37·8 per cent. on the average; the head longer. It seems to me all these differences are sufficiently explained by the greater proportion of younger and smaller specimens. The mean numbers of the dorsal and ventral rays was a little lower, but in such a small number of specimens the difference does not seem of great importance.

From Niendorf and Kiel there were 26 males, 30 females; the length of the males was 20·1 cm. to 38·5 cm., of the females 20·8 cm. to 30·6 cm. According to Duncker the squamation and coloration are intermediate between the Greifswald and Königsberg forms. The Niendorf males were narrow, and these were few in number and of large size; the length of head slightly greater than in the Königsberg sample, a fact very probably due to the greater proportion of females. The mean of the numbers of dorsal fin-rays was only a little over 56, that of the ventral the same as in the Greifswald sample.

Duncker's North Sea specimens were collected near Heligoland, therefore in the sea; at Cuxhaven at the mouth of the Elbe; and at Hamburg. Considering the migratory habits of the species, it is obvious that these must be considered as belonging to one region, and Duncker admits that they are difficult to distinguish. The Heligoland specimens are stated to have been obtained in July and August, and it is surprising that flounders should be found abundantly in the sea at that time of the year. But perhaps the fact is explained by the shallowness of the water, and the proximity of the two large rivers Elbe and Weser. We find, however, as might be expected, that the Heligoland specimens are the largest and doubtless the oldest. The numbers and sizes are :—

Heligoland . . .	15 males,	23·0 cm. to 31·5 cm.
	29 females,	23·8 cm. to 42·1 cm.
Cuxhaven . . .	18 males,	22·4 cm. to 28·0 cm.
	7 females,	22·5 cm. to 26·1 cm.
Hamburg. . . .	14 males,	15·1 cm. to 27·8 cm.
	13 females,	22·2 cm. to 27·8 cm.

In these North Sea flounders the rough tubercles are limited to the bases of the fins and the lateral line, while the scales on the rest of the body are smooth and cycloid; the tubercles occur chiefly at the anterior part of the lateral line, and in the middle region of the bases of the fins. The number of gill-rakers is on the average two or three higher than in the Baltic (15 to 22). The fin-rays are more numerous. The body is narrower; but in the length of head no constant difference was evident.

I cannot altogether agree with Duncker in his views with regard to the comparison between the variations of the plaice and flounder in the North Sea and Baltic. He considers that the two forms approach one another to some extent in the Baltic more than they do in the North Sea. In the two cases we find a similar modification in the greater roughness of the scales, in the greater breadth of the body, and the reduction in the number of fin-rays. The number of gill-rakers is higher in the flounder than in the plaice, and is reduced in the Baltic; in this respect the modification does reduce the difference between the species, and the difference in the coloration is also reduced in the Baltic. The length of the caudal peduncle in the flounder is reduced in the Baltic, while in the plaice it is somewhat increased. The three modifications which are in the same direction are those which take place in passing from south to north; and it is a fact that the Baltic is colder than the North Sea. On the other hand, it seems to me probable that as the Baltic is fresher than the North Sea the flounder there may live less in the rivers, and therefore, on the whole, in salter water, while the plaice lives in fresher, and that this may have something to do with the brighter red spots in the flounder in the Baltic.

The flounder in the Mediterranean has been described under different names in the belief that it formed distinct species. The synonyms, or names given to these local forms, are:—

Pleuronectes luscus, Pallas, Zoogr. Rosso-Asiat. iii. p. 427. 1811 (Black Sea).

Platessa glabra, Rathke, Fauna der Krym., p. 352. 1837 (Crimea).

Platessa passer, Bonaparte, Fauna Italica, Pesc. 1838–40.

Pleuronectes italicus, Günther, Cat. Fish. Brit. Mus. iv. 1862 (Dalmatia).

I have not taken the trouble to go through the descriptions given by the authors cited, but have examined the specimens in the British Museum, details of whose characters are given in the lists below. The chief peculiarity of *italicus,* according to Günther's description, is that the lateral line is smooth, not furnished with thorny tubercles. In the smallest of the three specimens from Dalmatia there were no tubercles on the lateral line, and no spinules on the scales on the middle fin-rays of the dorsal and ventral fins. In the next specimen in order of size there were spinules on 22 of the dorsal and ventral rays, no tubercles on the lateral line or on the head. In the third specimen two tubercles were found at the anterior end of the lateral line, but only one spinule was detected on the dorsal fin, none on the ventral. Spinules on the fins are not present in the North Sea flounders. The number of the fin-rays is not greater than in the North Sea flounders, but is as great, and therefore greater than in the flounders of the Baltic. The height of body also resembles that of the North Sea specimens, while the length of the caudal peduncle is as short as in the Baltic. The length of head shows nothing remarkable.

Of the local form described as *luscus* there were seven specimens in the British Museum: four from Constantinople and the Bosphorus, three from the Black Sea. In all these there were a number of tubercles along the front part of the lateral line, but these were not very abundant or very prominent. The spinules on the fin-rays were also more numerous and more regular. The fin-rays are scarcely different from those of the Dalmatia form, but the body is higher and the head apparently a little longer; these, however, are differences of age, the body being higher in the larger specimens, the head longer in the smaller. In the Black Sea specimens, as in those from Dalmatia, the tubercles along the bases of the fins are present, more developed in the former. Again, we find here that the greater development of tubercles corresponds to a colder climate; the Black Sea is considerably colder, at least in winter, than the Adriatic. The presence of spinulated scales on the fin-rays, as in the plaice, is remarkable.

On the northern coast of the eastern hemisphere the flounder is not known to occur further east than the White Sea. Smitt states that Lieut. Sandeberg brought specimens from the White Sea in which the body was entirely smooth, with the exception of the spinous tubercles at the bases of the fin-rays, and a few on the head and near the lateral line. They were described as a distinct species under the name *Pleuronectes Bogdanovii;* but quite similar forms may, according to Smitt, be found in the Baltic. These were apparently individual variations, and it is not clear whether or not the flounder on the whole is as strongly spinous in the White Sea as in the Baltic.

The flounder is not included in Lütken's *Fishes of Greenland*, and is not mentioned as occurring on the north-east coast of North America. Yet there is a form, scarcely distinct as a species, in the Pacific, remarkable chiefly for the extensive development of spiny tubercles, but in the character of these tubercles, and in other respects, very closely similar to the European flounder. The chief difference is, that according to the descriptions of Jordan and Goss there are no cycloid scales in the Pacific form, to which they actually give a distinct generic name, *Platichthys stellatus.* This form extends from Point Conception on the coast of California, latitude 34°, to Coronation Gulf on the Arctic coast of America, which is north of latitude 70°, and not very far west of Hudson's Bay. It is difficult to understand why the flounder-like form should be absent on the intervening coasts, or in the intervening rivers, between the north-west coast of America and the coast of Europe. On the Asiatic side of the Pacific the form *stellatus* extends southwards to Saghalien, and indeed from the descriptions appears to be the same species as *Pleuronectes asperrimus* of Japan.

Smitt suggests in one passage that the forms which culminate in the plaice and flounder started from one of the three *limanda* (dab) *glacialis* or *cicatricosus,* and considers the latter two varieties to be diverging in the same directions as *flesus* and *platessa.* Duncker, on the other hand, considers the plaice the oldest form on account of its cycloid scales, and to have come from the far north; to have formed the variety *glacialis* on the Arctic coasts, and then with this variety to have entered the Baltic, where the plaice gave rise to the Baltic form of plaice, and the *glacialis* to the flounder.

The conclusions at present suggested by the facts to my own mind are as follows: The plaice is by no means necessarily the original form, as there is reason for holding that the original form of these and other flat-fishes had ctenoid scales of the usual kind, as in the dab. The facts show that the species *glacialis* is the Arctic form, the flounder the fluviatile form of the plaice. Whatever the causes which led to the reduction of the scales in the plaice, it is certain that the ctenoid condition is more developed in the Arctic form: this form is also without tubercles and has fewer fin-rays. There are objections to the view, which Duncker appears to take, that the development of the tubercles in the flounder is a further stage in the development of the spinules on the scales in the plaice and in *glacialis*. The most spinulated scales occur in the two latter forms on the fin-rays and in the interspinous regions, while in the flounder it is precisely in these two regions that the scales are most rudimentary, and along the base of the fins and along the lateral line the scales are developed into spiny tubercles. As we have seen, the spinules on the fin-rays are retained to some extent only in the smoothest flounders, those of the Mediterranean, while in those of more northern latitudes the fin-rays are scaleless. Thus we might almost say that the condition of the flounder was due to the further progress of a modification in the same direction as that of the plaice, that the ctenoid scales first underwent reduction, and then when they had become rudimentary some of them in particular parts of the body developed into tubercles. This view, however, is not consistent with the fact that both plaice and flounder become rougher, their calcified skin armature more developed, in the north than in the south. The correct interpretation of this fact is evidently that the development of scales has taken a different direction in the flounder, and that in both directions cold, or some condition accompanying a northern climate, has the effect of producing enlargement of the structures connected with the scales. It is not possible at present to see any connection between the fact that the flounder lives in rivers, and the peculiar development of its tubercles, nor can we see any advantage to the fish in the possession of these structures.

We do not find that the correspondence which is observed between climate and development of spines on the scales in the plaice and flounder exists when we compare the species of flat-fishes with one another. The sole, for instance, is a distinctly southern form, and its scales are strongly ctenoid all over the body. The dab, however, is more closely allied to the plaice and flounder, and also has ctenoid scales all over its body, except the area covered by the pectoral fin; ctenoid scales extend also on to the fin-rays. Now it is not a fact that the dab inhabits more northern regions than the plaice, and still less than *glacialis*. On the contrary the dab and plaice are constantly taken together on the same ground. The dab extends on the European coast from the Bay of Biscay to the Kara Sea, and is plentiful on the south coast of Iceland, and is found in the Baltic at least as far east as Gothland. On the American side of the Atlantic the dab lives in the same latitudes as *glacialis*, but in a slightly different form, described by American naturalists as a distinct species, under the name *Limanda ferruginea*. In the North Pacific, however, we do find that the local form of the dab, like the local form of the flounder, is rougher than in other parts of the world. This form is described under the name *Limanda aspera*, and extends from Sitka and Saghalien to Wrangel Island off the coast of Siberia. Thus, although we find here again that rougher scales in the same species characterise the more northern forms, and appear to indicate a direct influence of climate, we do not find that northern and southern species are constantly distinguished by a similar difference in the character of the scales. The occurrence of spinulation as a secondary sexual character, developing in the males, as such characters generally do, only when maturity is reached, is peculiar to the plaice, and at present we have no evidence that, as Duncker suggests, the character is of any importance in the relations of the sexes.

A.—TABLES SHOWING THE CHARACTERS OBSERVED IN EACH SPECIMEN EXAMINED.

The specimens of each sex in each locality are arranged in order of size.

The Height of Body, Length of Head, Length of Caudal Peduncle, and Length of Caudal Fin, are expressed in hundredths of the Total Length. The Total Length is measured from the extremity of the lower jaw to the end of the middle ray of the caudal fin.

The degrees of spinulation of the scales, often called ciliation, are as follows:—

1. On the fin-rays only: the numbers of spinulated dorsal rays and ventral rays are added together in one column; the degree on the body is shown in the next column.
2. On the fin-rays, and also on the head in front of the preopercular bone.
3. Also on the operculum.
4. Also on the body in the region of the interspinous bones.
5. Also on a greater extent of the body.

Locality: Plymouth—grounds near Eddystone.

Males. Total Number, 15.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill-Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
29·3	40	23	5	20	5	9	71	54	Commencing	0	i
29·4	39	23	5	19	5	11	74	55	0	0	m
30·2	38	22	6	19	5	10	73	56	36	2	m
32·2	36	22	5	18	3	9	76	56	37	2	i
32·3	37	21	5	19	4	11	72	53	37	2	m
32·4	39	21	6	18	5	10	74	55	31	0	i
32·5	38	23	6	20	6	11	70	52	58	4	m
32·8	40	21	6	19	5	10	67	53	40	0	?
33·3	39	23	6	19	6	10	72	52	0	0	?
33·5	37	22	5	19	5	9	71	53	55	3	m
33·7	38	21	5	17	5	10	77	58	40	2	m
33.9	41	22	6	18	5	9	72	54	50	2	?
37·4	39	22	5	18	5	10	73	53	43	2	m
38·7	37	21	5	19	4	10	75	56	37	0	m
42·4	35	21	5	18	3	11	69	52	40	0	m

Females. Total Number, 21.

29·5	38	23	6	18	5	9	75	56	—	—	i
30·1	38	22	5	19	5	10	75	57	—	—	i
30·2	40	21	5	19	5	10	75	55	—	—	i
30·7	37	23	6	18	5	10	74	55	—	—	m
30·7	41	24	5	19	5	10	72	55	—	—	i
31·1	38	22	6	20	5	9	76	56	—	—	i
31·7	39	22	5	18	5	10	75	53	—	—	m
32·1	39	21	6	19	5	?	75	55	—	—	i
32·2	38	22	5	19	5	10	74	56	—	—	m
32·5	38	22	6	20	5	10	74	55	—	—	i
34·6	38	22	5	17	5	9	75	56	—	—	i
35·2	38	23	6	23	5	10	66	53	—	—	m
35·5	40	21	7	17	7	10	71	51	—	—	i
36·1	41	22	6	18	6	10	74	54	—	—	m
37·4	40	23	5	18	5	10	72	52	—	—	m
38·6	38	22	6	18	4	10	74	56	—	—	m
39·0	38	22	5	18	5	10	72	55	—	—	m
39·0	37	23	5	20	5	11	75	56	—	—	m
40·5	36	21	6	18	5	11	72	56	—	—	m
42·6	38	21	5	17	5	10	76	57	—	—	m
43·3	39	23	6	18	5	9	68	51	—	—	m

Locality: Brown Ridges, North Sea.

MALES. TOTAL NUMBER, 52.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
22·1	36	24	5	18	5	11	72	53	0	0	i
24.9	37	22	5	21	5	10	68	51	0	0	i
26·2	39	21	6	18	5	11	74	55	42	0	?
26·9	40	22	6	18	5	9	73	55	29	0	i?
27·5	39	22	6	17	5	10	73	54	17	0	i?
27·5	38	22	6	18	5	9	74	56	9	0	i?
27·7	37	21	6	18	5	9	71	53	35	0	?
28·1	39	22	6	18	5	10	72	53	36	2	—
28·3	39	22	6	18	5	10	78	57	37	0	—
28·4	39	22	6	19	5	9	76	55	34	2	m
28·5	38	23	5	19	5	10	78	55	26	0	—
28·6	39	22	5	17	5	10	73	56	42	2	m
28·8	37	22	5	19	5	9	73	53	32	0	—
28·8	38	21	6	18	5	10	69	53	42	0	—
29·2	40	22	5	17	6	9	73	52	36	2	—
29·3	37	22	5	18	5	10	75	54	39	0	—
29·5	38	22	6	18	5	10	73	52	39	2	m
29·6	39	22	6	18	5	10	71	51	21	0	—
30·0	38	22	6	18	5	11	71	52	24	0	—
30·0	40	23	6	19	5	10	72	53	10	0	—
30·1	37	22	6	18	5	10	76	56	42	2	m
30·1	39	21	6	17	5	12	72	55	32	0	—
30·3	37	22	5	18	5	10	74	55	40	2	—
30·3	40	22	6	18	6	11	75	55	25	2	m
30·7	40	22	5	17	5	10	74	55	37	0	—
30·7	38	23	5	22	5	10	70	51	9	0	—
31·2	38	22	7	17	5	10	73	55	47	3	m
31·6	41	22	6	18	5	9	77	58	33	0	m
31·8	38	22	5	18	5	10	70	55	48	2	—
32·0	38	21	6	21	6	9	73	54	37	2	m
32·1	38	23	6	19	5	9	72	53	41	2	m
32·3	39	22	6	16	5	9	73	55	47	2	—
32·4	38	21	6	18	6	9	70	52	41	2	m
32·9	36	21	6	18	6	9	70	53	34	0	—
32·9	39	22	5	20	5	10	69	50	35	2	—
33·2	37	21	6	18	5	10	73	53	36	2	—
33·4	39	22	6	18	5	10	68	50	26	2	m
33·8	36	20	4	17	5	11	71	55	39	3	—
33·8	36	21	4	17	5	9	75	58	47	2	—
34·1	36	20	6	16	6	10	76	53	25	2	—
34·2	36	22	5	19	5	10	75	57	0	0	—
34·2	39	22	5	19	5	11	73	52	37	0	m
34·6	40	21	7	19	5	9	75	55	17	0	m
34·8	37	22	6	18	5	11	68	51	26	0	—

MALES—*continued.*

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
34·8	40	20	5	18	5	9	67	51	39	2	—
35·1	36	20	6	17	5	9	76	56	35	3	—
35·4	35	20	6	19	5	11	74	56	44	2	—
35·7	38	22	6	17	6	11	76	56	2	0	—
35·8	39	20	7	18	7	10	71	52	41	2	—
35·8	39	20	5	18	5	11	69	54	36	3	m
36·0	40	21	6	17	7	10	74	55	39	2	—
36·8	41	22	5	18	6	10	75	58	41	2	m

FEMALES. TOTAL NUMBER, 57.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
24·9	37	22	6	18	5	12	72	51	0	0	m
25·1	37	22	5	18	6	10	77	57	—	—	i?
25·1	40	24	6	19	6	10	72	50	—	—	i
26·0	38	23	6	19	5	10	71	51	—	—	i
26·1	39	23	5	18	5	10	70	52	—	—	—
26·4	36	23	6	18	5	9	70	51	—	—	i
26·6	39	23	7	17	5	10	72	55	—	—	i
26·7	38	22	5	18	5	10	71	54	—	—	i
27·0	37	22	5	19	5	9	72	55	—	—	i
27·5	39	23	5	19	5	10	73	54	—	—	i
27·7	39	22	6	17	5	—	74	56	—	—	—
27·8	39	23	6	20	5	9	72	55	—	—	i
28·1	40	22	6	17	5	10	75	57	—	—	i
28·2	38	23	6	17	5	10	76	57	—	—	i
28·5	37	23	6	17	5	11	70	50	—	—	i
28·8	39	22	5	17	5	11	70	54	—	—	m
29·7	38	23	7	17	5	9	69	51	—	—	i
29·8	38	23	6	18	5	10	76	58	—	—	i
29·8	38	22	6	18	5	10	75	54	—	—	i
30·3	39	22	6	18	5	10	76	56	—	—	i
30·4	38	22	6	18	5	10	79	58	—	—	i
30.5	40	23	6	18	6	11	77	55	—	—	i
30·5	37	21	6	18	6	10	70	52	—	—	i
30·6	39	22	5	19	6	11	76	58	—	—	i
30·6	38	22	7	17	5	10	75	53	19	0	m
30·8	41	21	6	20	5	10	75	55	—	—	m
31·1	38	22	6	18	5	10	71	52	—	—	m
31·2	37	23	6	20	5	11	69	51	—	—	—
31·2	40	21	6	17	5	10	78	57	—	—	i
31·2	38	22	5	19	5	10	71	52	—	—	m
31·6	40	22	5	18	5	10	73	53	—	—	m
31·6	40	22	5	19	5	10	71	51	—	—	—
31·7	39	22	6	18	5	10	81	59	—	—	i
31·9	36	21	6	17	5	9	75	58	—	—	i
31·9	39	23	5	18	6	9	73	55	—	—	—

Locality: Brown Ridges, North Sea.

FEMALES—*continued.*

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
31·9	41	22	5	17	5	10	74	55	—	—	i
32·1	38	23	5	18	5	10	70	52	—	—	i
32·4	39	23	6	17	6	11	74	52	—	—	m
32·6	37	23	6	18	5	11	76	55	—	—	—
33·3	36	23	6	17	5	10	79	57	—	—	—
33·4	39	23	6	18	6	10	69	50	—	—	—
33·9	36	21	5	18	5	10	75	55	—	—	—
34·0	40	22	5	18	5	10	70	51	—	—	—
34·2	39	22	6	18	5	9	79	57	—	—	—
34·3	39	21	6	18	6	10	68	53	—	—	—
34·3	39	22	5	17	5	11	74	54	—	—	m
34·8	36	20	5	17	5	10	74	55	—	—	—
34·8	40	22	6	18	5	10	73	54	—	—	m
36·1	36	21	6	18	6	9	73	56	—	—	—
36·2	39	22	6	18	5	11	77	57	—	—	—
36·4	39	23	6	19	6	10	68	52	—	—	m
37·0	38	22	6	17	6	11	77	55	—	—	m
37·3	39	21	5	19	5	10	71	55	—	—	m
37·7	39	22	6	18	5	10	68	54	—	—	m
38·4	41	23	5	19	5	13	64	48	—	—	m
38·9	39	23	5	18	5	10	76	56	—	—	m
39·4	39	22	5	18	5	11	76	55	—	—	m

Locality: Norfolk Coast.

MALES. TOTAL NUMBER, 49.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
20·7	45	23	6	19	5	10	73	54	0	0	—
23·5	40	24	6	17	5	10	73	55	21	0	—
23·8	39	24	6	20	4	9	69	53	0	0	—
24·6	38	23	5	19	6	10	73	53	21	0	—
24·9	38	23	6	18	5	10	67	51	38	0	—
25·2	42	22	6	17	5	10	74	54	37	0	—
25·5	36	22	6	18	5	10	79	56	27	0	—
25·8	40	22	6	20	5	9	71	54	Commencing	—	—
26·1	37	23	6	19	5	11	70	54	25	0	i
26·6	40	22	5	19	4	8	72	52	0	0	—
27·1	37	22	6	18	5	10	72	55	15	0	i
27·3	36	22	6	19	5	10	67	49	38	2	—
28·5	38	22	6	19	4	12	78	57	17	0	—
28·8	38	22	5	18	7	10	70	55	43	2	—
29·2	40	21	6	19	5	11	74	57	37	0	—
29·3	39	22	7	18	5	10	70	52	27	0	—
29·5	42	23	7	17	5	9	73	54	38	2	—
29·5	40	22	6	21	6	11	69	53	35	0	—
30·0	38	22	6	19	5	10	73	56	35	2	—
30·3	38	23	6	18	5	9	76	56	0	0	—
30·6	41	24	5	17	5	10	69	51	10	0	—
31·5	37	21	6	19	5	9	72	52	27	0	—
32·6	38	21	5	20	5	10	72	53	44	2	—
33·2	39	22	6	20	5	9	71	53	42	2	—
33·2	37	21	6	18	5	10	71	53	34	2	—
33·2	39	23	6	19	6	9	74	54	0	0	—
33·3	40	22	6	19	5	11	75	56	33	2	i
34·2	38	22	5	18	5	10	76	57	32	0	i
35·1	37	22	5	18	6	10	72	54	16	0	—
35·3	40	22	5	17	6	10	76	57	23	0	--
35·5	36	21	5	20	5	10	76	57	43	0	m
35·8	39	22	6	18	6	10	74	58	28	2	—
35·8	38	23	6	19	5	10	76	57	Commencing	2	i
36·0	39	22	6	19	5	10	73	57	49	3	—
36·5	38	21	6	17	6	10	74	53	28	0	—
36·5	38	22	6	18	5	9	73	56	0	0	m
36·8	38	22	6	18	5	10	76	56	41	2	—
36·9	39	22	6	20	4	9	75	53	37	2	m
37·0	37	21	6	19	5	10	75	59	26	2	m
37·7	39	21	6	20	4	10	71	54	32	3	m
38·3	39	21	6	18	5	—	73	56	37	2	—
38·6	40	21	5	19	5	10	70	51	4	0	m
39·4	36	22	5	19	3	10	74	54	52	2	—
40·4	40	21	6	18	4	10	71	54	33	3	m
40·5	39	22	6	19	5	11	71	51	38	2	m
43·0	40	22	5	19	5	10	74	56	30	2	m
43·1	41	21	6	19	5	12	74	53	42	4	—
43·2	40	22	6	19	5	11	74	55	50	2	m
48·9	38	22	6	17	4	10	74	53	44	4	—

Locality: Norfolk Coast.

FEMALES. TOTAL NUMBER, 91.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
21·5	37	22	6	19	5	9	70	54	—	—	i
22·7	39	23	7	19	5	9	71	55	—	—	i
22·7	40	24	5	19	5	10	73	53	—	—	i
23·0	40	23	6	18	5	10	73	56	—	—	i
23·9	39	23	6	19	5	10	71	56	—	—	i
24·7	39	23	6	18	5	9	76	56	—	—	i
25·6	37	22	7	17	5	9	76	56	—	—	i
27·0	39	22	5	18	5	10	78	57	25	—	i
27·4	40	24	5	19	6	10	69	52	—	—	i
27·5	39	22	6	18	5	10	74	57	—	—	i
28·5	41	23	5	20	7	10	75	54	—	—	i
28·7	38	22	7	18	5	10	74	56	—	—	i
28·8	39	24	5	19	5	13	74	54	—	—	i
28·9	40	22	6	19	5	10	72	54	—	—	i
29·4	37	22	6	19	5	11	71	53	—	—	i
30·5	40	23	6	19	4	11	75	55	—	—	i
31·4	39	23	6	18	5	10	72	54	—	—	i
31·6	38	23	6	17	5	11	72	54	—	—	i
31·9	37	22	6	18	5	9	72	53	—	—	i
32·0	39	22	6	20	5	9	72	54	—	—	i
32·2	42	22	6	19	5	10	73	54	—	—	i
33·2	42	23	5	19	5	11	73	52	—	—	i
33·6	37	22	6	19	6	12	73	52	—	—	i
33·8	41	23	5	20	5	10	71	51	—	—	i
33·8	39	22	7	19	5	10	74	55	—	—	i
33·9	38	21	6	19	5	11	71	53	—	—	i
34·2	38	23	5	19	5	10	73	53	—	—	i
34·7	39	21	5	20	5	11	75	55	—	—	i
34·9	40	21	6	19	5	10	74	55	—	—	i
34·9	41	23	6	19	5	10	72	52	—	—	i
35·1	39	22	6	19	5	11	72	52	—	—	i
35·1	38	24	6	17	5	9	73	53	—	—	i
35·1	37	23	6	18	6	8	71	53	—	—	i
35·4	38	22	5	19	6	11	72	54	—	—	m
35·5	40	23	6	19	5	11	74	53	—	—	i
35·7	39	22	6	18	5	9	70	53	—	—	i
36·0	40	23	6	20	5	10	72	52	—	—	i
36·5	38	22	6	19	7	9	76	54	—	—	i
36·6	39	22	6	18	5	9	72	54	—	—	i
36·6	37	22	5	18	5	10	79	61	—	—	i
36·7	42	23	5	18	5	8	67	52	—	—	i
36·7	39	23	5	19	5	10	70	52	—	—	—
37·0	37	24	6	18	5	11	78	57	—	—	i
37·9	37	23	6	18	5	11	70	52	—	—	i
37·9	36	23	6	19	3	10	78	57	—	—	m
38·2	37	23	6	18	5	11	72	55	—	—	m
38·5	39	22	5	19	5	12	72	53	—	—	m
38·6	40	22	5	20	4	11	73	53	—	—	m
38·8	38	22	6	18	4	—	70	51	20	0	i

FEMALES—*continued.*

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
39·1	39	23	6	17	5	9	72	53	—	—	m
39·2	42	22	6	18	5	9	76	54	—	—	i
39·8	38	24	5	19	5	9	73	54	—	—	m
40·0	40	22	6	19	5	10	75	56	—	—	i
40·2	40	22	5	19	5	11	74	53	—	—	m
40·3	38	23	6	18	5	11	68	50	—	—	i
40·5	39	22	6	19	5	11	70	51	—	—	—
40·7	39	22	6	19	5	10	69	52	—	—	m
40·7	37	22	5	17	5	10	76	56	—	—	m
40·9	39	22	7	18	5	10	75	56	—	—	—
41·8	38	22	5	19	5	11	76	55	—	—	m
42·5	39	23	5	20	5	10	74	55	—	—	i
43·4	43	22	5	18	5	10	71	55	—	—	m
43·7	37	22	5	19	5	12	75	58	—	—	m
44·0	42	23	5	20	4	10	74	55	—	—	m
44·7	39	21	6	20	5	10	73	55	—	—	m
45·0	39	22	6	20	5	10	73	55	—	—	m
45·0	38	22	6	16	5	10	71	54	—	—	m
45·5	37	23	6	17	5	12	75	55	—	—	m
45·7	37	22	5	18	5	10	75	55	23	—	m
46·0	36	22	6	18	4	10	76	57	—	—	m
46·2	40	21	6	19	5	9	73	53	—	—	m
46·3	39	23	6	18	6	10	71	52	—	—	m
46·8	39	23	5	18	3	11	70	52	—	—	m
47·4	40	22	7	17	5	10	70	53	—	—	m
47·5	38	23	5	17	4	11	78	56	—	—	m
48·2	40	23	6	18	5	9	74	55	—	—	m
49·2	37	23	6	18	5	10	74	56	—	—	m
49·3	39	23	5	18	4	12	76	56	—	—	m
49·5	40	25	5	18	4	10	70	54	—	—	m
49·7	38	23	5	19	5	11	73	53	—	—	m
51·0	39	21	6	17	5	11	76	57	—	—	m
51·6	37	23	6	18	5	10	71	57	—	—	m
51·9	38	23	5	17	2	10	74	55	—	—	m
52·7	36	23	5	18	2	9	73	54	—	—	m
52·8	38	22	6	19	5	10	75	53	—	—	m
52·9	38	21	5	19	3	8	72	54	—	—	m
54·8	38	22	5	20	3	11	75	55	—	—	m
55·9	39	23	5	20	5	11	76	57	—	—	m
56·3	38	25	5	17	5	8	75	55	—	—	m
56·8	40	24	5	16	5	11	72	52	—	—	m
63·0	36	24	5	16	5	11	76	56	—	—	m

Locality: North-eastern end of Dogger Bank, 25 fathoms.

MALES. TOTAL NUMBER, 16.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
28·7	38	22	5	19	5	13	72	54	0	0	i
32·8	40	22	7	18	5	10	70	53	0	0	i
32·9	41	21	6	19	5	10	73	54	33	2	i
35·3	40	20	7	18	5	11	70	52	44	3	m
35·4	39	23	6	18	5	10	69	54	17	2	i
36·2	38	22	6	17	5	10	70	55	36	2	?
38·9	40	22	5	19	5	11	74	56	34	2	m
39·2	41	22	6	18	6	9	70	53	34	0	—
42·1	42	21	5	19	6	12	73	54	42	2	m
42·6	41	21	6	19	5	10	68	52	31	4	m
42·7	42	22	6	17	5	10	69	52	44	4	m
43·4	42	22	7	16	5	10	72	55	39	4	m
43·4	40	23	6	18	5	9	74	54	42	4	m
46·2	42	21	6	18	5	10	74	52	41	4	m
47·1	39	21	5	19	7	10	70	55	43	4	m
47·3	35	19	5	17	5	9	75	54	48	5	m

FEMALES. TOTAL NUMBER, 27.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
30·6	41	23	6	18	5	10	75	53	—	—	i
31·3	38	24	6	19	5	10	72	54	—	—	i
33·4	38	23	5	18	5	11	71	54	—	—	i
35·0	39	22	6	19	6	9	74	53	—	—	i
35·2	40	22	6	17	5	10	73	55	—	—	i
38·5	41	22	6	18	6	11	75	55	—	—	i
40·0	43	23	7	18	5	11	74	54	—	—	?
40·1	37	22	6	19	5	10	75	57	—	—	i
40·4	42	23	5	19	5	10	72	53	—	—	i
40·7	41	23	6	18	5	11	72	53	—	—	m
42·8	40	22	6	18	6	11	70	53	—	—	m
43·5	41	21	6	17	4	11	76	56	—	—	i
44·1	39	23	6	19	5	11	72	54	—	—	i
44·4	39	22	6	17	6	10	76	57	—	—	m
44·7	40	23	6	19	7	12	72	53	—	—	i
45·0	42	22	6	19	5	10	75	54	—	—	m
45·1	40	21	6	18	6	11	70	55	—	—	m
45·1	39	22	6	17	5	10	72	55	—	—	m
45·6	38	21	5	17	5	10	80	56	—	—	m
45·7	39	22	5	17	6	12	77	56	—	—	m
45·9	39	22	6	18	5	9	74	56	—	—	m
49·2	41	22	6	16	5	10	79	58	—	—	m
49·3	41	21	6	17	5	11	77	60	—	—	m
50·4	39	21	6	18	6	10	76	57	—	—	m
53·2	40	21	5	17	6	11	74	55	2	2 (trace)	m
55·9	40	22	6	18	5	11	72	54	0	2 (trace)	m
57·0	41	24	6	17	5	10	69	52	—	—	m

Locality : Off South Coast of Iceland.

Specimen in spirit, collected by Mr. Holt.

MALE.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
60·6	40	21	6	19	5	9	72	54	47	5	—

Locality : Fisher Bank, North Sea.

Specimen in spirit, collected by Mr. Holt.

MALE.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
49·1	37	23	6	17	5	11	74	55	51	5	—

Locality : Baltic Sea.

Specimens in spirit, sent to Mr. Holt from Hamburg, probably caught near Kiel.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
MALES.											
23·5	36	23	6	20	4 (flat)	9	64	47	50	4	—
23·8	40	23	7	19	5	9	70	54	50	5	—
24·1	37	23	6	21	5	10	69	52	55	5	—
24·2	38	23	5	21	5 (flat)	9	69	52	49	5	—
25·3	38	22	7	21	5	11	65	48	29	5	—
29·4	38	23	7	19	4	10	73	53	44	5	—
FEMALES.											
23·4	38	25	6	21	5	10	63	48	—	—	m
25·2	39	25	6	22	6	9	70	51	—	—	m
26·8	39	23	6	20	6	11	67	54	—	—	m
30·4	37	22	6	20	6	9	70	55	—	—	m
31·5	41	23	6	17	5	9	75	54	—	—	m

SPECIMENS IN THE BRITISH MUSEUM COLLECTION.

Variety of *Pleuronectes platessa.*

Collected by U.S. Fishery steamer *Albatross*, at Herendeen Bay, Alaska.

Length, cm.	Ht. of Body.	Length of Head.	Cau. Ped.	Cau. Fin.	Tubercles.	Gill Rakers.	D. Rays.	A. Rays.	Ciliated Rays.	Cil. Body.	Maturity.
23·3	42	24	6	18	5	—	70	51	40	0	♂ i

Varieties of *Pleuronectes glacialis.*

Collected by U.S. Fishery steamer in Nushagak River, Alaska.

18·3	39	23	9	16	0	—	55	41	many	5	♀ i
17·1	?	24	8	16	0	—	59	40	many	4	♀ i

Collected at Kotzebue Sound, Alaska.

18·3	39	23	9	16	0	—	53	39	34	5	♀ m

Varieties of *Pleuronectes flesus.*

Pl. Italicus, Günther; *passer*, Bonaparte.

Specimens from Dalmatia.

13·7	37	22	7	18	2	—	58	42	0	—	i
19·6	36	23	8	18	2	—	62	42	22	—	♀ i
20·1	37	23	8	18	2	—	59	42	1	—	?

Pl. 'luscus, Pallas.

Specimens from the Bosphorus.

28·3	42	22	7	18	2	—	60	43	few	—	♀ m
28·3	37	22	8	18	2	—	56	41	28	—	♂ m

Specimens from the Black Sea.

10·5	41	23	6	18	2	—	59	42	some	—	—
10·7	38	25	8	18	2	—	57	43	some	—	—
14·2	39	25	6	21	2	—	60	41	some	—	—

Specimens from Constantinople, labelled *Platessa vulgaris.*

29·1	41	23	8	19	2	—	57	42	some	—	—
34·6	43	21	8	16	2	—	59	43	some	—	—

B.—TABLES SHOWING THE NUMBER OF INDIVIDUALS IN WHICH EACH OBSERVED VARIATION OCCURRED.

Height of Body in hundredths of Total Length.	Plymouth. (15) ♂	(21) ♀	Brown Ridges. (52) ♂	(57) ♀	Norfolk Coast. (49) ♂	(91) ♀	N.E. of Dogger Bank. (16) ♂	(27) ♀	Southern. (67) ♂	(78) ♀	Northern. (65) ♂	(118) ♀
35	1	—	1	—	—	—	1	—	2	—	1	—
36	1	1	7	6	4	4	0	—	8	7	4	4
37	3	2	8	7	6	16	0	1	11	9	6	17
38	3	10	12	12	13	19	2	3	15	22	15	22
39	4	3	14	21	10	27	2	7	18	24	12	34
40	2	3	8	8	11	16	4	6	10	11	15	22
41	1	2	2	3	2	3	3	7	3	5	5	10
42	—	—	—	—	2	5	4	2	—	—	6	7
43	—	—	—	—	0	1	—	1	—	—	0	2
44	—	—	—	—	0	—	—	—	—	—	0	—
45	—	—	—	—	1	—	—	—	—	—	1	—
Length of Head, ditto.												
19	—	—	—	—	—	—	1	—	—	—	1	—
20	—	—	7	1	—	—	1	—	7	1	1	—
21	6	5	11	8	12	7	5	6	17	13	17	13
22	5	9	29	26	26	38	7	12	34	35	33	50
23	4	6	4	21	8	36	2	7	8	27	10	43
24	—	1	1	1	3	8	—	2	1	2	3	10
25	—	—	—	—	—	2	—	—	—	—	—	2
Caudal Peduncle, ditto.												
4	—	—	2	—	—	—	—	—	2	—	—	—
5	9	10	17	21	12	37	5	5	26	31	17	42
6	6	10	30	33	35	48	8	21	36	43	43	69
7	—	1	3	3	2	6	3	1	3	4	5	7

		Plymouth.		Brown Ridges.		Norfolk Coast.		N.E. of Dogger Bank.		Southern.		Northern.	
	Length of Caudal Fin, ditto.	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
	16	—	—	2	—	—	3	1	1	2	—	1	4
	17	1	3	11	16	7	11	3	9	12	19	10	20
	18	5	9	26	28	14	30	6	10	31	37	20	40
	19	7	5	9	10	20	35	6	7	16	15	26	42
	20	2	3	1	3	7	12	—	—	3	6	7	12
	21	—	0	2	—	1	—	—	—	2	0	1	—
	22	—	0	1	—	—	—	—	—	1	0	—	—
	23	—	1	—	—	—	—	—	—	—	1	—	—
	Number of Tubercles.												
	2	—	—	—	—	—	2	—	—	—	—	—	2
	3	2	—	—	—	1	4	—	—	2	—	1	4
	4	2	1	—	—	7	8	—	1	2	1	7	9
	5	9	18	42	45	33	70	13	17	51	63	46	87
	6	2	1	8	12	7	5	2	8	10	13	9	13
	7	—	1	2	—	1	2	1	1	2	1	2	3
	Gill Rakers.		*		*	*	*						
	8	—	—	—	—	1	4	—	—	—	—	1	4
	9	4	4	16	8	9	16	3	2	20	12	12	18
	10	7	14	25	35	30	39	9	12	32	49	39	51
	11	4	2	10	11	6	25	2	11	14	13	8	36
	12	—	—	1	1	2	5	1	2	1	1	3	7
	13	—	—	—	1	—	1	1	—	—	1	1	1

* Not noted in one specimen of each of these groups.

		Plymouth.		Brown Ridges.		Norfolk Coast.		N.E. of Dogger Bank.		Southern.		Northern.	
	Dorsal Rays.	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
ζ	64	—	—	—	1	—	—	—	—	—	1	—	—
ζ	65	—	—	—	0	—	—	—	—	—	0	—	—
η	66	—	1	—	0	—	—	—	—	—	1	—	—
η	67	1	0	1	0	2	1	—	—	2	0	2	1
η	68	0	1	3	3	0	1	1	—	3	4	1	1
η	69	1	0	3	3	3	2	2	1	4	3	5	3
η	70	1	0	4	7	4	9	5	2	5	7	9	11
θ	71	2	1	5	6	6	10	0	1	7	7	6	11
θ	72	3	4	5	5	5	15	2	7	8	9	7	22
θ	73	2	0	11	5	8	14	2	1	13	5	10	15
θ	74	2	5	6	5	10	12	3	4	8	10	13	16
θ	75	1	7	6	6	3	11	1	4	7	13	4	15
ι	76	1	2	5	7	6	11	—	3	6	9	6	14
ι	77	1	—	1	4	0	0	—	2	2	4	0	2
ι	78	—	—	2	1	1	4	—	0	2	1	1	4
ι	79	—	—	—	3	1	1	—	1	—	3	1	2
ι	80	—	—	—	0	—	—	—	1	—	0	—	1
	81	—	—	—	1	—	—	—	—	—	1	—	—

	Anal Rays.	Plymouth.		Brown Ridges.		Norfolk Coast.		N.E. of Dogger Bank.		Southern.		Northern.	
		♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
γ	48	—	—	—	1	—	—	—	—	—	1	—	—
γ	49	—	—	—	0	1	—	—	—	—	0	1	—
γ	50	—	—	2	3	0	1	—	—	2	3	0	1
δ	51	—	2	5	7	4	3	—	—	5	9	4	3
δ	52	3	1	6	7	3	13	4	1	9	8	7	14
δ	53	4	2	10	3	10	17	2	6	14	5	12	23
δ	54	2	1	4	7	10	17	6	6	6	8	16	23
δ	55	2	6	14	13	4	18	3	5	16	19	7	23
ε	56	3	7	6	4	8	12	1	4	9	11	9	16
ε	57	0	2	2	7	7	8	—	3	2	9	7	11
ε	58	1	—	3	4	1	1	—	1	4	4	1	2
ε	59	—	—	—	1	1	0	—	0	—	1	1	0
ε	60	—	—	—	—	—	0	—	1	—	—	—	1
	61	—	—	—	—	—	1	—	—	—	—	—	1

Ciliation.	Plymouth.		Brown Ridges.		Norfolk Coast.		N.E. of Dogger Bank.		Southern.		Northern.	
	♂	♀	♂*	♀	♂*	♀	♂	♀	♂		♂	
None	2	—	1	56	3	88	2	25	3	—	5	—
1. Fins only	5	—	22	1	15	3	1	0	27	—	16	—
2. Also head	6	—	23	—	18	—	5	2	29	—	23	—
3. Also operculum..	1	—	4	—	3	—	1	—	5	—	4	—
4. Also interspinous region	1	—	—	—	2	—	6	—	1	—	8	—
5. More	—	—	—	—	—	—	1	—	—	—	1	—

* Specimens under 26 cm. in length not included.

TABLE SHOWING THE FREQUENCY OF EACH VARIATION WITHOUT SEPARATION OF SEXES.

Height of Body.	Plymouth. (36)	Brown Ridges. (109)	Norfolk Coast. (140)	N.E. of Dogger Bank. (43)	Southern. (145)	Northern. (183)
35	1	1	—	1	2	1
36	2	13	8	0	15	8
37	5	15	22	1	20	23
38	13	24	32	5	37	37
39	7	35	37	9	42	46
40	5	16	27	10	21	37
41	3	5	5	10	8	15
42	—	—	7	6	—	13
43	—	—	1	1	—	2
44	—	—	0	—	—	0
45	—	—	1	—	—	1
Length of Head.						
19	—	—	—	1	—	1
20	—	8	—	1	8	1
21	11	19	19	11	30	30
22	14	55	64	19	69	83
23	10	25	44	9	35	53
24	1	2	11	2	3	13
25	—	—	2	—	—	2
Caudal Peduncle.						
4	—	2	—	—	2	—
5	19	38	49	10	57	59
6	16	63	83	29	79	112
7	1	6	8	4	7	12
Caudal Fin.						
16	—	2	3	2	2	5
17	4	27	18	12	31	30
18	14	54	44	16	68	60
19	12	19	55	13	31	68
20	5	4	19	—	9	19
21	0	2	1	—	2	1
22	0	1	—	—	1	—
23	1	—	—	—	1	—
Number of Tubercles.						
2	—	—	2	—	—	2
3	2	—	5	—	2	5
4	3	—	15	1	3	16
5	27	87	103	30	114	133
6	3	20	12	10	23	22
7	1	2	3	2	3	5

Gill Rakers.	Plymouth.	Brown Ridges.	Norfolk Coast.	N.E. of Dogger Bank.	Southern.	Northern.
8	—	—	5	—	—	5
9	8	24	25	5	32	30
10	21	60	69	21	81	90
11	6	21	31	13	27	44
12	—	2	7	3	2	10
13	—	1	1	1	1	2

Dorsal Rays.	Plymouth.	Brown Ridges.	Norfolk Coast.	N.E. of Dogger Bank.	Southern.	Northern.
64	—	1	—	—	1	—
65	—	0	—	—	0	—
66	1	0	—	—	1	—
67	1	1	3	—	2	3
68	1	6	1	1	7	2
69	1	6	5	3	7	8
70	1	11	13	7	12	20
71	3	11	16	1	14	17
72	7	10	20	9	17	29
73	2	16	22	3	18	25
74	7	11	22	7	18	29
75	8	12	14	5	20	19
76	3	12	17	3	15	20
77	1	5	0	2	6	2
78	—	3	5	0	3	5
79	—	3	2	1	3	3
80	—	0	—	1	0	1
81	—	1	—	—	1	—

Anal Rays.	Plymouth.	Brown Ridges.	Norfolk Coast.	N.E. of Dogger Bank.	Southern.	Northern.
48	—	1	—	—	1	—
49	—	0	1	—	0	1
50	—	5	1	—	5	1
51	2	12	7	—	14	7
52	4	13	16	5	17	21
53	6	13	27	8	19	35
54	3	11	27	12	14	39
55	8	27	22	8	35	30
56	10	10	20	5	20	25
57	2	9	15	3	11	18
58	1	7	2	1	8	3
59	—	1	1	0	1	1
60	—	—	0	1	—	1
61	—	—	1	—	—	1

The Oyster Culture of the Ancient Romans.

By

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With Plate I.

WHILE engaged in the examination of some vase pictures which have been stated to represent certain parts of the shores of the Bay of Pozzuoli as it existed in Roman times, I was struck by two drawings of Roman oyster culture grounds, or ostrearia, which seem to me to be of considerable interest, not only as affording us direct information concerning the method of oyster culture employed by the Romans in the neighbourhood of Baiæ, but also because they show clearly that that method was the same as the one which still survives and is still carried on, in common with so many other Roman customs in the same locality, exactly as it was nearly two thousand years ago.

Our knowledge of the methods pursued by the Romans in the cultivation of oysters is derived from two sources. In the first place we meet with scattered allusions to oysters and their cultivation in many classical authors; and secondly, there are still preserved to us certain vases decorated with views of the apparatus employed in oyster culture.

Although passages alluding to oysters are fairly numerous, Latin authors seem to have found their gastronomic qualities a more attractive theme than their natural history. Some, however, surprise us with the close and careful observation displayed by their remarks.

The credit of having been the first to lay out artificial oyster beds is commonly given to C. Sergius Orata. Orata was Praetor in 97 B.C., and was one of the most noted connoisseurs in the matter of oysters in his time. We read in Valerius Maximus that he closed the Lucrine Lake with extensive and lofty buildings, in order that the molluscs (conchylia) might always be obtainable in a fresh condition. The works undertaken by Orata were evidently necessary to preserve the tranquillity of the waters of the oyster grounds, because it is probable that in stormy weather the waves rolled right into the lake from the sea (Strabo). It is further recorded that Orata became involved in a lawsuit with one Considius, who held that the Lucrine waters had been leased to him by the State, whose property they really were.

Notwithstanding his lawsuit he derived, writes Pliny, great profit from the oysters which he grew in his "ostrearum vivarium," and which he advertised as the finest obtainable. It must be remembered that at that time Britain had not begun to supply the Roman market with the much-praised Rutupian* oysters.

In Pliny's day, oysters were brought by sea from Brundusium to the Lucrine, where they were fattened after their long voyage. Pliny unfortunately gives no details which might enable us to form some opinion of what an "ostrearum vivarium" was like, although he has plenty to say about the conditions favourable to their growth. He states that they like the fresh water of streams falling into the sea; in the open sea they are small and rare. They grow best at the beginning of summer, wherever the sunlight beats upon the bottom. If they cannot be reached by the sun's rays they grow more slowly and eat little for sadness. The best are found on firm ground, on rocks, not on sand or mud. They are not tolerant of being transplanted to other waters.

The only passage with which I am acquainted that may be construed as referring to the artificial cultivation of oysters on ropes, which will be described in detail below, occurs in the comparatively late author Ausonius, who flourished in the latter half of the fourth century A.D. Ausonius writes of oysters, *quae Baianis pendent fluitantia palis.* This to my mind means that at Baiæ the oysters hang swaying about in the waves on the stakes—an interpretation which agrees perfectly with the vase drawings to be described. Ausonius certainly could not have applied the word *fluitantia* to oysters lying immovable on the bottom of the sea.

Owing to the absence of any detailed description of artificial oyster cultivation as practised by the Romans, the two vase pictures have a unique archæological interest, and constitute the only real foundation for our knowledge of Roman oyster culture.

One representation (Fig. 1) occurs upon a glass vase, which was found at Piombino, the ancient Populonia, and was figured and described by Domenico Sestini, when it formed part of the collection of the Grand Duchess of Tuscany, Princess of Lucca di Piombino. The vase is almost globular, with a narrow tubular neck. Its height is 25 cm.; widest diameter 13 cm. The lower globular portion of the vase is decorated with a scene, which has been identified with the coast

* Richborough.

between Puteoli and Baiæ, as it existed in Roman times. It is not impossible that both this vase and others like it were sold at Roman watering-places to the visitors as mementoes of their holiday, just as similar topographical crockery is sold at our own seaside resorts to our more sentimental contemporaries.

The Piombino vase bears a panoramic view of the chief buildings along a coast line. At one end of the picture is a pier carried on four arches jutting out over the water. Upon the pier are two columns, with birds, inscribed PILAE, and two arches bearing four sea-horses. At the land end is a building with four gables, a type very common in Pompeian frescoes. Then follow two large buildings, perhaps built on piles, and connected by a bridge beneath which are the OSTRIARIA. At the sides of the two large buildings and also behind the ostriaria are indications of waves. The vase bears the following inscription:—

ANIMA · FELIX · VIVAS

STAGNU · PALATIU P
I
OSTRIARIA RIPA L
A
E

If the scene be really a representation of a portion of the Bay of Baiæ and of the pier of Puteoli, the STAGNU referred to must be the Lucrine Lake.

The other vase (Figs. 2 and 3) is smaller, being less than half as high as the Piombino vase. It was originally described by De Rossi some forty years after Sestini had published the first, and is now in the Museo Borgiano di Propaganda Fede at Rome. It bears the inscription:—

MEMORIAE · FELICISSIMAE · FILIAE
FAROS · STAGNU · NERONIS · OSTRIARIA · STAGNU · SILVA · BAIAE.

Beneath the inscription are depicted several buildings, to the left of which is a reclining female figure holding two palm-branches in her right hand, and supposed by De Rossi to impersonate Baiæ.

To the right of this allegorical figure follow drawings of the objects specified in the inscription. The lighthouse (FAROS), pond or marsh (STAGNU(M) NERONIS), a wood (SILVA), and two buildings of similar architecture, with oyster-culture (OSTRIARIA) in between, are all represented.

The exact localisation of the scene is not an easy matter. Authorities are not agreed on the question whether the bit of coast lies to the south or east of Baiæ, nor even as to whether the view has been sketched from the sea or from the land. Those who support the last theory base their conviction on the fact that there are lines indicated between the houses, which they believe to represent waves of the sea as viewed by a spectator looking seawards. According to this theory the scene would have been situated to the south of Baiæ. The lighthouse (FAROS) might have been built on the site of the Fortino la Tenaglia, just beneath the hill on which Toledo's castle now stands; and the oyster-culture ground (OSTRIARIA) might have been in the shallows between the Fortino la Tenaglia and Baiæ, where at the present day from a boat many ruined walls can be seen below the clear water. On the other hand, it may be urged that if indeed the lines seen between the houses were meant to indicate water and not to be purely decorative, they might with equal truth represent the ripples of the Lucrine Lake seen from the sea, and their obviously artistic effect might have induced the artist to fill up his background with similar lines all round the vase.

Be the scene where it may, there can be no doubt that here we have a contemporary representation of Roman oyster cultivation not far from Baiæ.

Before proceeding to describe the ancient system of cultivation, a brief sketch of the modern system may facilitate the interpretation of the details shown none too clearly in the vase drawings. The method of culture employed at the present day in the Lucrine Lake is a method of *hanging culture*, as opposed to oyster culture in beds on the bottom.

The oysters are attached to coarse ropes, of loosely-twisted or plaited spartum grass, by being thrust between the strands (Fig. 6). These ropes, called *pergolari* at Taranto, are hung in the water from other ropes which are stretched horizontally between stakes driven into the mud at the bottom of the shallow lake. The tops of the stakes, and the horizontal ropes connecting them, are usually conspicuous objects on the surface of the water (Fig. 4). In the Mare piccolo, or inner harbour of Taranto, and in Lake Fusaro * (Fig. 5), a similar method of culture obtains. At Taranto the horizontal ropes are arranged so as to enclose quadrangular spaces, which are known as *sciaje*.

If we now turn to the OSTRIARIA as depicted on the vases, we find that the oysters and pergolari are shown as well as the perpendicular stakes, but that the modern horizontal ropes are replaced by more solid cross poles of wood. The ropes (*pergolari*) used for suspending the

* For a description of the oyster culture of Lake Fusaro, see Coste's *Voyage d'exploration sur le Littoral de la France et de l'Italie.* Although he makes no statement to that effect, Coste's illustrations (cf. Figs. 9–12) would lead one to suppose that the round objects hanging from the framework of the Roman ostrearia were intended to be baskets of oysters similar to those in use at the present day, both in Lake Fusaro and in the Lucrine, in addition to the ropes of the larger oysters. This interpretation may apply to the Piombino vase-picture, although even there the ropes project beyond the round objects, but does not, I think, agree with the Borgiano vase-picture so well as the one advanced above. My thanks are due to Mr. E. J. Allen for drawing my attention to Coste's memoir.

oysters were evidently of a very rough make, to judge from the inequalities represented in Fig. 1.

The structure of the framework is rather difficult to make out. The drawings were apparently intended to show both the front elevation and the top view of the framework. In the Borgiano vase (Fig. 2) the framework is quite regular, and consists of four bars crossing five others at right angles (cf. the *sciaje* of Taranto). At the intersection of the bars a number of lines are drawn which may possibly represent either pegs or cord lashings used to fix or tie the bars together. The horizontal framework was supported by a number of vertical posts. Of these four are represented, and between them are shown three ropes with three oysters each. On the right-hand side is another similar rope of oysters, and above it two bars crossing, which were probably used to strengthen the fabric.

On the Piombino vase (Fig. 1) the picture of the ostrearium probably represents a similar view. The ostrearium lay between two houses and under a bridge—an arrangement analogous to that of the oyster cultivation of Lake Fusaro, accidentally shown in a photograph taken by myself (Fig. 5). Here, too, the end of the bridge abuts on an isolated building, the pleasure-house constructed by Ferdinand I. (not shown in Fig. 5). The poles for the oysters may be seen projecting above the water both beyond and under the bridge. In the Piombino vase the cross-bars of the framework are not arranged with such regularity as on the Borgiano vase.

In conclusion, the object of the present communication is to demonstrate that the only type of artificial oyster culture of the ancient Romans, of which we have an adequate knowledge, was the method of hanging rope culture, which still continues to exist at the the same spot, viz. the Lucrine Lake and its neighbourhood, and in an almost identical manner. Even the importation of oysters into the Lucrine is similar. At the present time they are brought from Taranto. In the days of the Romans, according to Pliny, they were imported from Brundusium.

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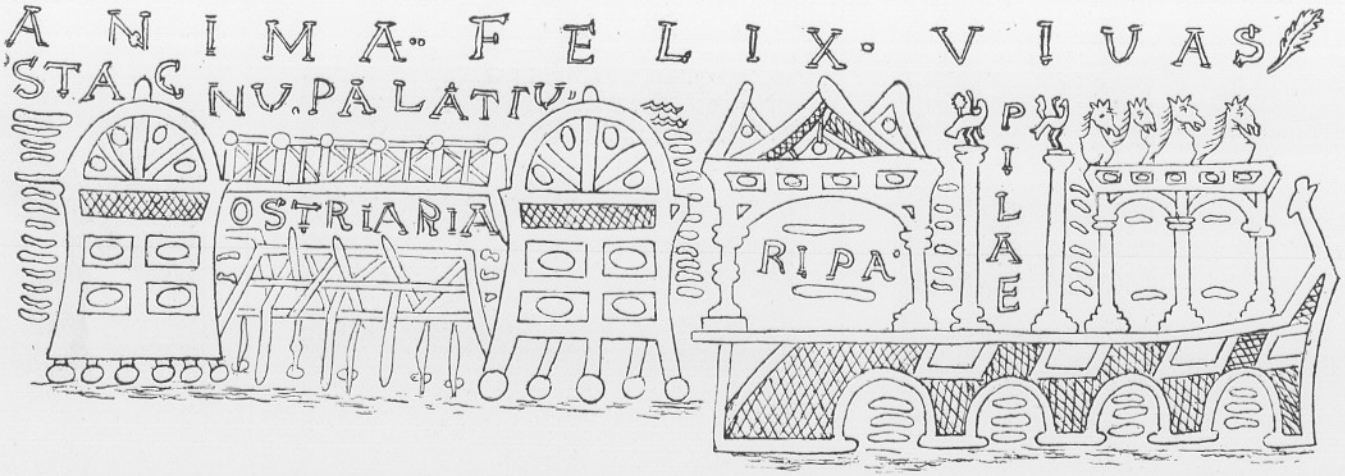

Fig. 1.

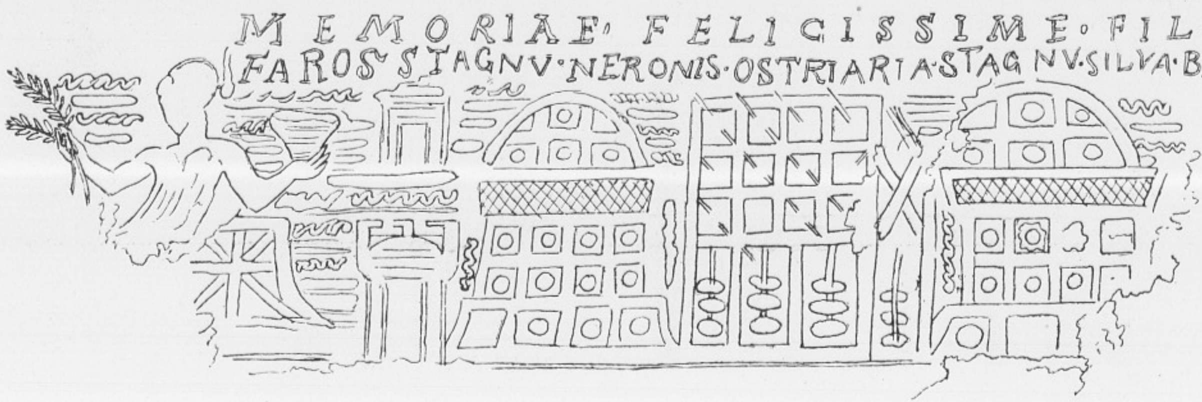

Fig. 2.

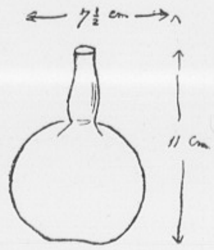

Fig. 3.

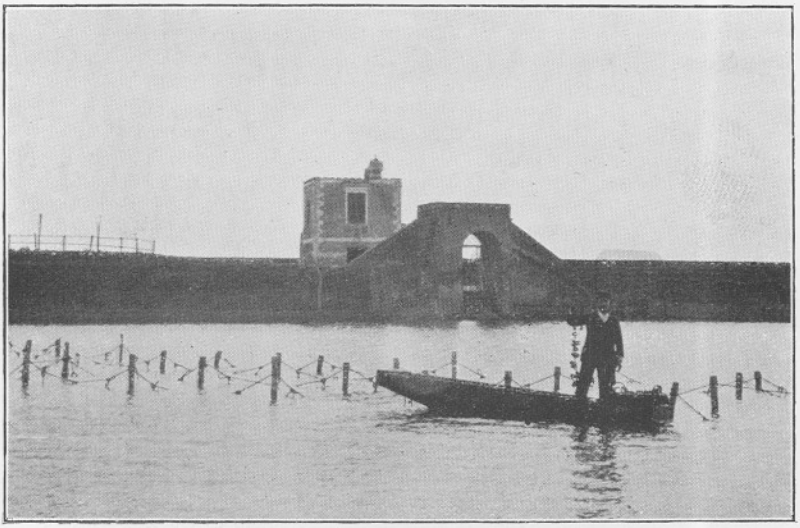

Fig. 4.

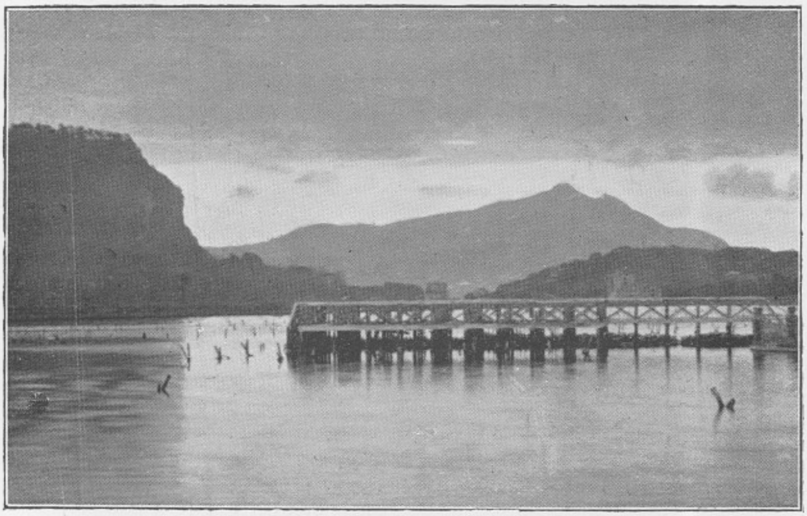

Fig. 5.

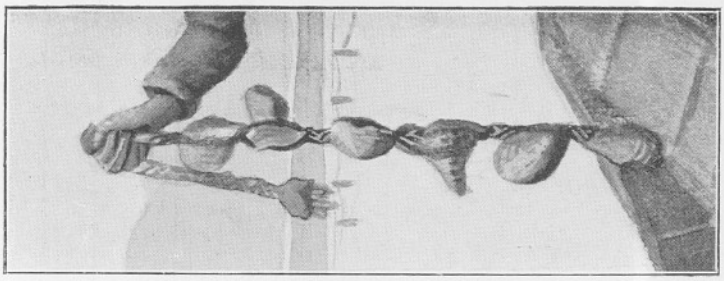

Fig. 6.

EXPLANATION OF PLATE I.

Illustrating Mr. R. T. Günther's Paper on "The Oyster Culture of the Ancient Romans."

Fig. 1.—OSTRIARIA beneath a bridge connecting the upper stories of two buildings, similar to those represented in Fig. 2. One oyster is shown attached to each rope. To the right is a pier. Piombino vase. After De Rossi.

Fig. 2.—OSTRIARIA and buildings near Baiae. Three oysters are attached to each rope. The ropes hang from a framework, as in Fig. 1. Borgiano vase. After De Rossi.

Fig. 3.—Glass vase. Museo Borgiano.

Fig. 4.—Oyster culture in Lucrine Lake. The man in the punt is shown holding up a rope of oysters (cf. Fig. 6), which he has just detached from the cross-ropes between the posts.

Fig. 5.—View of Lake Fusaro, showing the upper ends of the posts used to support the oysters. On the left is the steep profile of the Monte di Procida. The volcanic peak in the distance is Mont' Epomeo in Ischia.

Fig. 6.—Rope with oysters (*pergolaro*), showing mode of insertion between the strands. I am indebted to Mr. C. Hallett for this sketch from my photograph.

Recent Reports of Fishery Authorities.

The Scottish Report for 1895.

Fourteenth Annual Report of the Fishery Board for Scotland, being for the year 1895. *Edinburgh,* 1896.

The Effect of the Closure of Inshore Areas upon the Size and Abundance of the Food-Fishes which they contain.—In the Report under consideration Dr. T. Wemyss Fulton, the Scientific Superintendent of the Scottish Fishery Board, publishes an important Review of the Trawling Experiments of the *Garland* in the Firth of Forth and St. Andrews Bay in the years 1886–1895. As is well known, these areas have been closed to trawlers during the ten years under consideration. The Board's steamboat *Garland* has from time to time made experimental hauls with a 25 ft. beam-trawl along certain fixed lines within the areas, the fish captured being measured and recorded, and the results of the experiments published from year to year in the Reports. After ten years' work, Dr. Fulton now gives a general review of the whole investigation, and indicates the conclusions to which, in his opinion, the results of the experiments seem to point.

The views expressed are of so much importance that we prefer to give the account of the manner in which the observations were recorded, and the summary and general conclusions, in Dr. Fulton's own words:—

"In conducting the trawling experiments the aim has been, as far as possible, to trawl over each station at intervals of about a month, and to keep careful records of each haul, and of the conditions under which it was made. The regular trawling work has been done only in the day-time . . . . The observations at each station comprised (1) the date and hour of the haul and its duration; (2) the temperature of the air and of the water at surface and bottom; (3) the density of the water at surface and bottom; (4) the transparency of the water, as indicated by the depth at which an enamelled disc just ceased to be visible; (5) the direction and force of the wind, the state of the tide, the condition of the weather and of the sea in regard to surface disturbance, and the height of the barometer — the temperature, density, and other observations being taken at the beginning and at the end of the trawling; that is to say, at each end of the station; (6) the nature of the pelagic fauna, collections being made by means of tow-nets at surface and bottom, and occasionally at intermediate depths; (7) the number of each species of fish, and the length of each individual caught in the trawl; (8) the nature and relative abundance of the invertebrate organisms found in the trawl, which form a large portion of the food of the bottom-living fishes."

"SUMMARY AND CONCLUSIONS.

"While the trawling experiments of the *Garland* in the Firth of Forth and St. Andrews Bay have been productive of a great body of scientific knowledge respecting the reproduction, spawning areas, and the natural history generally of the food-fishes, the immediate practical object in view was to ascertain the influence which the cessation of beam-trawling would have upon the relative abundance of the food-fishes within the closed areas. The method adopted for this purpose has been already explained, namely, the periodic examination of certain selected stations in each of the areas, the enumeration and measurement of the fishes caught, and the comparison of the statistics thus obtained from month to month and year to year. A question which confronts one at the outset is whether the period during which the experiments have been carried on is sufficiently long to enable definite conclusions to be formulated with certainty. It is evident, on the one hand, that if trustworthy conclusions in regard to the influence of beam-trawling can be drawn from the ten years' experiments in the Firth of Forth and St. Andrews Bay, it is unnecessary that they should be continued there. On the other hand, it would be obviously unwise to terminate them until definite conclusions are obtained, since so much depends upon them.

"The problem is complex, inasmuch as the natural causes, which are of course by far the most important in producing fluctuations in the abundance of the food-fishes in any given area, are very variable and very obscure. There is in the first place the group of physical influences, such as the weather, storms, currents, and temperature, acting directly upon the fishes themselves at all stages of their life, from the floating egg onward to the adult condition, and upon the organisms upon which they feed; and in the second place, a group of biological causes, such as variations in reproductive activity, migrations from the closed area to the outer waters, and *vice versa*, and the presence, or absence, of other fishes upon which particular species feed, *e.g.*, the herring. For example, it was discovered by the fine-meshed nets of the *Garland* that in the autumn of 1889 a vast shoal of young whiting —computed after careful observations to number over 200,000,000— was present in the Firth of Forth. They were too small to be caught that year in the ordinary net used in the trawling experiments, and the average for that year was not large. But in 1890 the average number rose in the closed waters of the Forth from 13·6 to 56·9, and in the open waters from 19·9 to 121·6; and the fishermen in the district caught very nearly double the quantity of whitings that they did in 1889. This increase in the abundance of whitings was local, and may have been due to a combination of causes. Another example was the sudden and extraordinary abundance of small haddocks all along the east coast of Scotland in 1893. In the Firth of Forth the average sprang up from 22·1 to 118·8 in the closed waters (over 1000 being sometimes taken in a haul), and in the open waters from 42·4 to 176·3; and in the closed waters of St. Andrews Bay the average rose from 1·0 to 23·8, and in the open area from 8·8 to 43·8.

"These instances will suffice to show how sudden and marked the natural fluctuations may be, and how they tend to obscure the influence of a minor though constant factor, such as a mode of fishing. The answer to the question as to how long it is necessary to continue the observations in the Firth of Forth and St. Andrews Bay depends to a large extent upon the continuity of the results underlying the variations, as determined by a comparison of the averages in the first and second parts of the period during which they have been carried on. From the statistical analysis given in the foregoing pages, and summarised below, it appears to be fairly well proved that there has been a diminution of the more important flat-fishes in the closed waters, instead of an increase, as was anticipated; and that this may probably be traced to the influence of beam-trawling in the open waters where the fishes spawn; but with regard to round-fishes, which are more numerous and migratory, the same conclusion cannot at present be drawn. In my opinion, after full consideration of the question, the best course is in the meantime to suspend the trawling experiments in the Firth of Forth and St. Andrews Bay, and to carry them on systematically in the Firth of Clyde and the Moray Firth. Both of these areas contain within the closed limits extensive spawning grounds (which are absent from the Firth of Forth and St. Andrews Bay) that are frequented by successive shoals of the food-fishes at the spawning time; and it is of great importance to ascertain the effect of the protection of these spawning places.

"The statistics of the ten years' observations in the Firth of Forth and St. Andrews Bay point to the following conclusions:—

"1. No very marked change has taken place in the abundance of the food-fishes generally within the closed or open waters since the prohibition of trawling. The average number of the food-fishes (taken together) caught in each haul of the net in the years 1886–1890 was 242·6 in the closed waters of the Forth, and 160·9 in the open waters; in the closed waters of St. Andrews Bay the average was 290·2, and in the open waters 190·4. In the five years 1891–1895, the general averages were 252·8 for the closed area of the Forth, and 171·7 in the open area; for the closed area of St. Andrews Bay the average was 184·5, and for the open area 182·7. There was thus a decrease in both areas of St. Andrews Bay, and an increase in both areas of the Forth.

"2. Among round-fishes, cod increased in numbers in all the areas, closed and open. Haddocks increased in the closed and open areas of the Forth, and in the open waters of St. Andrews Bay, and decreased in the closed waters of St. Andrews Bay. Whitings decreased in abundance in all the areas, and gurnards increased in the closed waters of the Forth, and decreased in the other three areas.

"3. Flat-fishes, taking the different kinds together, increased in the open waters of St. Andrews Bay, and decreased in all the other areas. Plaice decreased in all the areas to the extent of 8·7 fishes per haul of the net in the closed waters of the Firth of Forth, and no less than 74·9 fishes per haul in the closed waters of St. Andrews Bay; in the open waters of St. Andrews Bay the decrease was 23·1 fishes per haul, and in the open waters of the Forth, where they are scarcer, 0·6 per haul. Lemon soles, in like manner, diminished in abundance in all the areas—to the extent of 8·4 fishes per haul of the net in the closed area of the Firth. In the other areas, where they are much scarcer, the decrease was less striking. These are the most important and valuable of the flat-fishes obtained: turbot and brill were not caught in sufficient numbers to enable an average to be usefully calculated. On the other hand, the common and abundant dabs, commercially of little importance, increased rather than diminished in numbers. The common dab increased in the closed area of the Forth by 8·9 fishes per haul, and in the open area of St. Andrews Bay by 29·3 fishes per haul; they decreased in the closed area of St. Andrews Bay by 20·3 fishes per haul, and in the open waters of the Forth by 2·1 per haul. The long rough dab increased in all the areas, except in the closed area of St. Andrews Bay, where they are very scarce, the decrease there being 0·5 per haul. In the closed waters of the Forth their increase amounted to 6·2 fishes per haul, and in the open waters to 4·9 per haul; in the open waters of St. Andrews Bay the increase was 3·3 per haul.

"These facts in connection with the relative abundance of flat-fishes are of importance. On the face of it, it appears strange that there should have been a fairly continuous decrease in the numbers of plaice and lemon soles in the closed waters throughout the period. Fluctuations have undoubtedly occurred from year to year, but, as has been frequently pointed out in previous reports, the statistics show a fairly steady falling off in the abundance of the species; and of such a character, when compared with the variations of other species, as to preclude the idea that it is due to the operation of natural causes. It was naturally expected that the prohibition of the use of the beam-trawl in the Firth of Forth and St. Andrews Bay would be followed by an increase and not by a decrease in the numbers of these species within the closed area, because the beam-trawl is the most effective fishing instrument by which they are captured, and its interdiction was equivalent to the removal probably of their greatest enemy.*

"But such has not been the case. Before dealing with the probable cause of the falling off among plaice and lemon soles attention may be directed to the increase in the numbers of common dabs and long rough dabs, which may be said to have taken the place to some extent in the closed waters of the more valuable flat-fishes. Taking the figures for the closed area of the Firth of Forth as the result of 574 hauls of the net during the ten years, the decrease in the number of plaice caught per haul of the net is found to have been 8·7, and of lemon soles 8·4, a decrease almost exactly counterbalanced by the increase in common dabs, which was 8·9, and in long rough dabs, which was 6·2. This clearly indicates a change in the relative proportion of the flat-fishes in the area, from whatever cause arising. Now there are some important differences in this connection between the dabs on the one hand, and the plaice and the lemon soles on the other. The dabs become mature while still comparatively small, and escape in great numbers through the meshes of an ordinary trawl net, and they spawn to a large extent in the closed waters. Plaice and lemon soles, on the contrary, do not spawn within the closed waters, and immature individuals are caught in great numbers by the ordinary trawl net. Thus the size at which common dabs and long rough dabs become mature is about 5 inches—the males frequently at a smaller size—while plaice do not become

* "The proportion of the fish present in a given area that may be captured by fishing apparatus is frequently under-estimated. Of several thousands of plaice, marked for future identification and returned living to the closed waters, about 12 per cent. were subsequently recaptured and returned to me within 18 months—and mostly within a few months—of their liberation. They were nearly all retaken in the closed waters by hook; and as there is no reason to suppose that the marked fish were more prone to seize the bait than the fish around them which had not previously been captured, it may be assumed that at least 1 in 9 or 1 in 10 of the plaice living on an area fall victims to the hook of the fisherman. With the beam-trawl the proportion would have been very much greater.—*Vide* 'An Experimental Investigation on the Migrations and Rate of Growth of the Food Fishes,' Part III., *Eleventh Annual Report*, p. 176."

mature until they are 13 or 14 inches long, and lemon soles not until they reach a length of 9 or 10 inches.*

"The consequence of this difference in the length when sexual maturity is first reached in the two groups is that all adult plaice and lemon soles, and large numbers which have not yet reached maturity, which enter an ordinary trawl net, cannot escape through the meshes, and are captured; while large numbers of adult dabs of both species, and by far the greater proportion of the immature, do escape through the meshes of the net, and are therefore not caught. In other words, the ordinary beam-trawl is not anything like so destructive to dabs as to plaice and lemon soles. The special experiments made on the *Garland* bring out this matter in a marked manner.†

"Thus in 43 hauls of the *Garland's* ordinary net, having meshes in the cod-end of 1½ inches from knot to knot, 2705 plaice of all sizes were retained in the net, and only 67 escaped through the meshes; among lemon soles 371 were retained, and 154 escaped; among common dabs 3367 were retained and 9892 escaped; and among long rough dabs 506 were retained, and 2562 passed through the meshes. Of the 67 plaice which escaped, 59 were 7 inches or less in length, and only 8 above that size (8 inches); of the 154 lemon soles none were above 7 inches; of the 9892 common dabs which found their way out of the net, 2086 were 6 inches or over—that is to say, of adult size—and 5426 were 5 inches in length, or about the size at which maturity is reached; of the 2562 long rough dabs which escaped, 1238 were 5 inches or over.

"The other point is also of importance, namely, the place where the fishes spawn; and the information on this subject obtained by the *Garland* is of great value.‡ The plaice and the lemon sole spawn outside the territorial waters, and therefore beyond the limits of the closed areas. All the plaice and almost all the lemon soles in the Firth of Forth and St. Andrews Bay come in from the outer waters, their floating pelagic eggs, or their equally helpless larvæ, being borne in by the currents; or some may have migrated thither at a later stage. The abundance of these forms in the closed areas is therefore strictly and directly dependent on the outer seas. It is not the same with the dabs. They seem to spawn indifferently in the closed and in the open waters, although spawning individuals are rather more numerous in the latter.

* "*Vide* 'Observations on the Reproduction, Maturity, and Sexual Relations of the Food-Fishes,' Part III., *Tenth Annual Report*, p. 232."

† "*Vide* 'The Capture and Destruction of Immature Sea Fishes,' Part III., 'The Relation between the Size of the Mesh of Trawl Nets and the Fish Captured,' Part III., *Twelfth Annual Report*, p. 302."

‡ "*Vide* 'The Spawning and Spawning-Places of Marine Food-Fishes,' Part III., *Eighth Annual Report*, p. 257; also Part III., *Tenth Annual Report*, p. 235."

An area like the Firth of Forth is therefore, to a very large extent, independent of the outer seas so far as concerns its supply of dabs, it being in large measure self-productive.

"The differences above described between the plaice and lemon soles and the dabs seem to furnish a reasonable explanation of their decrease and increase respectively. When beam-trawlers were prohibited from working in the Firth of Forth and St. Andrews Bay, they naturally concentrated their efforts in the free waters outside, and trawling operations there have very greatly increased since the Bye-laws were passed. The immediate consequence of the cessation of trawling in the Firth of Forth and St. Andrews Bay appears to have been an increase in the abundance of flat-fishes within the closed areas, as shown by the very high averages in the year 1887. The fact that this increase was not only not maintained, but that a progressive decrease in plaice and lemon soles occurred subsequently, indicates another influence, namely, excessive trawling on the offshore grounds where these fishes spawn. This would affect the abundance of the important flat-fishes, such as plaice and lemon soles, in two ways. By general overfishing, the numbers are decreased on the fishing-ground, as indicated by the averages for the open area; and in the second place, by the removal of too great a proportion of the mature spawning fishes, the supply of floating eggs and larvæ to the inshore closed areas, and upon which they are dependent, is diminished below the normal, with the result that the supply of adults is also subsequently diminished. This appears to me to be the only feasible explanation of the facts stated, and it would indicate protection of the spawning areas as the proper course to be pursued. The protection of the immature fishes, which has been so strongly advocated by many authorities, will not, it can be safely said, be sufficient in the areas under consideration. This is clearly proved by the fact that the fish which, above all others, has the nurseries of its young located in the inshore waters is the plaice. The distribution of immature plaice is special in this respect, by far the largest number being got near the shore, and fewer and fewer the further from the shore.* In the Firth of Forth and St. Andrews Bay immature plaice have therefore been particularly well protected since 1886, and yet this is the species whose diminution is most marked.

"The results of the trawling experiments hitherto conducted in the Firth of Forth and St. Andrews Bay point to two main conclusions of great importance for fishery regulations. One, which may be regarded as demonstrated, is that the mere closure of even large areas in the territorial waters, such as the Firth of Forth and St. Andrews

* "*Vide* 'The Distribution of Immature Sea Fish and their Capture by various Modes of Fishing,' Part III., *Eighth Annual Report*, p. 166."

Bay, which are destitute of spawning-grounds, will have little or no permanent effect in increasing the abundance of the important food-fishes, and especially the flat-fishes, within them. The other, which, although highly probable, has not yet been actually demonstrated by experiment, is that protection of the offshore spawning-grounds for certain periods is the most likely method of increasing the abundance of the fishes in the inshore waters. In completion of the experiments in the Firth of Forth and St. Andrews Bay, it would be desirable if a part at least of the offshore waters from which the supplies of floating eggs and larvæ to these areas are drawn were closed during the spawning season. It would then be possible to ascertain, by comparison of the results with those already obtained, to what extent protection of spawning areas will lead to an increase in the fish supply within the territorial waters. The extent and situation of the offshore areas which stand in this direct and close relationship to a given portion of the territorial waters have not yet been satisfactorily determined; but experiments are now being made to clear up this point."

The Dunbar Hatchery.—Mr. Harald Dannevig gives an account of the working of the Marine Hatchery at Dunbar during 1895. Three species, the turbot, the lemon sole, and the plaice, were dealt with. As in previous years, the great difficulty has been in obtaining a sufficient supply of spawning fish in a healthy condition. In the case of the turbot, the supply consisted of thirty-four fish, which had to be brought to Dunbar from Girvan on the west coast, and no natural spawning took place. Eggs were, however, pressed from the ripe fish and successfully fertilised. About 3,800,000 larval turbot were hatched and distributed in the neighbourhood of Dunbar.

Less difficulty was experienced with the lemon soles, which, when they reached the hatchery uninjured, spawned naturally. About 4,480,000 fertilised eggs were obtained during the season from a stock of sixty-eight healthy fish, and from these 4,145,000 larvæ were successfully hatched out and distributed in the local waters and westwards as far as the Bass Rock, the loss of eggs during development being thus only 7·5 per cent.

In the case of the plaice again it was found necessary, in order to ensure a good supply of eggs, to press them from the ripe females and artificially fertilise. In this way 14,970,000 eggs were obtained, and from them 11,350,000 larvæ were hatched. About 7,000,000 of these larvæ were distributed in the North Sea in the neighbourhood of Dunbar. It was considered advisable, however, to test, if possible, the effect produced by thus placing large numbers of newly-hatched larvæ in the sea, and in order to do this it was determined to attempt to place them in a more or less confined area. For this purpose Loch

Fyne, on the west coast of Scotland, was selected, 4,000,000 larvæ being conveyed there by train in four separate consignments. The transport appears to have been fairly successful, though on two occasions the larvæ are reported as showing a certain amount of weakness when put out in the loch. This difficulty will no doubt be got over after further experience in the best methods of transport has been gained.

THE OYSTER BEDS OF THE FIRTH OF FORTH.—Dr. Fulton contributes a second valuable paper to the Report, in which he discusses the past and present condition of the oyster beds in the Firth of Forth. The causes of the exhaustion of the beds are considered, and various suggestions made as to the measures which should be adopted in order to make them again productive. Dr. Fulton considers that the present condition of the beds is entirely due to improper fishing and the neglect of efficient regulations; and further, that there is still a chance of restoring at least a part of them by judicious aid. The measures recommended are (1) the laying down of a stock of oysters to furnish spat; (2) the supply of suitable cultch for the reception of the spat; and (3) keeping the ground clean and as free as possible from enemies. As no oysters are so suitable for any locality as the oysters which naturally live there or in the neighbourhood, by far the best means of obtaining the breeding stock would be to collect the oysters at present scattered over the beds, and to lay them down in one or more selected places. This might be done by purchasing from the fishermen the oysters taken when dredging for mussels and clams. The oysters thus obtained for breeding purposes might be supplemented by others obtained elsewhere.

In order to obtain a supply of clean cultch for the spat to settle upon, mussel and clam shells might be collected from the various villages and exposed to the sun and air until the spatting time, when they should be strewn on the various grounds. Dr. Fulton calculates that an expenditure of £600 per annum for five or six years would be sufficient to carry out the scheme he recommends, including the protection of the areas where the breeding stock was deposited. On the other hand, the fishermen on the south side of the Firth of Forth have lost during the last twenty years fully £150,000 by the exhaustion of the beds, to say nothing of the loss to the citizens.

RATE OF GROWTH OF THE HERRING.—Mr. Masterman's paper, "On the Rate of Growth of the Food-Fishes," deals with the rate of growth of the Herring at St. Andrews, and the author gives the following summary of his conclusions:—"The young larva, hatched at from 5 to 7 mm. ($\frac{2}{10}$ inch) in length, lives near the bottom till some 10 mm. ($\frac{4}{10}$ inch) is attained by a rapid increase in length. The attenuated post-larval herring then migrates upwards through the mid-water to the surface, the mid-water stage lasting from about 10 mm. ($\frac{4}{10}$ inch) to

23–24 mm. ($\frac{9}{10}$ inch), and the surface stage from 24 mm. to 27–28 mm. (about 1 inch), when a movement shorewards takes place, and the littoral habit is acquired." The young herring of the spring-spawning remain near shore, chiefly at the mouths of rivers, until mid-winter, when the length of some 50 mm. (2 inches) has been reached. They are not found during the spring and summer, but recur in the same localities in the autumn with a length of about 80 mm. ($3\frac{1}{5}$ inches), which is increased to 100 mm. (4 inches) by the end of the year.

OTHER PAPERS.—Dr. J. H. Fullarton contributes a memoir on the European Lobster, in which he deals chiefly with the breeding and development of that animal. His results agree in the main with those obtained by Ehrenbaum in Heligoland, a full account of which was given in this Journal, vol. iv. pp. 60–69. A series of figures is given, showing the external appearance of the embryos and larvæ at various stages of development.

Amongst the other papers may be mentioned Professor M'Intosh's "Contributions to the Life-Histories and Development of the Food and other Fishes," and Mr. Thomas Scott's faunistic papers, dealing with the Firth of Forth, the inland waters of Scotland, and the inland waters of the Shetland Islands.

The Danish Report.

Report of the Danish Biological Station to the Home Department. V. 1894. *By C. G. John Petersen, Ph.D., Copenhagen,* 1896.

THE BRIDAL-DRESS OF THE COMMON EEL.*—Dr. C. G. J. Petersen's paper—"The Common Eel (*Anguilla vulgaris, Turton*) gets a particular breeding-dress before its emigration to the sea. The bearings of this fact on the classification and on the practical Eel-fisheries"—forms an important contribution to the solution of the mystery which has surrounded the life-history of the eel, and serves to complete the brilliant observations of Professor Grassi, an account of which was given in this Journal two years ago by Mr. Cunningham.

Three different kinds of eel have been recognised both by fishermen and naturalists. Thus Yarrel distinguishes three species, the sharp-nosed eel—silver eel of the fishermen—(*Anguilla acutirostris*), the broad-nosed eel—grig or frog-mouthed eel of fishermen—(*Anguilla*

* On this subject compare also Professor G. B. Grassi, "The Reproduction and Metamorphosis of the Common Eel (*Anguilla vulgaris*)." *Proceed. Roy. Soc. London*, No. 363, December, 1896. An account of Grassi's observations is given by Cunningham, "The Larva of the Eel," *Journ. Mar. Biol. Assoc.*, vol. iii. pp. 278-287.

latirostris), and the snig or yellow eel (*Anguilla mediorostris*). Later authors have, for the most part, regarded the three kinds as varieties of one species, *Anguilla vulgaris*. Günther, however, in his *Catalogue of the Fishes in the British Museum*, attempts to distinguish two species, *A. vulgaris* and *A. latirostris*, the latter being the frog-mouthed or broad-nosed eel of Yarrel.

In the Report now under review Petersen regards the three so-called varieties as representing three stages in the development of one and the same animal, and his conclusions, based upon a large number of carefully-considered observations, appear to be well founded. Briefly stated the result arrived at is, that the yellow eels comprise both males and females, but are all young fish, which have not yet commenced to assume the bridal-dress of the adult, and in which the generative organs are little developed. The frog-mouthed eels are larger females still in the same conditions, whilst the silver eels comprise both males and females which have taken on the bridal-dress. The generative organs of the latter class are more fully developed, and the animals just on the point of migrating to the sea to spawn.

The following more detailed account of the three kinds of eels is derived from that given by Petersen.

Yellow Eels.—The yellow eels are generally of rather light colour, the back, for instance, being grey or brownish, often with a greenish shade, the sides pale yellow, and the belly either like the sides or of a pure white. They are found in both salt and fresh water, and are taken during the winter as well as in summer. The digestive organs are well developed, and the eels feed voraciously. The snout in front of the eyes is much flattened; the eyes are small, the interorbital space being greater than the horizontal diameter of the eye—in larger specimens generally about double the size. Looked at vertically from above the eyes face upwards rather than sideways, and the corners of the mouth, with the lips, can be seen distinctly outside the eyes. The pectoral fins are light in colour and rounded posteriorly. The skin is thin, the scales are but slightly visible, and very little *guanine*, which gives the metallic, silvery look to the silver eels, is deposited. The lateral line and its branchings can be seen, but not very distinctly. The yellow eels comprise both males and females, but there are no good external characters to distinguish the sexes excepting size, the males being never longer than 48 cm. (19 inches), whilst the females can reach ½ to 1 metre (20 to 40 inches). The generative organs are but little developed in either sex, although they are sufficiently so to make it quite possible to distinguish males from females, without microscopic examination, in specimens 10 inches long and upwards. With the aid of the microscope the sexes may be distinguished by an examination of the reproductive organs in specimens down to 8 inches. Below this size the distinction is impossible.

FROG-MOUTHED EELS.—These are really the same as the yellow eels, excepting that they are much larger and are all females. They are large females, with ovaries as yet but little developed, and which have not commenced to take on the breeding-dress. Their bodies are long and lean, and they feed voraciously. The pectoral fins are light coloured and rounded behind. The heads appear large in proportion to the bodies, and possess the same characters as the heads of the yellow eels in a more exaggerated form. These large, lean fish appear in numbers at the beginning of summer, having probably been starving during the winter. They are caught in large numbers on hooks baited with fish, and their stomachs are often much dilated with food. Later in the year they become less frequent, having become fat and taken on the breeding-dress.

SILVER EELS.—These are yellow eels, which have assumed the breeding-dress, and are about to migrate to the sea to breed. The author has observed all transition stages between yellow and silver eels, and yellow eels with commencing metallic lustre kept in caufs he has frequently observed transformed in a few weeks into silver eels.

Silver eels are all of large size, and comprise both males and females. No males have been found under 29 cm. (11½ inches) long, and they are rare at this size. The smallest female observed was 42 cm. (16½ inches) long, but these also are seldom seen so small. The bodies of the silver eels are plump and fat. The snout in front of the eyes, particularly in the males, is high and a little compressed, probably owing to the considerable development of the olfactory organs and an increase in the size of the eyes. When the head is looked at vertically from above, the eyes protrude beyond the lips, and face sideways or outwards rather than, as in the yellow eels, upwards. The eyes are also considerably larger than in yellow eels of the same length. This was proved both by measuring and weighing eyes from the two kinds. The colour of the back is dark, nearly black; there are bronze streaks at the sides, and the ventral side is silver-white with a metallic lustre. The pectoral fins are dark coloured, even black, pointed behind, and longer in proportion to the head than those of the yellow eels, which are bright coloured and rounded. The skin of the body is thick and firm, the outlines of the scales distinct, and the lateral line, with its ramifications, easily seen.

The silver eels do not feed much, and are seldom caught on hooks. The digestive organs are comparatively much smaller than those of yellow eels, as the author has proved by weighing them, whilst the reproductive organs of both males and females are in a much more advanced condition. The silver eels emigrate from the rivers to the sea in summer and autumn, and are caught in traps, the mouths of which are set to face up-stream. In winter all the eels caught are yellow eels.

Petersen points out that, in consequence of the above relations between the different kinds of eels in closed waters or rivers, where all the silver eels can be caught as they emigrate to the sea, the yellow eels should not be taken at other times, but allowed to remain until they become silver eels of larger size and greater value.

In confirmation of Petersen's views, and in order to complete the history, we may add the following quotation from Grassi's most recent paper in the *Proceedings of the Royal Society**:—

"In another point my researches have yielded a very interesting result. As a result of the observations of Petersen, we know now that the common eel develops a bridal coloration or 'mating habit,' which is chiefly characterised by the silver pigment without trace of yellow, and by the more or less black colour of the pectoral fin, and finally by the large eyes. Petersen inferred that this was the bridal coloration from the circumstance that the individuals exhibiting it had the genital organs largely developed, had ceased to take nourishment, and were migrating to the sea. Here Petersen's observations cease and mine begin. The same currents at Messina, which bring us the Leptocephali, bring us also many specimens of the common eel, all of which exhibit the silver coloration. Not a few of them present the characters described by Petersen in an exaggerated condition; that is to say, the eyes are larger and nearly round instead of elliptical, whilst the pectoral fins are of an intense black. It is worth noting that in a certain number of them the anterior margin of the gill-slit is intensely black, a character which I have never observed in eels which had not yet migrated to the sea, and which is wanting in the figures and in the originals sent to me by Petersen himself. Undoubtedly the most important of these changes is that of the increase of the diameter of the eye, because it finds its physiological explanation in the circumstance that the eel matures in the depths of the sea. That, as a matter of fact, eels dredged from the bottom of the sea have larger eyes than one ever finds in fresh-water eels, I have proved by many comparative measurements, made between eels dredged from the sea-bottom and others which had not yet passed into the deep waters of the sea. Thus, for instance, in a male eel taken from the Messina currents, and having a total length of $34\frac{1}{2}$ cm.,

* *Proceedings Roy. Soc.*, vol. lx. No. 363. See also *Quart. Journ. Micr. Sci.*, New Series, vol. xxxix. part 3.

the eye had a diameter, both vertical and transversal, of 9 mm.; and in another eel of 33½ cm. the same measurement was recorded. In a female eel, derived from the same source and purchased in the market, whose length was 48½ cm., the vertical diameter of the eye was 10 mm., and the transversal diameter rather more than 10 mm. These are not the greatest dimensions which I observed, and I conclude from these facts that the bridal-habit described by Petersen was not quite completed in his specimens, and that it becomes so only in the sea and at a great depth. In relation to these observations of mine stands the fact that the genital organs in the eel taken in the Messina currents are sometimes more developed than in eels which have not yet entered the deep water. Thus it has happened that male individuals have occurred, showing in the testes here and there knots of spermatozoa. These spermatozoa are similar to those of the *Conger vulgaris,* and must be considered as ripe. As is well known, so advanced a stage of sexual maturity has never before been observed in the common eel. This appears to be due to the fact that the males hitherto examined had not yet migrated into the deep water of the sea. . . . .

"To sum up, *Anguilla vulgaris,* the common eel, matures in the depths of the sea, where it acquires larger eyes than are ever observed in individuals which have not yet migrated to deep water, with the exception of the eels of the Roman cloacæ. The abysses of the sea are the spawning places of the common eel: its eggs float in the sea water. In developing from the egg, it undergoes a metamorphosis, that is to say, passes through a larval form denominated *Leptocephalus brevirostris.* What length of time this development requires is very difficult to establish. So far we have only the following data:—First, *Anguilla vulgaris* migrates to the sea from the month of October to the month of January; second, the currents, such as those of Messina, throw up from the abysses of the sea specimens which, from the commencement of November to the end of July, are observed to be more advanced in development than at other times, but not yet arrived at total maturity; third, eggs, which according to every probability belong to the common eel, are found in the sea from the month of August to that of January inclusive; fourth, the *Leptocephalus brevirostris* abounds from February to September. As to the other months, we are in some uncertainty, because during them our only natural fisherman, the *Orthagoriscus mola,* appears very rarely; fifth, I am inclined to believe that the elvers ascending our rivers are already one year old, and I have observed that in an aquarium specimens of *L. brevirostris* can transform themselves into young elvers in one month's time."

Report of the Heligoland Biological Station.

Wissenschaftliche Meeresuntersuchungen herausgegeben von der Kommission zur wissenschaftlichen Untersuchung der deutschen Meere in Kiel und der Biologischen Anstalt auf Helgoland. Neue Folge, Zweiter Band. Heft 1, Abt. 1. 1896.

THE EGGS AND LARVÆ OF FISHES.—In the present communication, which is to be followed by others on the same subject, the author deals with the eggs and various larval stages of the flat-fishes found in the neighbourhood of Heligoland, and with the eggs and larvæ of the sprat. Excellent figures are given of stages in the larval development of the plaice, dab, flounder, turbot, brill, scald-back, sole, solenette, and of the sprat. Similar larvæ of most of these species have already been figured by naturalists, but many intermediate stages are now shown for the first time, and it will be a great convenience to other workers to have such excellent figures of successive larvæ thus brought together.

The most important additions to our knowledge of the development of fishes which Dr. Ehrenbaum makes are the full accounts which he furnishes of the eggs and various larval stages of the scald-back (*Arnoglossus laterna*) and the solenette (*Solea lutea*), concerning which little was previously known. He has been able to show that in the case of the former species (*Arnoglossus laterna*) metamorphosis takes place in a similar way to that described by Steenstrup, Agassiz, and Pfeffer in the genus *Plagusia;* that is to say, the right eye, during metamorphosis, does not pass round the top of the head, as in the turbot, brill, etc., but appears to come through it. What really happens, however, in these cases is not that the eye actually comes through the skull of the fish, but that the dorsal fin extends forwards to the snout, whilst the eyes are still on each side, and with the rotation of the head during metamorphosis the eye is carried round and pierces the fleshy portion of the base of this fin.

Microscopic Marine Organisms in the Service of Hydrography.*

By

Professor P. T. Cleve,

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It has for a long time been known that the sea abounds in microscopic organisms, both animal and vegetable. Among the former are entomostraca, infusoria, radiolarians, foraminifera, as well as larvæ of mollusca, radiates, and bryozoa. Among the plant-life the mass consists of diatoms, cilioflagellates, flagellates, and certain unicellular chlorophyllaceous algæ. For these pelagic forms Prof. Hensen has proposed the name *plankton*, which has been universally accepted.

Some years ago I examined the samples of vegetable plankton collected by the Swedish Arctic expeditions, as well as samples from various parts of the tropical seas, and I became convinced that certain parts of the oceans are characterised by different species. In the year 1893 I spent the summer at the west coast of Sweden, where I had the opportunity of examining the plankton at the marine biological station of Christineberg; that is to say, in a fjord (loch) called Gullmarsfjord. I found that in the month of June the plankton consisted mainly of cilioflagellates, *Ceratium tripos* being the most common. During the last days of the month, however, the plankton changed. The water was from that time very rich in entomostraca, and the cilioflagellates became less abundant. At the same time the mackerel appeared in the fjord. All my samples had been collected at the mouth of the fjord, where the water is not very deep. In the interior the fjord becomes deeper, as is the case also with the Scotch lochs, and I now wished to know the character of the plankton at different depths. What I hitherto had examined was the plankton of the current, called by the Swedish hydrographers the Baltic current, which in the spring and summer runs along the Scandinavian coast up to Bergen, in Norway. Below that surface current there exists, according to the Swedish hydrographers, water with lower temperature and greater salinity. In

* Reprinted from *Nature*, vol. lv. No. 1413.

company with Prof. G. Théel, and with the aid of his net, which could be closed and opened below the water, I made in July an attempt to get plankton from different depths of the fjord. We found in the cold bottom-water very little plankton, some few specimens of a large *Sagitta* and of *Calanus finmarchicus* only. At about 30–40 metres the cilioflagellates (among them *Ceratium divergens*) were abundant, and on the surface the entomostraca. This examination was repeated during the first days of August, when I and Dr. Aurivillius had the opportunity of accompanying Prof. Pettersson and Mr. G. Ekman on the hydrographical expedition which went out at the time. The result was the same as before; but from the determination of the temperature and the salinity of the water, it became clear that the plankton had been collected in water differing in those respects, and consequently that the different strata of water were characterised by different amounts of plankton, and by different species. Samples of plankton were afterwards collected by the Swedish hydrographical expeditions at the same time as samples of water for physical and chemical research. The examination of the plankton was carried out by Dr. Aurivillius, who took charge of the animal plankton, and by myself, who undertook the vegetable.

Having examined a large number of samples, I have lately found that the plankton of the Skagerack and Kattegat can be classed according to the prevailing species, and in this way I distinguished four types, namely: (1) *Tripos-plankton,* (2) *Didymus-plankton,* (3) *Tricho-plankton,* and (4) *Sira-plankton.*

(1) The *Tripos-plankton* is characterised by its scarcity in diatoms, and its abundance in cilioflagellates and entomostraca, which give to the spirit, in which the samples are preserved, an orange or yellow colour, all the other kinds of plankton colouring it more or less deep green. Among the entomostraca, according to the publications of Dr. Aurivillius, *Paracalanus parvus, Pseudocalanus elongatus,* and *Evadne spinifera* are the most abundant. Among the cilioflagellates *Ceratium tripos,* with the variety *macroceros,* is the most common. *C. divergens, C. furca,* and *C. fusus* occur in less numbers. Diatoms are, as I have said, scarce, the most abundant being *Coscinodiscus concinnus* and *Rhizosolenia gracillima.* In winter and early spring the unicellular alga, *Halosphaera viridis,* is found in abundance. This kind of plankton characterises the water of the Baltic current, and prevails in the summer in the Kattegat and Skagerack. The organisms consist chiefly of euryheline and eurythismic species, which can withstand the dilution of the salter North Sea water by the slightly saline Baltic water.

It seems very probable that this first type of plankton may by future researches be split up into different kinds. We may thus, perhaps, distinguish one kind, characterised by *Halosphaera viridis*, and occurring in the winter; another by *Rhizosolenia gracillima*, occurring in the summer; one with *Paracalanus parvus*, and another with *Pseudocalanus elongatus*, and so on.

In all cases it seems to be certain that the water containing this first type is derived from the North Sea as well as from the Baltic.

(2) The *Didymus-plankton* consists principally of diatoms, among which the most characteristic species are *Chaetoceros curvicetus*, *Ch. didymus*, *Ditylum Brightwellii*, *Rhizosolenia alata*, and *gracillima* (the latter probably a residuum of Type 1), *Skeletonema costatum* and *Thalassiothrix Frauenfeldii* (the latter probably common to Type 3). A silicoflagellate, *Dictyocha speculum*, occurs constantly, but not abundantly. The cilioflagellates, as well as the entomostraca, are scarce.

This kind of plankton was predominant in the Skagerack and Kattegat in November, 1893, filling the fjords from the bottom to the surface. With the water containing this kind of plankton the herring arrived on the shores of Scandinavia. It seems to have been a very large bulk of water that at this time set in to the coast, as it drove away the whole of the summer water from bottom to surface.

The diatoms of this type are not known from the Arctic Ocean or from the Northern Atlantic, but are well known from the coasts of France and Belgium and the English Channel. It seems thus to be beyond doubt that the water came from the southern North Sea, along the western coast of Denmark. The temperature, as well as the salinity, were found to be variable, but the plankton constant. In the Gullmarsfjord the water at the surface had a temperature of 7° C., at a depth of 30 m. nearly 12°, and at the bottom only 4° to 5°. The salinity amounted respectively to about 26–27, 32 and 33 to 37 per thousand. This variation may be explained by the mixture of the water of the second type with the water previously present in the Kattegat. Probably the warmest water was the most pure water of Type 2, and corresponds to one of the kinds of water called by the Swedish hydrographers the *bank-water*.

(3) The third type of plankton, the *Tricho-plankton*, is distinguished by its diatoms, especially the following species: *Thalassiosira longissima*, *Rhizosolenia styliformis*, *Chaetoceros atlanticus* (in a less degree also by *Ch. borealis* and its variety *Brightwellii*), and *Biddulphia mobilensis*. The first-named species occur abundantly and almost pure in the Northern Atlantic, south of Iceland; the last-named I observed at Plymouth, West Scotland, and in the North Sea. This plankton may thus be considered a Northern Atlantic plankton. At the Scandinavian coast it seems to occur very rarely in a pure state; in fact, I have seen

it only once, in February of this year, gathered at the bottom of the Christiania fjord (100 m.), where the temperature amounted to 7·5° C., and the salinity to 34–76 per thousand, the highest figures obtained by the hydrographical examinations of all the samples gathered in February, 1896.

On the other hand, this plankton was frequently found mixed with the next type in samples collected at the time named.

(4) The fourth type, the *Sira-plankton*, consists also mainly of diatoms, but of different species, the most characteristic being *Thalassiosira Nordenskiöldii* and *Th. gravida*, *Chaetoceros graenlandicus*, *Ch. socialis*, *Ch. scolopendra*, *Ch. teres*, *Nitschia seriata*, many of which belong to the Arctic seas, and some of which are new to science. Among the cilioflagellates the most abundant is a variety *arctica* of *Ceratium tripos*, distinguished by Dr. Aurivillius as a constituent of the plankton of Baffin's Bay.

There can be no doubt about the Arctic origin of this type. It occurred in the Skagerack and Kattegat this year in February and March, always more or less mixed with (3) and (1). In the Skagerack the water with Types (3) and (4) was covered by a shallow layer of water with Type (1); but in the Kattegat it reached the surface. The admixture of Type (3) shows that the water on or before its arrival at the coast of Sweden was mixed with Atlantic water. The temperature and the salinity were found to vary greatly, owing to the admixture of the slightly saline Baltic water, at this time of the year very cold.

I have observed the same type of water in some slides collected on the west coast of Scotland by Mr. George Murray, and sent to me by Mr. Grove. These samples had been gathered in the spring of 1888—a year remarkable in England as an unusually cold one.

As far as the plankton researches are advanced at present we may conclude that the surface-water around the Swedish coast consists in the summer of water from the North Sea mixed with Baltic water; that in the autumn its place is taken by water from the southern part of the North Sea; and in the winter by water from the Northern Atlantic and the Arctic Ocean. Whether these changes occur regularly every year, or in certain years only, cannot be answered for the moment. Probably the last change is in correspondence, as Professor Petersen has recently suggested, with variations in the amount of water which the Gulf Stream carries past Iceland, westwards to Davis Strait, and eastwards to the Arctic Ocean.

I think I have proved by the above that the examination of plankton is a matter of the greatest interest, not only in relation to hydrography, but also to meteorology and to fishery questions. There can be no doubt about the close connection between the state of the sea and the movements of the air, and the still obscure causes of the migration of fishes may be found to be intimately connected with the change of water containing different kinds of plankton.

It is thus an important matter that the plankton of the North Sea should be thoroughly and systematically examined; but for this, international co-operation of all the nations around the North Sea is required. I imagine that a central station, under the direction of competent persons and provided with adequate accommodation, might be erected. Samples could be collected at certain intervals, and by the same kind of apparatus at different stations, and sent to the central one for examination. The details should be published every month, and the general results formulated in a way that would be useful to hydrographers, meteorologists, etc. The marine biological stations already in existence will probably be found willing for co-operation in such an undertaking; but they will be able to collect plankton only near the shores, or at short distances from them. For getting samples from the open seas, the officers of the steamers crossing the North Sea and the Northern Atlantic might be found willing to assist, as the plankton may, as Dr. John Murray hinted to me, be procured by pumping water into a silk net. I recently tried this method whilst crossing from Edinburgh to Göttenburg. I fastened the net to the pump when the deck was being washed, and in this way I obtained sufficient plankton to prove that in the last days of July the North Sea was almost free from diatoms, and its plankton consisted mainly of cilioflagellates and entomostraca.

The Regulations of the Local Sea Fisheries Committees in England and Wales.

By

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

THE powers conferred on the Board of Trade, under the Sea Fisheries Regulation Act of 1888, to create, upon the application of a County or Borough Council, a local Fisheries District, and to provide for the constitution of a Local Fisheries Committee for the regulation of the sea fisheries carried on within the district, have been requisitioned by the majority of the Councils of the maritime counties of England and Wales, and at the present time Fisheries Districts and Fisheries Committees are constituted around nearly the whole coast line, the Committees having jurisdiction over all fishing carried on within the three-mile limit. The only portion of coast still unprovided for is that which lies in the counties of Norfolk and Suffolk, between Happisburg and Dovercourt.

The following is a list of the Fisheries Districts, with their boundaries, as they now exist:—

NORTHUMBERLAND—from the boundary between England and Scotland to the river Tyne.

NORTH-EASTERN—from the river Tyne to Donna Nook Beacon, on the coast of Lincolnshire.

EASTERN—from Donna Nook Beacon to Happisburg, on the coast of Norfolk.

Between Happisburg in Norfolk and Dovercourt in Essex no Fisheries District has been established.

KENT AND ESSEX—from Dovercourt in Essex to Dungeness.

SUSSEX—from Dungeness to Hayling Island.

SOUTHERN—from Hayling Island to the western boundary of Dorset.

DEVON—*Southern section*, from eastern boundary of Devon to Rame Head in Cornwall. *Northern section*, from eastern to western boundary of Devon.

CORNWALL—from northern boundary of Cornwall to Rame Head.

GLAMORGAN—from Nash Point to Worms Head.

MILFORD HAVEN—from Worms Head to Cemmaes Head in Pembroke.

WESTERN—from Cemmaes Head to the boundary between Carnarvon and Denbigh.

LANCASHIRE—from the boundary between Carnarvon and Denbigh to Haverigg Point in Lancashire.

CUMBERLAND—from Haverigg Point to Sark Foot.

The powers of the Local Fisheries Committees, as extended by subsequent Acts (Fisheries Act, 1891, and Sea Fisheries [Shell Fish] Regulation Act, 1894), include the making of bye-laws, subject to the approval of the Board of Trade, for the prohibition or regulation of any method of fishing for sea fish, for the establishment of close seasons for any sea fish, and for the regulation, protection, and development of fisheries for all kinds of shell fish (molluscs and crustaceans). Those powers have been largely exercised by the Committees, and the full text of all the bye-laws, which have received the sanction of the Board of Trade, is published in the *Annual Reports of the Inspectors of Sea Fisheries for England and Wales.*

It may be useful to those interested in the protection of fisheries, more especially of inshore fisheries, to bring together under subject headings the regulations now in force, which vary considerably in the different districts around the coast. The regulations and restrictions apply to the sea within three miles of the coast, but not to those tidal estuaries which are under the jurisdiction of Boards of Salmon Conservators.

Trawling with Steam Vessels.

Trawling from vessels propelled otherwise than by sails or oars is entirely prohibited on the east coast of England, from Northumberland to the southern limit of the Eastern Fisheries District at Happisburg, on the coast of Norfolk. South of this point steam trawling is permitted along the east coast, and along the south coast of Sussex as far westward as Hayling Island, the mesh of the trawl, however, being regulated, as for sailing trawlers (*see below*), within the limits of the Kent and Essex and the Sussex Sea Fisheries Districts.

Along the remainder of the south coast (Southern, Devon, and Cornwall Districts), and along the west coast of England and Wales, steam trawling is forbidden, excepting in the Milford Haven and Cumberland Districts.

Trawling with Sailing Vessels.

I. Trawling for Sea Fish.

NORTHUMBERLAND DISTRICT.—Trawling is prohibited.

NORTH-EASTERN DISTRICT (*Durham and Yorkshire*).—Prohibited, excepting in Bridlington Bay, between February 1st and September 1st; beam not to exceed 22 ft., and net to be raised and cleared at least every half-hour.

EASTERN DISTRICT (*Lincolnshire and north coast of Norfolk*).—In northern portion of district,* the length of trawl beam must not exceed 22 ft., and the net must be raised and cleared not less than once in every hour.

In southern portion of district † trawling is prohibited.

Norfolk (east coast) and Suffolk.—No district, and therefore no restrictions.

KENT AND ESSEX DISTRICT.—No trawl net may be used having more than **36** rows of knots to the linear yard.

SUSSEX DISTRICT.—No trawl net may be used having more than **30** rows of knots to the yard.

SOUTHERN DISTRICT (*Hants and Dorset*).—No restrictions.

DEVON DISTRICT.—Trawling is prohibited in the bays on the south coast. On the north coast there are no restrictions.

CORNWALL DISTRICT.—No restrictions.

GLAMORGAN DISTRICT (*south coast of Wales*).

Mesh—not less than $1\frac{1}{2}$ inch gauge.‡

Circumference of net—not less than 100 meshes.

Beam—not greater than 40 feet.

MILFORD HAVEN DISTRICT.—No restrictions.

WESTERN DISTRICT (*west coast of Wales*).

Mesh—not less than $1\frac{1}{2}$ inch gauge.

Circumference of net—not less than 100 meshes.

Beam—not greater than 45 feet.

* "That portion of the said district which lies to the westward of a line drawn true north-east from the lightship known as the 'Lynn Well Light,' and to the northward of a straight line drawn from Gibraltar Point to Gore Point."

† "That portion of the said district which lies between a line drawn true north-north-east from the building standing upon Salthouse Beach, known as Randall's Folly (or the Sailor's Refuge), and a line drawn true north-east from Cromer Lighthouse."

‡ "No person shall use any trawl net for taking sea fish, other than shrimps or prawns, having a mesh through which a square gauge of $1\frac{1}{2}$ inches measured across each side of the square, or 6 inches measured round the four sides, will not pass without pressure when the net is wet."

LANCASHIRE DISTRICT.

Mesh—not less than 1¾ inch gauge.

[Except south of Formby Point, from July 1st to October 15th, mesh not less than 1½ inch gauge may be used.]

Circumference of net—

With beam	greater	than	25 ft.,	circumference	not	less than	80	meshes.
"	"	"	18 ft.	"	"	"	60	"
"	less	"	18 ft.	"	"	"	50	"

Beam—

From January 1st to June 30th not to be greater than 30 feet.

Vessel—

From January 1st to June 30th not to be greater than 15 tons.

CUMBERLAND DISTRICT.—No restrictions.

II. Shrimps and Prawns.

(All regulations applying to fishing for shrimps and prawns, whether by trawling or other means, will be included under this heading.)

NORTHUMBERLAND DISTRICT.—Trawling prohibited.

NORTH-EASTERN DISTRICT (*Durham and Yorkshire to Donna Nook*).—Beam not to exceed 8 feet in extreme length, and net to be raised and cleared at least once in every half-hour.

Excepting:—(1) Between a straight line drawn true east from Castle Eden Dene, and a straight line drawn true north-east from Skinningrove Beck, a push net only may be used.

(2) In the River Humber, between a straight line drawn from the entrance to St. Andrew's Dock to the northern extremity of the pier at New Holland, and a straight line drawn from Spurn Head Lighthouse to Donna Nook Beacon, between March 1st and October 31st, a trawl having a beam not exceeding 20 feet may be used, the net to be raised and cleared not less than once in every hour.

EASTERN DISTRICT (*Lincolnshire and north coast of Norfolk*).—Length of trawl beam not to exceed 20 feet, and net not to have any pocket. Between December 1st and the last day of February no trawl net may be used for taking shrimps or prawns.

East coast of Norfolk and Suffolk.—No district, and therefore no restrictions.

KENT AND ESSEX DISTRICT.—No trawl net may be used having more than 108 rows of knots to the linear yard, except that for a length of 8 feet from the cod end there may be not more than 144 rows of knots to the yard.

SUSSEX DISTRICT.—No restrictions.

SOUTHERN DISTRICT (*Hants and Dorset*).—No restrictions.

DEVON DISTRICT.—Trawling in the bays on the south coast is prohibited, with the exception of trawling for shrimps or prawns in Plymouth Sound, with a beam not exceeding 8 feet in length, the net to be raised and cleared at least once every half-hour.

CORNWALL DISTRICT.—No restrictions.

GLAMORGAN DISTRICT (*south coast of Wales*).
Mesh—not less than $\frac{3}{8}$ inch gauge.*
Circumference of net—not less than 160 meshes.
Beam—not greater than 40 feet.

MILFORD HAVEN DISTRICT.—No restrictions.

WESTERN DISTRICT (*west coast of Wales*).
Mesh—not less than $\frac{3}{8}$ inch gauge.
Circumference of net—not less than 160 meshes.
Beam—not greater than 45 feet.

LANCASHIRE DISTRICT.
Mesh—not less than $\frac{3}{8}$ inch gauge.
Circumference of net—
With beam greater than 20 ft., not less than 140 meshes.
„ „ less „ 20 ft. „ „ 120 „
Beam—not greater than 25 feet.

CUMBERLAND DISTRICT.—No restrictions.

Seining.

In the North-eastern (*Yorkshire and Lincolnshire*), Western (*west coast of Wales*), and Lancashire Districts seining is prohibited, excepting for the capture of sand-eels for bait in the North-eastern, and for herring, mackerel, and sparling in the Western and Lancashire Districts. In these cases also the net is regulated.

In the Kent and Essex, Sussex, and Glamorgan Districts there are general mesh regulations for all nets used in the capture of sea fish, which would include seines.

In other districts there are no regulations.

The following regulations in the above-named districts may be mentioned:—

NORTH-EASTERN DISTRICT.—A net may be used for taking sand-eels for bait, without a pocket; net 108 feet long and 12 feet deep, the central portion (12 ft. × 12 ft.) to be of closely-textured netting.

* "No person shall use any net for taking shrimps or prawns having a mesh through which a square gauge of three-eighths of an inch measured across each side of the square, or $1\frac{1}{2}$ inches measured round the four sides, will not pass without pressure when the net is wet."

KENT AND ESSEX DISTRICT.—No net may be used for sea fish having more than 144 rows of knots to the yard.

SUSSEX DISTRICT.—No seine or draft net may be used having more than 30 rows of knots to the yard, excepting when fishing for herring or mackerel, at any time, or for sprats during November, December, and January.

GLAMORGAN DISTRICT.—No net for sea fish (except sprats) may have a mesh less than 1 inch gauge.

WESTERN DISTRICT (*west coast of Wales*). — No net for taking mackerel or herring may have mesh less than 1 inch gauge.

LANCASHIRE DISTRICT.—Similar to Western District.

Trammel, Stake, and Stop Nets.

On the east coast the only bye-law relating to such nets is one made by the North-eastern Committee, whereby the use of trammel nets is prohibited in certain specified districts off the mouths of the principal rivers. On other parts of this coast the use of these nets is unrestricted.*

On the south coast the only regulation applies to Chichester Harbour, where no stop nets may be set across the creeks within one hour before and after low water.

On the west coast regulations exist in the Glamorgan, Western, and Lancashire Districts only, as follows:—

GLAMORGAN DISTRICT (*south coast of Wales*). — Stop nets for sprats must have a mesh not less than $\frac{9}{16}$ inch gauge. All stake and stop nets must be marked by buoys or poles, must be at least 10 yards from other stake nets or any fishing weir, and a pool 12 inches deep at low water must be kept for each net from May to October, at other times 6 inches deep, such pool to be three-quarters the size of the cage of the net, and not less than 36 square feet in area.

WESTERN DISTRICT (*west coast of Wales*). — Trammel nets are prohibited. The position of stake nets must be marked by poles or buoys: the nets must not be nearer the centre of any stream than the edge of the stream at low water, and they must not be nearer than 50 yards to any other stake net.

* In this connection particular notice should be taken of the fact that we are not considering any bye-laws applicable to estuaries under the jurisdiction of Boards of Salmon Conservators.

LANCASHIRE DISTRICT.—Trammel nets are prohibited. The regulations for stake nets are generally similar to those in force in the Western District, but the distance from other stake nets must be 150 yards. There is also a somewhat curious bye-law, which reads as follows:—"No person shall use, in fishing for mackerel or herring, any stake net except at the times and places at which, and in the manner in which, such nets have been heretofore commonly used for the capture of such fish respectively."

Smelt or Sparling.

In the Northumberland District there are no restrictions. In the North-eastern sparling nets may be used only between July 21st and March 21st, and mesh of net must not be less than six-tenths of an inch from knot to knot.*

In the Eastern District the nets must have not more than 24 knots to the foot, and they may not be used between April 1st and August 31st.

In the Kent and Essex District the net must have not more than 72 rows of knots to the yard, and must not be more than 60 fathoms long.

On the south coasts of England and Wales there are no restrictions.

In the Western District (*west coast of Wales*) the mesh of the net must allow a square gauge with each side ¾ inch long to pass through, whilst in Lancashire the fish may only be taken with seine or draft net, the size of mesh is increased to one inch, and the fish may not be caught between April 1st and October 31st.

Crabs and Lobsters.

In considering the regulations relating to crabs and lobsters, it must be borne in mind that the Fisheries (Oyster, Crab, and Lobster) Act, 1877, applies to the whole country, and makes it illegal to take, have in possession, sell or expose for sale, any edible crab which measures less than 4¼ inches across the broadest part of the back (except when for use as bait); or any edible crab carrying spawn attached to the tail; or any edible crab which has recently cast its shell; or any lobster which measures less than eight inches from the tip of the beak to the end of the tail, when spread out flat.

The Sea Fisheries Committees have made the following additional regulations in their respective districts:—

NORTHUMBERLAND DISTRICT.—No additional restrictions.

* There is also a restriction as to the nature of the material of which the net is made.

NORTH-EASTERN DISTRICT (*Durham and Yorkshire*).—Crabs under $4\frac{1}{4}$ inches not to be taken, even for bait. Lobsters under 9 inches long not to be taken. No lobsters or crabs to be taken between September 1st and January 31st of following year.

EASTERN DISTRICT (*Lincolnshire and north coast of Norfolk*).—Crabs under $4\frac{1}{4}$ inches not to be taken, even for bait.

No lobster carrying spawn, and no lobster which has recently cast its shell and is still soft, to be taken. From November 1st to June 30th no crabs known locally as "whitefooted" to be taken.

KENT AND ESSEX DISTRICT.—No lobster carrying spawn to be taken.

SUSSEX, SOUTHERN (*Hants and Dorset*), AND DEVON DISTRICTS.—No restrictions.

CORNWALL DISTRICT.—No male edible crab less than 6 inches broad,
" female " " 5 "
may be taken.

GLAMORGAN AND MILFORD DISTRICTS.—No restrictions.

WESTERN DISTRICT (*west coast of Wales*) .
LANCASHIRE DISTRICT . . . . .
} No lobsters or crabs carrying spawn may be taken.

No lobster less than 9 inches from beak to tail; no edible crab less than 5 inches across broadest part of back, may be taken.

CUMBERLAND DISTRICT.—No restrictions.

Molluscs.

Oysters.—In addition to the close times fixed by Act of Parliament, viz., for deep-sea oysters from 15th June to 4th August, and for all other oysters from 14th May to 4th August, the following are the regulations made by Local Fisheries Committees for their respective districts:—

KENT AND ESSEX DISTRICT.—No cultch may be removed from an oyster ground.

SOUTHERN DISTRICT (*Hants and Dorset*).—No oysters may be taken from 15th May to 30th September, and none may be taken at any time which will pass through a circular ring of 2 inches in internal diameter, except for stocking and breeding purposes.

No cultch or other material for the reception of spat may be removed.

WESTERN DISTRICT (*west coast of Wales*) .
LANCASHIRE DISTRICT . . . . .
} No oysters may be taken which will pass through a circular ring $2\frac{1}{2}$ inches in internal diameter.

In other districts no additional restrictions have been made.

Mussels. — Eastern District (*Lincolnshire and north coast of Norfolk*). — No mussels may be taken from May 1st to August 31st, nor any less than 2 inches in length at other times, except for stocking or breeding.

No instrument may be used for taking mussels other than a rake not exceeding 18 inches broad, and with the teeth 1 inch apart.

Glamorgan District (*south coast of Wales*).—No mussels may be taken in May, June, or July, except for stocking or breeding purposes.

Mussels may be taken only (*a*) with a dredge, (*b*) by hand, or (*c*) with a rake not more than 3 feet wide, with the teeth 1 inch apart.

Western District (*west coast of Wales*).—No mussels may be taken in May, June, July, or August, excepting for stocking, breeding, or bait (in one part of the district the prohibition extends also to April, September, and October), and none may be taken at any time less than 2¼ inches long.

Mussels may be taken only (*a*) by hand, (*b*) with a rake not exceeding 3 feet wide, used from a boat, and when the bed is covered with at least 4 feet of water.

Lancashire District.—No mussels may be taken in May, June, July, or August, and none at any time less than 2¼ inches long.

Mussels may be taken only (*a*) by hand, (*b*) with a rake not exceeding 3 feet wide, used only from a boat, and when the bed is covered with at least 4 feet of water.

In other districts no restrictions have been made.

Cockles.—Regulations are in force as follows:—

Eastern District (*Lincoln and north coast of Norfolk*).—No instrument may be used for taking cockles except a rake not more than 12 inches long, with teeth ¾ inch apart.

Glamorgan District (*south coast of Wales*).—Cockles may only be taken by hand, or with a rake not more than 12 inches wide, with teeth ¾ inch apart.

Western District (*west coast of Wales*).—Cockles may only be taken by hand, or with a rake not more than 12 inches wide, with teeth ¾ inch apart. None may be taken which pass through an oblong gauge ¾ inch wide and 2 inches long.

LANCASHIRE DISTRICT.—No cockles may be taken which pass through an oblong gauge $\frac{3}{4}$ inch broad and 2 inches long. They may be taken only (*a*) by hand, (*b*) with a craam having not more than three teeth, (*c*) with other instruments under regulations which differ in different parts of the district.*

Periwinkles.—In the Sussex District periwinkles may not be taken between April 1st and October 31st, and in the Southern District not between May 1st and August 31st. In other districts no regulations exist.

Injurious Substances.

Bye-laws prohibiting the deposit or discharge of any solid or liquid substance detrimental to sea fish or sea fishing are in force in the following districts: Kent and Essex, Sussex, Southern, Devon, and Lancashire.

* Bye-law 20. No person shall fish for cockles except—

(*a*) By hand, or

(*b*) With an instrument locally known as a craam, having not more than three teeth: provided that—

(1) Between the 1st day of November and the last day of February following, both inclusive, it shall be lawful to use an instrument locally known as the jumbo, not exceeding 4 feet 6 inches in length, 14 inches in width, and 1 inch in thickness, provided that such instrument shall be constructed entirely of wood, and shall not be dragged across the cockle beds or artificially weighted.

(2) In that part of the district which lies to the southward of a line drawn true west from the mark known as "Rossall Landmark," near Fleetwood, it shall be lawful to use a rake not exceeding 12 inches in width.

(3) In that part of the district which lies between a straight line drawn seawards through the north-west sea marks near Formby Point, and a line drawn true west from the western extremity of the southern training wall in the river Ribble or Gut Channel, it shall be lawful to use a spade.

Contributions to Marine Bionomics.

By

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II. The Function of Antero-lateral Denticulations of the Carapace in Sand-burrowing Crabs.

THE antero-lateral margins of the carapace in many of the crabs of our own and of foreign coasts are beset with a row of teeth or spines, which vary in character and number in different species and genera. In the Oxyrhyncha (Spider-crabs) the whole surface of the carapace is generally studded with spines and stiff hairs of a peculiar character, but there is no general restriction of these processes of the carapace to the antero-lateral margins of the body. These crabs, moreover, do not adopt burrowing habits. Their armature of spines, tubercles, and hairs is employed, as is well known, for protective purposes: in some cases possibly as an actual defence against attack, in others (*i.e.*, *Eurynome aspera*) as a means of protective resemblance to their surroundings; but in the great majority as mere pegs and hooks for the fixation of foreign bodies, such as algæ, hydroids, polyzoa, and ascidians, for purposes of concealment and disguise.

In the Catometopa (Land-crabs, etc.) the carapace is usually smooth over its whole surface. These animals often burrow in sand, but for the most part their burrows are permanent subterranean tunnels and chambers.

In the Cyclometopa, however—the group which includes most of our commoner British crabs—the back of the carapace is generally smooth, while the antero-lateral margins are in most forms conspicuously serrated. Most of these animals inhabit sandy or gravelly areas, and show a marked propensity towards burrowing habits. Their burrows are never* permanent channels or tunnels in the sand, but are mere temporary excavations, the sand, mud, or gravel being in actual contact with their bodies when imbedded.

So far as I am aware no one has hitherto elucidated the remarkable constancy of antero-lateral serrations of the carapace in this group of crabs. I here present evidence which tends to show that the presence

* *Scylla serrata* of the Natal coast *appears* to be exceptional in this respect. (KRAUSS, *Die Südafricanischen Crustaceen*, 1843, p. 12.)

of conspicuous serrations on these margins of the carapace is functionally related to the exigencies of respiration when these animals are buried in sand.

The marginal teeth are perhaps best developed and most conspicuous in crabs of the family Portunidæ (Swimming-crabs). As M. Alphonse Milne-Edwards has remarked: "Je ne connais aucun Portunien où le bord latéro-antérieur de la carapace soit entier ou armé d'épines arrondies ou de tubercules obtus." (1860, p. 202.)

In *Bathynectes longipes* there are five sharp-pointed teeth on each of the antero-lateral borders. These teeth increase in size regularly from before backwards, and the posterior tooth is a particularly stout and sharp structure. This crab is almost invariably an inhabitant of sandy areas (*e.g.*, Mounts Bay in Cornwall); and the individual whose habits I am about to describe was also dredged upon a bottom of fine sand in the neighbourhood of the Eddystone.

In an aquarium containing sand the crab burrows into the sand just beneath the surface, leaving its eyes and the transverse slit-like aperture of the buccal frame exposed. The crab is actually imbedded up to the anterior edge of the external maxillipeds; but it pushes away the sand in front of it by means of these appendages, and when at rest maintains these appendages in a sloping posture, so that they act as a quadrangular sieve-like fence in front of the buccal area. This happens both in very fine siliceous sand and in fine shell sand. The crab was not seen at any time to go completely beneath the surface, though I do not mean to imply by this that the crab never buries itself entirely. This may or may not be the case. *Atelecyclus heterodon* is another sand-burrowing crab, whose habits I have studied for a much longer period; and this crab has very diversified habits. It may remain partially imbedded at the surface of the sand, with its eyes and a broad funnel formed by the second antennæ alone protruding, or it may disappear completely beneath the sand to a depth of several inches.

When the crab (*Bathynectes longipes*) is partially imbedded in the sand as above described, it may be noticed that the chelipeds are flexed and approximated to the under side of the antero-lateral regions of the carapace in an attitude precisely similar to that assumed by *Atelecyclus heterodon*, or the Oxystome crab *Matuta*, under the same conditions (1897). The position of the cheliped is such that the marginal teeth of the antero-lateral region of the carapace exactly overhang the slit-like orifice between the distal half of the cheliped (carpopodite and propodite) and the pterygostomial fold of the carapace. There is thus produced on each side of the crab, between cheliped and carapace, a channel similar to that which would be produced by the approximation in parallel planes of two flat plates. This channel communicates below with the afferent (inhalant) aperture of the branchial chamber, which is situated at the base of the cheliped, and opens above through the notches between the teeth of the antero-lateral margins of the carapace. Since the back of the crab is covered with sand, it will readily be understood from this description that the antero-lateral teeth act as a coarse sieve or grating placed over the orifice of this accessory channel, and that they prevent the accidental intrusion of sand-particles into the lumen of the channel, a function which it was easy to determine that they efficiently discharged.

The pair of accessory channels produced by the approximation of chelipeds to carapace I propose to term the "exostegal channels," owing to their situation on the external face of the branchiostegite. I show elsewhere (1897) that these channels probably represent in a generalised condition certain remarkable accessory afferent branchial canals of the Oxystome Brachyura, which attain their most specialised form and relations in *Ebalia* and other Leucosiidæ.

M. Alphonse Milne-Edwards (1860, p. 207) states that in the Portunidæ "les mains ne sont jamais conformées de facon à pouvoir s'appliquer exactement contre la région buccale, ainsi que cela se voit chez quelques autres Brachyures nageurs tels que les Calappes et les Matutes." This contrast is quite in accordance with my view, that the afferent channel of the Portunidæ represents a primitive and relatively unspecialised type, from which the highly elaborate canals of the Oxystomata have been derived.

That these accessory channels in the Portunidæ are functionally connected with the respiratory process, was demonstrated by me in the case of *Bathynectes longipes* in the following manner:—

When the crab was partially imbedded in sand with its face close to the front of a square glass aquarium, in the attitude already described, it could be seen that beneath the body of the crab was a shallow ventral water-chamber, free from sand. The crab was resting with its body in an approximately horizontal plane. Sand-particles were supported over the orifice of the exostegal channel by the sieve-like row of teeth along the antero-lateral margins. Some water, coloured black with Indian ink, was then added by means of a pipette to the water lying above the slit between cheliped and carapace. The coloured water was at once sucked downwards between the grains of sand into the exostegal channel in waves which apparently corresponded to blows of the scaphognathite, and after a few seconds emerged in a black stream out of the afferent orifice of the branchial chamber situated in front of the mouth. It was quite clear that the water passed downwards through the exostegal channel to the afferent aperture at the base of the cheliped, and that it entered the branchial chamber by this aperture.

Similar observations and experiments were made upon numerous specimens of *Atelecyclus heterodon*, a crab belonging to an altogether different family. In this crab the antero-lateral margins are provided with as many as nine teeth, but the function of the teeth was found to be essentially similar. Owing to the different form of the body, and the different shape of the cheliped in the two crabs, the orifice of the channel between cheliped and carapace is of greater relative extent in *Atelecyclus* than in *Bathynectes;* but the length of the denticulated margin of the carapace was found to correspond precisely with the extent of the inhalant gap in each case. The following conclusions may be drawn, therefore, from these observations:—

(1) Antero-lateral denticulations of the carapace in crabs may subserve a sieve-like function.

(2) The extent of the denticulated area corresponds with the extent of the inhalant gap between the carapace and the cheliped when the latter appendage is approximated to it in the flexed position.

It is also obvious that a new function must be ascribed to the chelipeds of sand-burrowing crabs provided with antero-lateral denticulations of the carapace. In such cases the chelipeds act as organs temporarily subservient to the respiratory process by providing a broad operculum to the exostegal channel. Attention may be recalled in this connection to the fact elucidated by Milne-Edwards in 1839, that in the Leucosiidæ the floor of the afferent branchial channel is also provided by one of the appendages, in this case by the external maxillipeds. The relations of the afferent channel in the Leucosiidæ to the external channel which I have now described in the Cyclometopa are discussed by me in the paper to which reference has already been made (1897).

The subservience of the chelipeds to the respiratory process enables me, moreover, to explain the function of a remarkable spine which in the Portunidæ is almost universally present on the inner margin of the distal extremity of the carpal joint (carpopodite or wrist) of the cheliped. This carpal spine, though usually strong and conspicuous, presents various minor modifications of form which are employed by systematists in the discrimination of different species.

The appearance of the spine in *Bathynectes longipes* is represented by Bell and Risso. When the cheliped is fully extended the carpal spine projects freely from its anterior margin; but when the propodite is flexed towards the proximal part of the cheliped, it is arrested at a certain angle with the carpopodite by the carpal spine in question. If now the arm (meropodite) of the cheliped be approximated to the carapace in the position requisite for the completion of the exostegal canal, it will be found that the angle at which the propodite has been arrested by the carpal spine is precisely the angle required for the proper apposition of cheliped to carapace in connection with the respiratory process. The carpal spine acts then as a stay or barrier to excessive flexion of the cheliped. Its function corresponds, therefore, in part to the function of such skeletal processes as the olecranon of the human ulna, which prevents excessive extension of the arm. Examination of a series of Portunids reveals that the variations in the form of the carpal spine in different species and genera are all functionally correlated with the different shapes and proportions of the carapace, and of the segments of the cheliped in the forms examined; the result in all cases being that the shape of the carpal spine is adapted to ensure the due amount of flexion of the cheliped for the completion of the respiratory channel between cheliped and carapace.

A similar function seems also to be discharged by the enlarged posterior spine of the antero-lateral margins in *Bathynectes longipes*, since the carpopodite presses upwards against it during flexion of the cheliped. An examination of preserved specimens of the Mediterranean *Lupa hastata*, and of the American *Callinectes sapidus*, in which the posterior spine is greatly elongated, seems to me to support this view, though I do not regard the evidence in this case as altogether unequivocal. A complete explanation of the enlargement of this posterior antero-lateral spine should also throw light on the great epibranchial spines of the Oxystome genus *Matuta*, and of the Lencosiid genera *Iphis* and *Ixa*. In the latter cases any relation between the development of the spines and the formation of an inhalant chamber between cheliped and carapace is precluded by the known course of the afferent current in a gutter running between the pterygostomial plate and the exopodite of the third maxilliped.

The phenomena presented by the respiratory processes of these sand-burrowing crabs throw light, as it seems to me, not only on the problem of the utility of a number of morphologically trivial, but systematically important features of Decapod Crustacea, but also on an altogether different problem, viz., the phylogeny of the Brachyura Oxystomata. Crabs of the latter group are all characterised by their sand-burrowing habits of life. Similarity of habits often induces homoplastic changes of form in types genetically distinct; but there are certain significant details of structure in the different Oxystome types which appear to me to be only explicable on the view that these crabs are descended from ancestors in which the form of the body closely resembled that of sand-burrowing Cyclometopa in being provided with antero-lateral serrated margins, and in which the chelipeds were employed for the production of an extensive inhalant channel, completely roofed over by the projecting teeth of the carapace. For a fuller discussion of this subject I must refer the reader to another paper to be published in the *Quarterly Journal of Microscopical Science* (1897).

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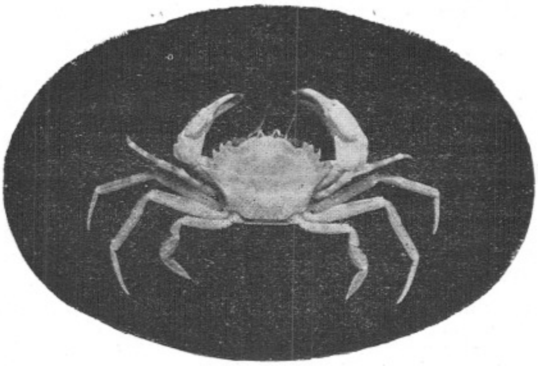

FIG. 1.

Fig. 1.—*Bathynectes longipes.* Dorsal view, showing the five teeth of the antero-lateral margins. The chelipeds are in a half-extended condition; their propodites (hands) are shown resting against the carpal spines. The specimen shows an abnormality in the union of the two anterior marginal teeth of the right side to form a single bifid tooth.

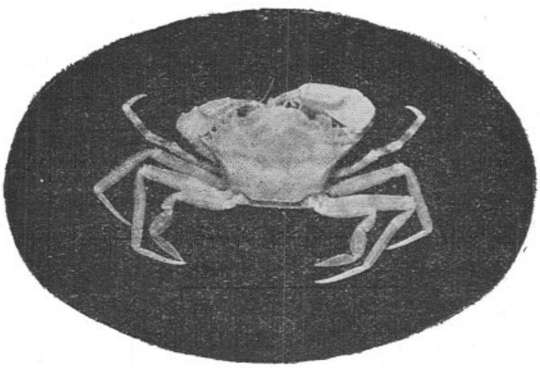

FIG. 2.

Fig. 2.—*Bathynectes longipes.* Dorsal view, showing the position of the chelipeds after flexion of the wrists (carpopodites) as well as of the hands. The left cheliped is in the attitude assumed by the crab when imbedded in sand; the antero-lateral teeth are seen to form a sieve above the orifice of the inhalant gap between cheliped and carapace. On the right side the arm (meropodite) of the cheliped does not rest in its proper position beneath the enlarged posterior marginal tooth; hence the inhalant gap is imperfectly formed, and its aperture is imperfectly covered by the marginal teeth.

III. The Systematic Features, Habits, and Respiratory Phenomena of Portumnus nasutus (Latreille).

The crab whose habits I now describe has not previously been recorded as an inhabitant of British seas. I found two specimens, both male, imbedded in a patch of coarse shell sand on the south side of Drake's Island at low water, spring tides: one on August 11th, 1896, and the other on the following day.

1. Nomenclature.

My first impression on noticing this remarkable little crab was that I had an abnormal specimen of a young *Carcinus maenas* before me; but the possibility of such a leap from the normal as the frontal area of this specimen would produce on a variation-chart was soon disposed of by Professor Weldon, and we identified the crab with the *Portunus biguttatus* of Risso (1816), now usually known under the name *Platyonichus nasutus* of Latreille (1825, p. 151; cf. also Milne-Edwards, 1834; Costa, 1853, p. 11; Carus, 1885).

The genus *Platyonichus* of Latreille (1818) was originally coextensive with the genus *Portumnus* of Leach (1815), Latreille having simply altered Leach's name owing to its similarity to the name *Portunus*, with which he feared it might be confused. Dana (1852), however, and Bell (1853), showed that the species included within the genus *Platyonichus* were separable into two well-marked groups, which were accordingly named by these writers *Platyonichus* and *Portumnus* respectively, the latter name being reapplied to the group which included Leach's type, viz., *Portumnus latipes*. It is to the latter group that *Platyonichus nasutus* belongs, so that I must refer to it for the future as *Portumnus nasutus*.

It is true that the earliest specific name applied to the present species is *biguttatus* of Risso (1816), the name *nasutus* of Latreille (1825) being nearly ten years later. Since, however, the species has been invariably referred to under Latreille's name, probably owing to the influence of Milne-Edwards' adoption of it, I submit that we have here an exceptional case which demands exceptional treatment. The rule of priority provides a decisive method of dealing with a confused and complicated synonymy; but its application in the present case could not be urged on such grounds, and would be distinctly inconvenient. I shall therefore adhere to the employment of Latreille's name *nasutus* in referring to the species under discussion. In the event, however, of possible differences being discovered between Mediterranean and Atlantic races of this species, I would point out that Risso's name was created for Mediterranean specimens, while Latreille's type came from the west coast of France.

2. Generic Characters.

The genus *Portumnus* takes its place together with *Carcinus*, *Platyonichus*, and *Polybius* in the Platyonichinæ, a sub-family of the Portunidæ distinguished from the Portuninæ by the absence of lateral ridges on the prælabial plate, and by the absence of a distinct accessory lobe to the endopodite of the first maxillipeds.

Portumnus is distinguished from *Platyonichus* by having the dactylus of the fifth thoracic leg of a slender lanceolate form, and the carapace not broader than long. In *Platyonichus* the dactylus is elliptical or broadly oval, and the carapace is broader than long. To these distinctions I may add that in *Platyonichus* the interorbital margin is at most tridentate or quadridentate, while in *Portumnus* the inner angle of the orbit contributes a distinct accessory tooth to the frontal margin, rendering this margin five-toothed, as in *Polybius Henslowii*.

3. Specific Characters.

The two species of the genus which alone are known to me are *P. latipes* (Pennant) and *P. nasutus*. A description of the former species may be found in Bell (1853) under the name *Portumnus variegatus*. The characteristic features of *P. nasutus* are as follows:—

Frontal area projecting in front of the orbits in the form of a conspicuous triangular lobe with gently undulate lateral margins.

The undulations mark the subdivision of the interorbital margin into five rounded lobules, which correspond to the five interorbital teeth of *P. latipes*. The interorbital lobe bends downwards in front.

The carapace is relatively broader than in *P. latipes*, so that the antero-lateral margins make a sharper angle with the median transverse axis.

The orbit shows two superior fissures and one inferior fissure (*pace* Latreille and H. Milne-Edwards, who mention only one superior fissure), while in *P. latipes* the orbit is stated to be either entire (Bell; Leach, 1815) or provided with a single fissure above (H. Milne-Edwards, 1834).

The basal joint of the second antenna is movable.

4. Colour.

The colour of the carapace of *Portumnus nasutus* is thus described by Risso (1816, p. 31)—"yellowish-white, adorned with two great spots of coral-red . . . The red spots are larger in the female than in the male." On account of the presence of these spots Risso named the species *Portunus biguttatus, portune à deux taches, portune bimaculé* (p. 25).

Costa, on the other hand (*Addizioni*, 1853, p. 11), describes the colour as "livid olive-brown tending towards purple; that of the feet and of the inferior face more pallid. In fresh specimens one may sometimes observe two rose-coloured spots in the middle of the carapace, which vanish after death."

Of my own specimens the larger one was of a uniform dull greenish yellow colour, the smaller one having the carapace and basal joints of the legs absolutely white, and the two terminal joints of the four posterior pairs of thoracic legs coloured pale brown and amethyst-violet. No reddish spots were visible in the living specimens. It is possible that these spots are only to be observed in the breeding season, and that they are due to the colour of the reproductive glands showing through the carapace. Such a phenomenon is at any rate described by Risso for *Bathynectes longipes.* He states (1816, pp. 30, 31): "La femelle, dans le temps des amours, est ornée de deux grandes taches d'un rouge foncé sur la partie antérieure du têt." The eggs of the latter species are described as "d'un rouge aurore," which would sufficiently account for the red colour of the ovarian regions before deposition of the ova; those of *P. nasutus* are described as "d'un jaune doré." Risso states that the eggs of *P. nasutus* are laid in May and August.

5. Sand-burrowing Habits.

The habits of *Portumnus nasutus* have hitherto been very imperfectly described. Risso (1816, pp. 25–31) states simply that at Nice the crab inhabits "la région des polypiers corticifères" (p. 25), or "la région des coraux" (p. 31). Latreille's specimen (1825, p. 151) was obtained by D'Orbigny on the coast of La Vendée, which probably implies a sandy habitat, especially as Latreille's specimens of "*Platyonichus variegatus*" (*Portumnus latipes*) were obtained by the same naturalist on the same coast (*Nouv. Dict. d'Hist. Nat.*, 1818), and the latter species is known to have sand-burrowing habits.

My own observations are, however, unequivocal. The specimens were found burrowing in coarse shelly gravel, and when the crabs were introduced into an aquarium containing a deep layer of the same gravel they were observed to burrow into it at once with extreme agility until their bodies were completely covered to a depth of an inch or more. The act of burrowing is effected by means of the hinder thoracic legs, as is usual among Portunids. The crabs can also burrow in fine siliceous sand.

When imbedded, *P. nasutus* seems always to adopt a nearly horizontal position—not the upright attitude exhibited by *Corystes cassivelaunus* (this Journal, 1896, p. 223). The anterior part of the body is, however, generally a little higher than the posterior.

6. Respiratory Currents.

Under these circumstances, *Portumnus nasutus* exhibits a reversed water-current through its branchial chamber, though this is much more difficult to demonstrate in the present species than in the case of *Corystes.* The method I adopted was as follows:—

The depth of gravel in the aquarium was so regulated that the crab could not burrow far beneath the surface. The fragments of sand and shell which lay upon the front of its carapace and upon its interorbital lobe were then gently removed, one by one, with a pair of fine forceps, until the aperture of the buccal frame was exposed. These proceedings were, however, incessantly watched by the crab, which, not unnaturally, did not hesitate to disturb my preparations whenever it conceived that there was due cause for alarm. I therefore took the precaution to leave some fragments of shell over its eyes, and thus did not seriously disturb its impression that it was safely ensconced. I eventually succeeded in getting the crab so suitably situated that, on the addition of a little black-coloured water by means of a pipette to the region in front of the crab's maxillipeds, I had the satisfaction of seeing the water sucked inwards on both sides, to reappear again in a pair of streams at the base of the chelipeds. The two exhalant streams rose above the surface of the sand in a pair of clouds, one on each side of the body. Suddenly, and without warning, the normal current was set up, and then the lateral clouds of inky water were rapidly sucked in again on each side, to re-emerge again a second or two afterwards in a continuous stream in front of the mouth. Without this kindly co-operation on the part of the crab it would have been difficult, if not impossible, to get so successful a demonstration of the reversal of the currents. One of the most interesting phenomena presented by this crab is indeed the frequency with which, when under observation, it will alternate the direction of the respiratory currents.* It may even suspend the respiratory currents altogether for long intervals; *e.g.*, for as long as fifty-five seconds. At such times there is absolutely no movement in the surrounding water.

7. Utility of Specific Characters.

The interorbital prolongation of the frontal area, which gives both its name and most peculiar feature to the species *Portumnus nasutus,* is

* Probably to eject distasteful particles. This is undoubtedly the explanation of similar phenomena in the case of *Corystes.* (See this Journal, vol. iv. 1896, p. 230.)

a feature usefully correlated with a habit of burrowing in coarse shelly gravel. It acts as an efficient buckler for the protection of the anterior sense-organs; but its unusual size and its downward bend seem to be more directly correlated with the reversal of the branchial currents, which I have shown to take place when the crab is imbedded. The advantage of reversal in the present case is a point to which I shall recur when dealing with the phenomenon in a more general manner; but, granted the reversal, the utility of the possession of a stout triangular shelf over the inhalant orifices is obvious after a study of the animal s habits and of the nature of the objects amid which the crab excavates its dwelling-place. In *Corystes,* which lives in fine sand, the inhalant antennal tube has been shown (1896) to subserve the double purpose of a supply pipe and a sieve. In *P. nasutus* a sieve is unnecessary so long as the crab inhabits coarse shell-gravel, the fragments of which are too large to enter the respiratory channels; and this appears to be the specific habit of the crab. But if the anterior inhalant apertures (during reversal) were altogether unprotected, the pointed fragments of shell might easily penetrate the inhalant orifices (during reversal), and so occlude their lumen. Such occlusion would prevent the crab from burrowing in the kind of material most suitable to its respiratory organisation, and thus expose the animal to increased risks of destruction by its ever-watchful enemies among fishes. The overhanging buckler provided by the prominent frontal lobe acts, however, as a very efficient means of supporting the shell-fragments well above the inhalant orifices—a function the existence of which I do not throw out as an academical suggestion, but the value of which I had frequent opportunities of observing and appreciating in my aquaria.

The interorbital lobe of *P. nasutus* is remarkably similar to the frontal protuberance of *Carcinus maenas* in the *Megalops* stage, which becomes reduced in later stages of development. Since I have found no indications of a reversal of the respiratory currents in the latter species, I am inclined to believe that the retention of this larval feature in *P. nasutus* is to be correlated with the reversal of the currents which occurs, as I have shown above, in this type; while its eventual loss in *Carcinus maenas* is to be indirectly attributed to the lack of any further use for it after the larval stages. The larval forms of *P. nasutus* are at present, however, unknown, and it is impossible to support this view with the necessary embryological facts.

The other specific characters of *P. nasutus* (viz., breadth of carapace, retention of two supra-orbital fissures, mobility of basal joint of second antenna) are not new features acquired within the history of the present species, but are merely heirlooms from Portunid ancestors of less specialised habits. It is not their presence in *P. nasutus* which is to be accounted for, but their absence in *Portumnus latipes.* The elucidation of those features will be attempted in a subsequent article dealing with the habits of the latter species.

In conclusion I may add that a good figure of *P. nasutus* is given in Costa's classical memoir on the fauna of the Bay of Naples (1853).

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The Distribution of Marine Plankton.

In order to endeavour to co-ordinate the work of the many naturalists who make use of the tow-net round the coasts of the British Isles during the year, the following circular has been issued. The list of organisms, upon the presence or absence of which information is desired, contains only such as can be quite easily recognised. The scheme must be regarded as more or less experimental for this year, with a view to finding out what can be done in this direction.

Marine Biological Association of the United Kingdom.

The Laboratory, Plymouth,
December 30th, 1896.

Sir,—Many of the organisms commonly found in the plankton of the sea around the British coast exhibit remarkable variations in their relative abundance at particular localities from year to year, but little is known as to the extent and causes of such variations. As a number of naturalists make use of the tow-net at many places round the coast, especially during the summer, much valuable information would be obtained if in all cases records were kept of the presence or absence of a limited number of the commoner species, and these records subsequently brought together.

In the hope that you may be willing to assist in obtaining such information, I enclose a short list of organisms, the presence or absence of which I would ask you to record at any locality and as often as you may be using the tow-net during the year 1897. The records may be forwarded to me from time to time, and all should be sent in before January 31st, 1898.

Additional copies of the list will be sent, if desired, and your assistance is requested in inducing other naturalists to co-operate in making the records.

I am, Sir, yours faithfully,

E. J. Allen,
Director.

LIST OF SPECIES.

List of Species to be recorded whenever and wherever possible, during the year 1897:—

Halosphaera viridis.
Noctiluca miliaris.
Aurelia aurita (including *Ephyrae*).
Agalmopsis.
Muggiæa atlantica.
Hormiphora plumosa.
Beroe.
Tomopteris.
Anomalocera Patersoni.
Doliolum.
Salpa.

Where the generic name only is given in the above list, the specific name of the specimens taken should be added. Should any doubt exist, preserved specimens should be kept.

In making a record the following should be stated:—

DATE.
HOUR.
LOCALITY. (With as much accuracy as possible.)
DEPTH. (Depth of water, and maximum depth at which net has been worked.)
QUANTITY
- 0. Absent.
- 1. Few only.
- 2. Moderately plentiful.
- 3. Exceptionally abundant.

Observations on the temperature of the sea, and notes on wind, tide, etc., will also be of value.

Records to be sent in before January 31st, 1898, or forwarded from time to time to the Director, Marine Biological Association, Plymouth.

An Examination of the Present State of the Grimsby Trawl Fishery, with especial reference to the Destruction of Immature Fish.* Revision of Tables.

By

Ernest W. L. Holt.

About a year subsequent to the appearance of my paper on the Grimsby Trawl Fishery my attention was directed to certain arithmetical errors in the table on pp. 406 and 407 (pp. 70 and 71 of the Reprint). These errors are in truth, considerable, though fortunately not of a nature to affect the arguments brought forward in the text, as will appear to such of my readers as may be at pains to compare the revised edition with the original.

Although I have no intention of seeking to evade the responsibility for the figures published under my name, I may ask, nevertheless, to be allowed to advert briefly to the circumstances under which they went to press. At the time my paper was in preparation I was suffering from an illness that ultimately compelled me, with much regret, to sever my connection with the Association; and when it seemed advisable to expand my original statistics of "boxes" into columns of other quantities, I found my eyesight unequal to the cyphering thereby entailed. I was therefore obliged to confide the calculations, in great part, to other hands, with results sufficiently disastrous to my own reputation for accuracy.

The revision of the tables has brought to light two errors, which are not those of arithmetic, and for which the responsibility is entirely my own. In the entries for June, July, and August, 1892, it has been explained that 1000 cwt. was subtracted from the Board of Trade returns, as representing approximately the quantity of fish landed from Iceland during the said months. My intention, though not clearly explained in the text, was to subtract the amount from the aggregate; but in the tables it was inadvertently taken from each separate month.

* *Journ. Mar. Biol. Assoc.*, vol. iii. No. 5, Special Number, pp. 339-448. Reprinted under the above title. 1895.

In the present edition this item will be found to have been altered in accordance with the actual conditions, the amount subtracted being divided between the three months in proportions which correspond roughly with the relative abundance of Iceland fish during the period concerned. The figures 49,000 in column i were a misprint for 41,000 —the Board of Trade total. A further error appears to have been made in the number of boxes for June, 1893, and this has accordingly been altered to the number originally published in the Journal of the Association, vol. iii. p. 124.

The table on p. 410 (Reprint, p. 74) is dependent on the calculations in the former table, and is therefore vitiated by the errors alluded to. It happens, however, that the revision of this table only brings into greater prominence the destruction of undersized fish.

My attention has recently been drawn to the absence of any definite statement in my text as to the method by which the averages of number of fish in boxes of different qualities were deduced. At this lapse of time I regret that I am unable to lay hands upon the original figures, and can only state that I deduced averages from the contents of a large number of boxes of each quality counted during the earlier period of my work, and checked the results so obtained from time to time during the later years; and in order to run no risk of exaggerating the proportion of undersized fish, I actually made use of averages which somewhat underestimated such proportion.

It remains for me to express my indebtedness to the Association for publishing this corrected version of my tables (which my own circumstances did not allow of my undertaking), and to Professor Weldon and Mr. E. J. Allen for the revision of my figures.

Table showing the Weight, Bulk, and approximate Number of Plaice
fishing power (in voyages of steam-trawlers)

The terms "large" and "small" in this table refer only to the market designation under

	All Deep-sea Grounds.			North Sea.		
	Total.			Total.		
	Cwt.	Boxes.	Fish.	Cwt.	Boxes.	Fish.
1892.	i	ii	iii	iv	v	vi
April	11,000	9,778	1,253,200	11,000	9,778	1,253,200
May	12,000	10,667	1,191,200	12,000	10,667	1,191,200
June				11,075	9,844	1,504,900
July	41,000 (June–August)	36,355	4,697,450	17,650	15,689	1,877,750
August				11,275	10,022	1,290,800
September	15,000	13,333	1,510,900	15,000	13,333	1,510,900
October	20,000	17,778	1,822,050	20,000	17,778	1,822,050
November	20,400	18,133	1,813,300	20,400	18,133	1,813,300
December	11,000	9,778	977,800	11,000	9,778	977,800
1893.						
January	10,000	8,889	892,050	10,000	8,889	892,050
February	7,600	6,756	680,250	7,600	6,756	680,250
March	10,000	8,889	888,900	10,000	8,889	888,900
April*	12,213	10,833	1,471,650	11,963	10,633	1,463,650
May	23,580	20,439	2,953,020	17,726	15,756	2,765,700
June	22,919	19,555	2,313,250	13,731	12,205	2,019,250
July	29,760	25,190	2,259,290	15,540	13,814	1,804,250
August	22,992	19,675	1,806,610	14,424	12,821	1,532,450
September	13,864	12,296	1,334,000	13,552	12,046	1,324,000
October	18,215	16,191	1,710,450	18,215	16,191	1,710,450
November	12,621	11,219	1,244,300	12,621	11,219	1,244,300
December	5,141	4,570	470,050	5,141	4,570	470,050
1894.						
January	5,021	4,463	477,650	5,021	4,463	477,650
February	4,134	3,674	377,900	4,134	3,674	377,900
March	9,378	8,336	1,061,150	9,378	8,336	1,061,150
Total for year ending March, 1894	179,838	156,441	17,479,320	141,446	125,728	16,250,800
April	21,179	18,705	3,068,490	19,822	17,619	3,025,050
May	17,914	15,577	2,174,230	14,018	12,460	2,049,550
June	18,277	15,939	2,139,720	14,829	13,181	2,029,400
July	17,880	15,559	1,752,160	14,119	12,550	1,631,800
August	19,441	17,206	1,886,590	18,608	16,540	1,859,950
September	19,466	17,303	1,871,300	19,466	17,303	1,871,300
Total for six months	114,157	100,289	12,892,490	100,862	89,653	12,467,050

* Totals previous to this date are taken from official returns.

landed at Grimsby by deep-sea trawlers, and (col. xvi) *the diversion of* *from the North Sea grounds in each month.*

which the fish so enumerated are sold. *Vide* text, pp. 402 and 403 (pp. 66 and 67 of Reprint).

North Sea.						Iceland.			
Large.			Small.						
Cwt.	Boxes.	Fish.	Cwt.	Boxes.	Fish.	Cwt.	Boxes.	Fish.	Voyages.
vii	viii	ix	x	xi	xii	xiii	xiv	xv	xvi
8,935	7,942	794,200	2,066	1,836	459,000	..	...	...	...
11,067	9,837	983,700	934	830	207,500	...	...	...	...
7,171	6,374	637,400	3,904	3,470	867,500	...	...	...	...
15,334	13,630	1,363,000	2,316	2,059	514,750	1,000	800	24,000	?
9,110	8,098	809,800	2,165	1,924	481,000	...	...	...	...
13,668	12,149	1,214,900	1,332	1,184	296,000	...	...	...	...
19,668	17,483	1,748,300	332	295	73,750	...	...	...	...
20,400	18,133	1,813,300	...	...	...	...	...	...	...
11,000	9,778	977,800	...	...	...	...	...	...	...
9,977	8,868	886,800	24	21	5,250	...	...	...	...
7,566	6,725	672,500	35	31	7,750	...	...	...	...
10,000	8,889	888,900	...	...	...	...	...	...	...
—	—	—	—	—	—	—	—	—	—
8,960	7,964	796,400	3,003	2,669	667,250	250	200	8,000	2
8,800	7,822	782,200	8,926	7,934	1,983,500	5,854	4,683	187,320	20
7,740	6,880	688,000	5,991	5,325	1,331,250	9,188	7,350	294,000	30
12,369	10,995	1,099,500	3,171	2,819	704,750	14,220	11,376	455,040	36
12,546	11,152	1,115,200	1,878	1,669	417,250	8,568	6,854	274,160	21
12,656	11,250	1,125,000	896	796	199,000	312	250	10,000	1
17,530	15,582	1,558,200	685	609	152,250	...	...	...	...
11,703	10,403	1,040,300	918	816	204,000	...	...	...	...
5,043	4,483	448,300	98	87	21,750	...	...	...	...
4,786	4,254	425,400	235	209	52,250	...	...	...	...
4,055	3,604	360,400	79	70	17,500	...	...	...	...
7,671	6,819	681,900	1,707	1,517	379,250	...	...	...	...
113,859	101,208	10,120,800	27,587	24,520	6,130,000	38,392	30,713	1,228,520	110
10,348	9,198	919,800	9,474	8,421	2,105,250	1,357	1,086	43,440	7
7,991	7,103	710,300	6,027	5,357	1,339,250	3,896	3,117	124,680	25
9,494	8,439	843,900	5,335	4,742	1,185,500	3,448	2,758	110,320	21
11,293	10,038	1,003,800	2,826	2,512	628,000	3,761	3,009	120,360	19
17,063	15,167	1,516,700	1,545	1,373	343,250	833	666	26,640	5
18,408	16,363	1,636,300	1,058	940	235,000	...	...	...	...
74,597	66,308	6,630,800	26,265	23,345	5,836,250	13,295	10,636	425,440	77

Table showing the Numbers and Proportion of Plaice of different sizes landed at Grimsby by deep-sea trawlers in one year.

	Sexually Mature. 17 inches and above.		Sexually Immature. Below 17 inches.		13 inches and above.		Below 13 inches.	
	No.	%	No.	%	No.	%	No.	%
	i	ii	iii	iv	v	vi	vii	viii
1893. April . .	557,480	38	906,170	62	783,485	53	680,165	47
May . .	547,540	20	2,218,160	80	902,330	33	1,863,370	67
June . .	481,600	24	1,537,650	76	752,325	37	1,266,925	63
July . .	769,650	43	1,034,600	57	1,060,025	59	744,225	41
August .	780,640	51	751,810	49	1,045,405	68	487,045	32
September .	787,500	59	536,500	41	1,032,400	78	291,600	22
October .	1,090,740	64	619,710	36	1,417,605	83	292,845	17
November .	728,210	59	516,090	41	956,670	77	287,630	23
December .	313,810	67	156,240	33	405,645	86	64,405	14
1894. January .	297,780	62	179,870	38	388,085	81	89,565	19
February .	252,280	67	125,620	33	326,110	86	51,790	14
March . .	477,330	45	583,820	55	651,635	61	409,515	39
Total for year .	7,084,560	44	9,166,240	56	9,721,720	60	6,529,080	40

Director's Report

THE number of workers who have occupied tables at the Laboratory during the winter months has not been large. It becomes increasingly evident that the amount of work which can be carried on during this period of the year must depend upon the number of naturalists who can be employed by the Association to undertake general or special investigations. At the present moment our funds will only permit of the employment of one such naturalist, who is engaged in fishery investigations. My own time is so much occupied with administrative and other duties, that comparatively little of it can be devoted to scientific research. It may be worth while to point out once more that whilst the United States Commission of Fish and Fisheries is allowed an annual sum of £35,000 for salaries alone, a considerable portion of which is devoted to the payment of naturalists engaged in research, the total income of the Marine Biological Association amounts to only about £2000 a year.

Since the publication in August of the last number of the Journal, the following naturalists have visited the Laboratory :—

Brebner, G., August 1st to October 6th, 1896, December 30th, 1896, to Jan. 18th, 1897 (*Marine Algæ*).
Brumpt, E. (Paris), September 8th to 24th (*General Zoology*).
Church, A. H., B.A., July 8th to September 30th (*Marine Algæ*).
Goodrich, E. S., B.A., January 4th to 11th (*Holothurians*).
Menon, R., August 24th to October 13th (*Nervous System of Mollusca*).
Riches, T. H., B.A., January 13th to December 10th (*Nemertines*).
Scott, S. D., B.A., July 28th to November 20th (*Ascidians*).

Early in December we received a visit from a party of four fishermen, who, under the auspices of the Technical Education Committee of the Aberdeenshire County Council, were making a tour of the various fishing centres of England and Scotland, accompanied by Mr. Robert Turnbull, B.Sc., who acted as instructor. We arranged for two lectures on the Natural History of Fishes to be given for the benefit of the party, and assisted them as much as possible in seeing the various methods of fishing practised in this port.

Mr. F. B. Stead, who has been working at food fishes at Plymouth, has left for Naples, where he is at present occupying the Cambridge

University table. Mr. S. D. Scott, of King's College, Cambridge, is temporarily assisting me to carry on the fishery investigations. The work on the east coast, commenced by Mr. Holt and subsequently continued by Mr. Cunningham, has now ceased owing to lack of the necessary funds for its maintenance.

The experimental trawling in the bays on the Devonshire coast has been continued during the autumn and winter. The results of the trawlings in January show clearly, as was to have been expected, that the larger plaice have left, probably for the spawning grounds, whilst the fish from the estuaries and from close inshore have come out into the bays. Thus in Teignmouth Bay, whereas in October and December 4 per cent. only of the plaice were 7 inches and under, in January the proportion at this size and under had increased to 32 per cent.

In connection with studies on the distribution of fish eggs, larvæ, and young fish, a series of experiments has been started for determining the surface drift in the western portion of the English Channel by means of floating bottles. The experiments are similar to those which have been made by Prof. Herdman in the Irish Sea, and by the Scottish Fishery Board in the North Sea; but we have adopted a bottle of somewhat larger size, in order to counteract as much as possible the direct action of the wind upon the bottle itself. Ordinary egg-shaped soda-water bottles are being used, weighted with shot in such a way that the bottle floats vertically, the shot being kept in place by being imbedded in solid paraffin. The thanks of the Association are due to Admiral the Hon. Sir E. R. Fremantle, Commander-in-Chief at Devonport, who has kindly arranged for bottles to be put overboard by the torpedo-boat destroyers cruising in the neighbourhood. This will enable us to carry out the experiments in a much more satisfactory way than would otherwise have been possible. Owing to the rugged nature of the coast, I do not anticipate that we shall recover so large a percentage of the bottles as was the case in Prof. Herdman's and the Scottish experiments.

With a view to obtaining information as to the distribution of marine plankton, a scheme has been arranged to endeavour to co-ordinate the work of the many naturalists who frequently make use of the tow-net around the British coasts. A further account of this will be found on p. 408.

The dredging and trawling work on the grounds between the Eddystone and Start Point was continued during last summer, and the results of about seventy hauls have been worked out. It is hoped that the results of this work, which has been carried on regularly for two summers, will shortly be ready for publication.

In promising to place on the estimates for the year 1897–98 the usual grant of £1000 to the Association, the Lords Commissioners of H.M. Treasury have made it a condition of the grant that the Association will give all the assistance in its power to the Inspectors of Irish Fisheries in investigations which they desire to be made on the habits, etc., of the mackerel visiting the Irish coast. In connection with this subject, a report is being prepared upon the present state of knowledge of the natural history of the mackerel in all parts of the world.

Mr. Cunningham's book on the *Natural History of the Marketable Marine Fishes of the British Islands,* which has been published for the Association by Messrs. Macmillan & Co., has been very favourably noticed by the Press, and there seems little doubt but that it will be regarded as a standard popular work on the subject.

The system of filtering sea-water through layers of blanketing, which was devised in connection with the hatchery at Dunbar, has been adopted for the Aquarium here with satisfactory results. The supply of water from the sea has been greatly interfered with owing to the pipe which brings the water to the ejector having been damaged by the stranding of the steamship *Ariel* on the rocks below the Laboratory. The pipe has been repaired, and we are advised that the owners are liable for the damage done.

The *Busy Bee,* which has now been in regular use for twelve months, continues in good condition, and has given very little trouble in the way of repairs. We have found her coal consumption remarkably low, and the expense of running her has been considerably less than was anticipated. We are now having a compact trawling winch, capable of carrying a drum of wire-rope, built for her, which will greatly increase her usefulness.

I regret to say that the whole of the money for this vessel has not yet been subscribed. With the necessary fittings, including the winch, a sum of nearly £700 has been spent. Towards this amount, as will be seen from the list which follows this Report, £537 14s. has been given. We are very anxious that the balance should be met during the present financial year, which ends in May.

E. J. Allen.

February, 1897.

Steamboat Fund.

LIST OF SUBSCRIPTIONS TO JANUARY, 1897.

	£	s.	d.
The Worshipful Company of Fishmongers	105	0	0
The Royal Society	100	0	0
J. P. Thomasson, Esq.	100	0	0
The Worshipful Company of Drapers	52	10	0
,, ,, ,, Grocers	50	0	0
,, ,, ,, Mercers	26	5	0
,, ,, ,, Skinners	21	0	0
,, ,, ,, Goldsmiths	20	0	0
The Earl of Ducie	10	0	0
Sir Henry Thompson	10	0	0
E. L. Beckwith, Esq.	5	5	0
Mrs. E. S. Heywood	5	5	0
The Earl of St. Germans	5	0	0
R. Assheton, Esq.	5	0	0
G. Fry, Esq.	5	0	0
J. Mackrell, Esq.	5	0	0
E. Grove, Esq.	3	0	0
S. F. Harmer, Esq.	2	2	0
S. Makowski, Esq.	2	2	0
W. H. St. Quintin, Esq.	2	2	0
A. O. Walker, Esq.	2	2	0
W. I. Beaumont, Esq.	1	1	0
	£537	14	0

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THE NATURAL HISTORY

OF THE

Marketable Marine Fishes of the British Islands.

Prepared by order of the Council of the Marine Biological Association expressly for the use of those interested in the Sea-fishing Industries,

BY

J. T. CUNNINGHAM, M.A.,

FORMERLY FELLOW OF UNIVERSITY COLLEGE, OXFORD; NATURALIST ON THE STAFF OF THE MARINE BIOLOGICAL ASSOCIATION.

With Preface by

E. RAY LANKESTER, M.A., LL.D., F.R.S.,

PROFESSOR OF COMPARATIVE ANATOMY IN THE UNIVERSITY OF OXFORD; PRESIDENT OF THE MARINE BIOLOGICAL ASSOCIATION.

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A TREATISE ON THE COMMON SOLE.

BY

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OBJECTS

OF THE

Marine Biological Association of the United Kingdom.

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

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 £27,000, of which £12,000 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 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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Members of the Association have the following rights and privileges; they elect annually the Officers and Council; they receive the Journal of the Association free by post; they are admitted to view the Laboratory at Plymouth, and may introduce friends with them; they have the first claim to rent a place in the Laboratory for research, with use of tanks, boats, &c., and have access to the books in the Library at Plymouth.

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