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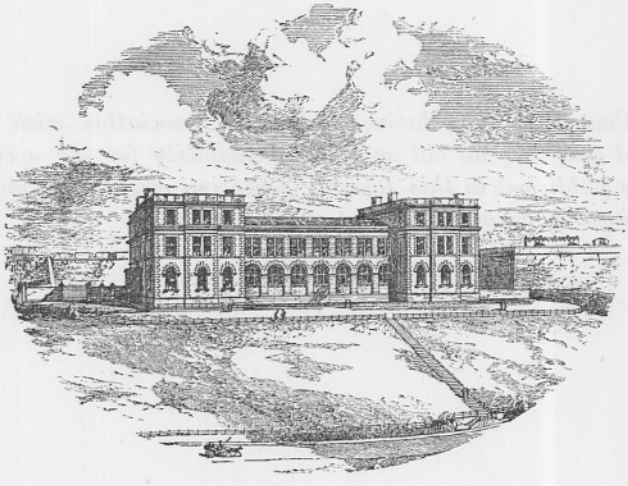

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PRINTED BY ADLARD AND SON,
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Journal of the Marine Biological Association.

A List of the Nemertines of Plymouth Sound.

By

T. H. Riches, B.A.,
Caius College, Cambridge.

The present list, the result of observations made at intervals in the course of last year, was undertaken with the view of determining for embryological purposes the resources of the Sound with regard to this group. It includes the species obtained during a great part of the year 1892.

Of the species recorded by McIntosh (1) as British, all but seven are here enumerated.* Of these seven, three, *Amphiporus hastatus, Tetrastemma Robertianæ,* and *Valencinia lineformis,* are northern forms, occurring in Bressay Sound, Shetland, though one specimen of the first has been taken by Hubrecht (2) at Naples, and two by Joubin (4) at Roscoff. One, *Borlasia Elizabethæ,* is a southern form, not yet recorded north of Herm. The fourth, *Meckelia asulcata,* described by McIntosh as having a wide range, has not been met with by any other writer. The fifth, *Nemertes carcinophila,* though included among the British Nemertines, has apparently not been found on the British shores—at least the only localities mentioned by McIntosh are Messina and the coast of Belgium. The last, *Amphiporus pulcher,* is said "to be generally diffused round the British coasts in water eight to thirty fathoms deep," and seems to be common on the French coast and in the Mediterranean. I am inclined to think that a species which I describe below under the name of *Amphiporus dissimulans,* and which much resembles *A. pulcher* in appearance, has occasionally been taken for the latter.

Since the publication of the monograph I only know of one addition to the Nemertine fauna of Britain, the interesting *Carinoma Armandi.* This has unfortunately not yet been found here.

The total number of species here recorded is thirty-two. Four of these are new, *Tetrastemma nigrum, T. immutabile, T. ambiguum,* and *Amphiporus dissimulans;* one, *Nemertes candida,* is new to

* An eighth, the deep-water *Cerebratulus marginatus,* should be added to the number of the British species which I have not yet obtained.

Great Britain; two are new to the coast of Britain, *Carinella polymorpha* and *Micrura aurantiaca*, these not being recorded previously north of the island of Herm; while *Drepanophorus rubrostriatus*, if, as I believe, identical with *Amphiporus spectabilis*, has not been met with north of Guernsey.

Of the parasitic forms I have only obtained *Malacobdella*. I have, however, examined several specimens of *Galathea strigosa* for Dieck's *Cephalothrix Galatheæ*, which he describes as parasitic upon the eggs and on the gills of this crustacean, and which I believe no other writer has seen. With regard to this species, I may remark in passing that it has been erroneously referred to the genus *Carinella* by Joubin and J. V. Carus (**8**). With the same want of success I have examined large numbers of specimens of *Phallusia mammillata* and other Ascidians for Joubin's *Amphiporus vittatus* and *Tetrastemma Marionis*, and an examination of female specimens in berry of *Carcinus mænas* has not resulted in finding *Nemertes carcinophila*.

In spite of the, in many cases, brilliant colours exhibited by Nemertines, and although many of them are conspicuously marked, I have been unable to find any very definite relation in this respect to the surroundings. This want of relation is especially marked among the Tetrastemmidæ, which exhibit a very large amount of colour variation, and yet varieties the most divergent in this respect live together under apparently the same conditions. The genus *Tetrastemma* exhibits a very high degree of variation among its members, not only in colour, but also in marking and in general appearance unconnected with colour. These variations will be described in some detail below.

I will only now remark that varieties have been obtained which in many respects connect such well-marked species as *T. candidum*, *T. vermiculatum*, and *T. melanocephalum*.

The observations of Keferstein, Claparède, and others on the existence of otocysts among the Nemertea seem not to be in favour with most modern writers. Bürger (**6**), however, in a paper published in November, 1891, stated that he had observed otocysts of oval form which were situated one on each half of the brain in some unidentified enoplous Nemertines, which he found living in sand with *Lineus lacteus* and Amphioxus. A week later du Plessis (**11**) published a paper on the subject, in which he described a pair of otocysts which he found in a thin orange-red eyeless Nemertine of 15 to 20 mm. in length, obtained under stones between tide-marks at Nice. These otocysts resembled those described by Bürger, and differed in many points from those observed by Claparède and Keferstein. On May 14th I found in sand on Drake's Island between tide-marks a few specimens of an armed Nemertine associated with *Lineus lacteus*. Each of these specimens exhibited a pair of otocysts of relatively large

size, one on each ventral brain lobe just posterior to the ventral commissure. In the centre of each capsule was a single refringent otolith; no cilia could be detected. Like the two previous writers, with whose accounts I was not at that time acquainted, I failed to identify the bearers of these interesting structures. They were unfortunately lost before I had completed my examination of them. The following points, however, were made out:—Length from 1 to 2 cm. Two of the specimens were pure white, the third was pinkish posteriorly; brain conspicuously red; head rounded, with oval transparency in dorso-median line; generative organs ripe. Proboscis long, reaching to end of body, with anterior terminal pore, with median stylet and two accessory capsules, one containing several reserve stylets, the other only two; mouth in front of ganglia; eyeless. It seems to me very probable that Bürger, du Plessis, and myself have found the same species, since not only are the otocysts precisely the same in structure, but the accounts of the worms themselves, though meagre, are in agreement, and all of them are found living under the same conditions. Du Plessis attempts to correlate the presence of otocysts with the absence of eyes, but the latter condition is not infrequent among Nemertines, while the rarity of those with otocysts is sufficiently evinced by the general scepticism with which their existence has been regarded. Joubin, in his *Poliopsis*, describes structures which he at first took for otocysts, but afterwards found to be the blind ends of the ciliated canals of the side organs. The otocysts above mentioned cannot, however, be thus explained away.

The classification of the Nemertines has until lately been very defective. In 1890 Bürger, in his admirable paper on the anatomy and zoology of the Nemertea (**5**), very ably criticised Hubrecht's system, which he showed to be untenable, and proposed temporarily to return to that of Schultze. In the following year (**6**) he brought out a new scheme dealing with the primary subdivisions only. In his system these are four in number, and are based upon the situation of the nerve-stems. Last March (**7**) this system was further developed and carried into detail as regards three of the subdivisions. One of them, however, that corresponding to the *Enopla* of Schultze, was left for a future paper, which as far as I am aware has not yet appeared.

As this classification will be the one here adopted, it may be well to state at once its leading characters. According to Bürger's scheme the whole group consists of the four following orders:

I. *PROTONEMERTINI* (*Carinella, Carinina,* and *Hubrechtia*).—Lateral nerves outside the circular muscular layer, situated either in the epidermis or beneath the basement membrane.

II. *MESONEMERTINI* (*Cephalothrix* and *Carinoma*).—Lateral nerves have penetrated the circular muscular layer, and lie embedded in the longitudinal layer.

III. *METANEMERTINI* (Hoplonemertini of Hubrecht).—Lateral nerves have penetrated the longitudinal muscular layer, and lie in the body parenchyma.

IV. *HETERONEMERTINI* (Schizonemertini of Hubrecht, together with the genera *Eupolia* and *Valencinia*).—Lateral nerves in the same position as in *Carinella*, but between the epidermis and the circular muscular layer a layer has developed consisting of gland-cells, connective tissue, and longitudinal muscles, in which the nerve-stems lie.

Of these divisions, that of the *Protonemertini* is of course regarded as the oldest, and Bürger regards it as giving rise to the *Mesonemertini* through *Carinella*, and to the *Heteronemertini* through his new form *Hubrechtia desiderata*, for which he has established a new family, *Hubrechtiadæ*. The *Metanemertini* he considers to have arisen from the *Mesonemertini*.

The subordinate changes concern the order *Heteronemertini*. This order is divided into two families,—the *Eupoliadæ*, including the genera *Eupolia* and *Valencinia*; and the *Lineidæ*. The latter consists of two sections, the *Micruræ* and the *Amicruræ*, characterised by the presence or absence of a caudal appendage. To the *Amicruræ* belong the genera *Micrura*, *Cerebratulus*, and *Langia*. Of these the first two were united by Hubrecht under the name of the second. They are now again separated, the differentiating characters being those of general shape and mode of life.

In the above arrangement of the Lineidæ there is obviously a return to the scheme laid down by McIntosh. Hubrecht objected to the caudal appendage being regarded as a feature of generic value, and while thus abolishing the genus *Micrura* and including its species under *Cerebratulus*, he added to the latter all the shorter and broader species included by McIntosh under *Lineus*, with the result of establishing two genera, *Lineus* and *Cerebratulus*, with absolutely no point of difference except a very problematical ontogenetic difference. With our present knowledge there are, it appears to me, only two ways out of this difficulty. Either the genera *Lineus* and *Cerebratulus* must be fused into one, with the result of forming a very large genus—a method of escape suggested by Hubrecht himself (**3**); or there must be a reversion to the McIntoshian system, which, with some alterations in detail, is the method adopted by Bürger. Of the two alternatives there can be no doubt that the last

is much the better, and in spite of the absence of any striking structural differences between the genera *Cerebratulus* and *Micrura*, and only that of the caudal appendage between these and *Lineus*, this arrangement is much more convenient and natural.

With regard to the spawning periods of the various species my observations are not at present very complete. It may, however, be stated generally, that during the whole year some one or more species are breeding, and I was considerably astonished to find a large number of species with ripe generative products from late summer to the middle of December when I left Plymouth. During this period my specimens of *A. dissimulans* laid several batches of fertilized eggs, and all the species of *Tetrastemma* and many *Schizonemertines* were ripe, as was also the parasite *Malacobdella*. The tow-net, too, contained many pilidia of different species, as well as numbers of *Cephalothrix* larvæ. The presence of the latter was surprising, as I did not meet with any ripe adults later than August.

I have nothing to add to the observations of Joubin on the vertical distribution of these forms, with which my own substantially agree.

I have not attempted to give a list of the synonyms ; a few only are given in the case of especially interesting species, or where there have been any recent changes in nomenclature.

The definitions of the different groups are those of Bürger.

Order 1.—PROTONEMERTINI, *Bürger.*

Brain and lateral nerves lie outside the muscular coat of the body-wall, either in the epidermis or beneath the basement membrane. Body-wall consists of epidermis and of a circular and longitudinal muscular layer. Mouth behind brain. Proboscis without a stylet.

Family CARINELLIDÆ (*McIntosh*).

Genus CARINELLA, Johnston.

1. C. POLYMORPHA, *Renier, Hubrecht.*

VALENCINIA SPLENDIDA, *de Quatr.*
TUBULANUS POLYMORPHUS, *Renier.*
CARINELLA ANNULATA (pars), *McIntosh.*

Only one specimen has been obtained. It was dredged in 25 fathoms off Stoke Point on March 22nd, and its occurrence

was recorded in the Journal of this Association for that month. As I then pointed out, it has not before been noticed on the British coast. I suggested, however, that a worm described by McIntosh as a variety of *C. annulata*, and obtained by him from the island of Herm, was probably identical with this form, and I am still inclined to think that this is the case. In the record to which I have alluded, I mentioned that upon very close examination under a lens extremely faint lines could be detected, apparently similar in position to those of *C. annulata*, except that the median ventral line was absent; these lines not being white, but distinguishable by the red colour being along their course somewhat paler than elsewhere. In the absence of the median ventral line this species resembles *C. McIntoshii*. In his specimen from Herm McIntosh describes a pale lateral line on each side, and faint transverse bars on the dorsum. These lines are not mentioned by other writers, nevertheless the general ground colour and the shape and size of the head sufficiently characterise my specimen as belonging to this species.

Distribution: Naples, but not common (Bürger); fairly common on French coast (Joubin).

2. C. LINEARIS (*Montagu*, MS.), *McIntosh*.

LINEUS LINEARIS, *Montagu*, MS.
CARINELLA ALBIDA, *Bürger*.

The validity of this species has lately been called in question by Joubin, who is inclined to regard it as identical with *Valencinia longirostris*. There is no doubt great external similarity, but sections clearly reveal that the two specimens which I refer here belong to the genus *Carinella*, and not to *Valencinia*. The position of the nerve-cords between the basement membrane and the muscular coat of the body, and the absence of an outer longitudinal muscular layer, in which in *Valencinia* the nerve-stems lie, are quite conclusive as to this.

Both my specimens were dredged at the Duke Rock, the one on May 17th, the other on September 30th. Both were small, the second specimen measuring 1 cm. in length and 0·5 mm. in breadth. The first specimen was too mutilated to allow of measurement, but, judging from the size of the head, was much the same length as the other. The colour was milk-white in both cases, but in the first specimen there was a reddish tinge over the head. A transverse groove was present at the back of the head dorsally, but was difficult to trace. The head was broader than the body and somewhat spathulate, though its mobility was such that no very definite shape could be assigned to it, the snout being at one time

pointed, at another rounded in outline. Passing from the point of the snout to the posterior region of the head was a median dark line, due apparently to a central opacity in this position, the rest of the head being relatively transparent. The mouth was a longitudinal slit in the position characteristic of the genus. The eyes were absent.

The short description which Bürger gives of his *Carinella albida* is so applicable to my specimens that I am inclined to regard it as identical with this species.

Distribution: South coast of England, and Lochmaddy in the Hebrides (McIntosh); Rizomi di Posidonia, Posilipo, not uncommon (Bürger).

3. C. ANNULATA, *Montagu.*

VALENCINIA ORNATA, *Quatr.*
CARINELLA ANNULATA (pars), *McIntosh.*
— — (pars), *Hubrecht.*
— — *Joubin.*

In the *Carinella annulata* of McIntosh, Bürger distinguishes two species, differing in colour, marking, size, and in the number and structure of the side organs.

Of the present species only one specimen has been obtained, and this was a fragment without head or tail of about 1 cm. in length. It was, however, readily recognisable by the presence of a median ventral white line. This specimen was dredged in nearly 40 fathoms, about six miles S.E. of the Mewstone. The apparent rarity of this species is, I believe, solely due to its living at depths at present quite inaccessible to us. While at St. Andrews I obtained a large number of specimens which were found adhering to the long lines of the haddock fishermen, and were thus brought up from considerable depths.

4. C. MCINTOSHII, *Bürger.*

CARINELLA ANNULATA (pars), *McIntosh.*
— — (pars), *Hubrecht.*
— ARAGOI, *Joubin.*

Not uncommonly dredged in from 5 to 20 fathoms. Readily distinguishable from the last by its much smaller size, its white snout, the different relation of the white rings to each other, and the absence of a median ventral white line.

The chocolate variety, though rarer than the dark red, has been met with on several occasions. Many specimens obtained during

the summer months had the white dots on the dorso-lateral regions of the middle and posterior parts of the body which mark the external openings of the generative organs. Whether the presence of these spots indicates sexual activity I do not know. Although many specimens were kept in captivity they did not spawn.

Order 2.—MESONEMERTINI, *Bürger.*

The lateral nerves are pushed down into the body musculature. The body-wall consists of epidermis, a circular and a longitudinal muscular layer. Mouth behind brain. Proboscis without a stylet.

Family CEPHALOTHRICIDÆ, *McIntosh.*

To this family, in addition to *Cephalothrix,* Bürger assigns *Carinoma.* He characterises it as follows:—Lateral nerves situated in the longitudinal muscular layer. Neither cephalic grooves, clefts, nor side organs present.

The negative characters here assigned, and which are repeated in the definition of the genus *Cephalothrix,* can scarcely be accepted in view of the recent positive statement by Joubin of the existence of side organs in *Cephalothrix linearis,* strengthening as it does the earlier assertion of Barrois (**9**) to the same effect. In 1877 Barrois stated, "Les organs latéraux du *Cephalothrix linearis* sont, en général, peu accusés; c'est là, ce qui fait que plusieurs auteurs les ont laissé passer inaperçus et ont dessiné le Némerte comme en étant dépourvu; je me suis assuré que c'était là une erreur: ces organes existent très-bien chez le Cephalothrix adulte et y présentent, avec le système nerveux, une disposition analogue à celle des Lineus."

This statement has been persistently neglected, but now that these organs have been again described, and this time with figures, their existence can scarcely be doubtful.

Genus CEPHALOTHRIX, Oersted.

5. C. LINEARIS, *Rathke, Oersted.*

This species appears to be much less common than the next, and reaches a very much greater size. Though I have never found any specimens of the gigantic length of 50—60 cm., such as Joubin describes are obtained on the French coast, I have had several

varying from 10 to 15 cm. in length. A few individuals have been obtained by dredging in the deeper water outside the Breakwater, but the bulk of my specimens have been obtained in the sand between tide-marks at Rum Bay. They have not yet been found in a similar situation in any other locality. Joubin states that his specimens came from black muddy sand, and he contrasts this species with *C. bioculata* in this respect, as, according to him, the latter lives in pure yellow sand. This difference of habitat in the case of the two species does not appear to hold good for Plymouth forms. Here both species are found in clean coarse sand, and I have occasionally found *C. bioculata* in black mud.

6. C. BIOCULATA, *Oersted.*

This common species may be obtained almost everywhere between tide-marks. As I have already said, a few specimens have been occasionally found in black mud, but the majority in clean, coarse sand. Large numbers live among corallines, and may be captured by collecting the latter. Unless Bürger's *C. hymenæus* is a variety of this species, it does not occur at Naples, but the difference between them is very slight, consisting as regards *C. hymenæus* in a reduction of the red pigment on the head to the two red specks, and the presence of grains of blue pigment in the latter. A difference of habitat is also mentioned, *C. hymenæus* never being found in sand, but associated with *Tetrastemma coronatum*. At Plymouth *Tetrastemma coronatum* is abundant among the corallines in tide-pools, where it is associated with the present species.

The breeding period lasts from early spring until the beginning of autumn. Ripe specimens were first found in April, and none were found later than August. As I have already mentioned, pelagic larvæ were obtained from the tow-net as late as December. The largest of these was 3 mm. long, and was provided with an additional pair of marginal lappets, situated between the pair figured by McIntosh and Barrois and the anterior extremity. The eyes were situated at the margin of the head, and relatively far back. Some days after the capture of this larva it gave up pelagic life, and sank to the bottom of the vessel. About this time the eyes began to atrophy, and very shortly the adult appearance was reached. I have succeeded in getting this species to breed in captivity, and hope soon to publish an account of its development.

Order 3.—METANEMERTINI, *Bürger.*

The lateral nerves have completely broken through the muscular coat of the body-wall, and have come to lie within it in the parenchyma. The body-wall consists of epidermis, a circular muscular layer, and a longitudinal muscular layer. The mouth is situated in front of the brain. The proboscis, with few exceptions, is provided with a stylet.

Family AMPHIPORIDÆ, *Hubrecht.*

Genus AMPHIPORUS, Ehrenberg.

7. A. LACTIFLOREUS, *McIntosh.*

Nearly as common as *L. obscurus.* Lives between tide-marks under stones. The arrangement of the eyes in two groups on each side, the posterior group generally forming a triangle, with one eye-speck (that most remote from the snout) much larger than the rest, is very characteristic.

The colour is very variable; many shades of white and whitish pink are represented, but the commonest colour is perhaps light brown. I have never met with a green variety, though this seems common on the French coast, and has been found at Guernsey.

Ripe specimens and eggs were found in the early spring.

8. A. DISSIMULANS, n. sp.

I have established this species for a very abundant Amphiporus which I at first took to be *Amphiporus pulcher.* It agreed with this species in the general shape of the body, with its oar-like tail; in the broadly spathulate pointed head, so different in appearance from that of *A. lactifloreus,* and, in contrast to the latter, sharply separated from the body; in the arrangement of the eyes, which are never divided into groups; and in habitat occurring only in from 15 to 20 fathoms.

The average length is 5 cm.; the colour is variable, but most frequently is a very pale pink, the pink being rather pronounced anteriorly, but posteriorly passing into a bluish tint. The tip of the snout has a central papilla, from which an opaque line passes back a short distance. The eyes are very numerous; in one specimen I counted forty on one side. The brain can be seen as a red object shining through the skin, but it is not so conspicuous as in *A. lactifloreus.*

The arrangement of the cephalic grooves is somewhat peculiar, it is the same as that described by Joubin in *A. pulcher*.

In the characters just given, the specimens included here do not seriously differ from *A. pulcher*, but they differ essentially in the structure of their proboscis, which resembles that of *A. lactifloreus*, while that of *A. pulcher*, according to the description given by McIntosh, is widely different, and in the situation of their side organs, which is in front of the brain as in *A. lactifloreus*, and not behind it.

These differences in proboscis structure and in position of the side organs rendering it impossible to assign these specimens to the species *A. pulcher*, it yet remains whether they ought not to be considered varieties of *A. lactifloreus*. But against this view are the characters above given of the shape of the head and of the tail, the number and arrangement of the eyes, the position of the cephalic grooves, and the difference of habitat, *A. lactifloreus* being a shallow water form, and these specimens being never obtained in less than 15 fathoms.

It seems very probable that this species has been occasionally described as *A. pulcher*. Joubin, for instance, in describing the specimens at Roscoff and Banyuls says nothing of the peculiar structure of the stylet region of the proboscis, so characteristic of the latter species, nor does he mention the situation of the side organs. On the other hand, he says that he has not seen the secondary cephalic grooves described by McIntosh ; and his figure of the arrangement of the primary grooves is, as has been said, perfectly applicable to this species. While, moreover, McIntosh finds only twenty-three eyes on each side of the head, Joubin describes as many as thirty-five or forty-five.

Ripe specimens occur in the spring, but are more common in October, at a time when *A. lactifloreus* is not breeding.

The only locality from which this species has hitherto been obtained is the Millbay Channel, where it occurs in considerable numbers.

9. A. BIOCULATUS, *McIntosh*.

Only one specimen of this northern species has been obtained. It was dredged in Millbay Channel on November 18th, with many examples of the last species. Its length was about 1 cm. In colour it was somewhat different from that of specimens previously described, being a milky white, while the Shetland specimens were dull orange, and the two obtained at Roscoff were green. The description and figure of the head given by Joubin exactly apply to the present specimen.

This species has not yet been found in the Mediterranean, and this is the only record from the coast of England.

Genus DREPANOPHORUS, Hubrecht.

10. D. RUBROSTRIATUS, *Hubrecht.*

AMPHIPORUS SPECTABILIS, *McIntosh.*

This species has been the centre of much controversy, and there is still some confusion regarding it. The controversy concerns the identity or non-identity of the Naples *Drepanophorus rubrostriatus* with the Atlantic *Amphiporus spectabilis* of McIntosh. Hubrecht is of opinion that they are not identical, and he accuses McIntosh of having referred the anatomical points which he obtained from Mediterranean forms to Atlantic specimens, thus, according to Hubrecht, "confounding specimens, species, and even genera." As far as I understand Hubrecht's position, he maintains that there are two species belonging to distinct genera, the one being an *Amphiporus*, the other a *Drepanophorus*, and that these two present great external similarity, and have hence been confounded; that the *Drepanophorus* is restricted to the Mediterranean; and that the Atlantic form described by McIntosh as *Amphiporus spectabilis* is distinct from it, being identical with the *Amphiporus splendidus* of Keferstein and Barrois, and not with the *Cerebratulus spectabilis* of De Quatrefages, which he regards as synonymous with his own species.

Joubin, on the other hand, who has had the advantage of working at both Atlantic and Mediterranean Nemertines, is of opinion that the two are identical, though he does not appear to have had anatomical evidence for this.

Apart from the very remarkable curved stylet in the proboscis, the genus *Drepanophorus* is characterised by the presence of transverse cæca belonging to the proboscis sheath, these cæca being arranged metamerically. And this character alone has been used by Hubrecht in referring some of his "Challenger" specimens to this genus. Now the specimens that I have obtained at Plymouth, which are in complete agreement with the description given by McIntosh of *Amphiporus spectabilis* in his monograph (his views as to the proboscis—which, however, he afterwards admitted to be erroneous—alone excepted), exhibit very clearly in sections these metameric cæca, so that no doubt can remain that they belong to the genus *Drepanophorus*. This being so, is not the identity of the *Amphiporus spectabilis* of McIntosh with Hubrecht's *Drepanophorus rubrostriatus* established?

Five specimens have been found. The first came from weeds dredged in Cawsand Bay on November 11th. It was 2 cm. in length, and exhibited the bright red stripes shown in Joubin's

figure. All the rest were dredged at Stork Point during the same month, and were found inside the honeycombed stones with which the bottom is there strewn. These specimens were considerably larger than the first, the largest being something over 6 cm. in length and the smallest between 3 and 4 cm. In all these the colour was much paler than in the Cawsand Bay specimen, the red lines being represented by buff-coloured lines, and the intermediate lines being grey instead of pale pink. In these larger individuals the generative organs were ripe.

This species has not previously been recorded so far north. It occurs on the Atlantic shores of France, but is much more common in the Mediterranean. A single specimen was found at Guernsey by McIntosh.

Family TETRASTEMMIDÆ, *Hubrecht.*

Genus TETRASTEMMA, Ehrenberg.

As has been already remarked, this genus is characterised by the very high degree of variation which its members exhibit. It is for this reason in many cases extremely difficult to identify a given species, or to come to anything like a satisfactory conclusion as to the amount and kind of difference which justifies specific separation. Such conclusions as are expressed by the recognition of the following species are provisional. They are, however, based on a consideration of the kind and degree of variation exhibited in each case.

11. T. FLAVIDUM, *Ehrenberg.*

This species is very different in appearance from the other members of the genus, and, unlike them, exhibits very little variation. It is very common, and may be found between tide-marks, but it is obtained in larger numbers by dredging in from 5 to 20 fathoms. The Duke Rock and Millbay Channel are favorable localities.

Ripe specimens occur in autumn.

12. T. DORSALE, *Abildgaard.*

This very common species seems to inhabit every level from Joubin's second zone to his fifth. It was especially common in spring and early summer among the Zostera in Cawsand Bay. Later in the year, however, it became less common in this locality, and late in the autumn it was quite the exception to find a single individual there, when a small Terebellid seemed to have taken its place.

Several varieties have been met with, agreeing with those described by other writers, but all were marbled. This species agrees with the two following, and differs from all other Tetrastemmas in the rounded shape of the body, and in the absence of a well-defined head region, so characteristic of the remaining species.

The breeding season is the autumn.

13. T. NIGRUM, n. sp.

I describe under this name a species which I at first considered as a variety of the last. Like *Tetrastemma dorsale* it has a rounded body, and there is no well-marked head ; but though highly variable in marking, it yet maintains certain characteristics to which no varieties of *T. dorsale* that I have met with in any way approach. The general ground colour, which is a pale yellow, may be entirely or partially hidden by a strong development of a very dark brown, almost black pigment, which is in the form of a close network. This dark pigment either covers the dorsal surface of the animal entirely, rendering it quite black to the naked eye, or the median dorsal line is left uncovered, which thus appears as a median yellow stripe. This stripe passes from the anterior to the posterior extremity, and is generally interrupted, but quite irregularly, by bridges of the dark pigment stretching across it. The breadth of the stripe is very variable, both in different animals and in different regions of the same animal, and its edges are much frayed. The cephalic grooves are more apparent than in the case of *T. dorsale*, owing to the absence of the dark pigment at their edges ; but the eyes, which are reddish, have the same position, and are deeply placed. The stylet region of the proboscis resembles that of *T. dorsale*, but there is considerable variability in the shape of the stylet handle.

This species is most commonly found on *Codium*, which it in some degree resembles in colour, enough at least to make it difficult to find. I have, however, obtained it from weeds of various kinds, in the Laminarian zone. The average length is 1 cm.

14. T. IMMUTABILE, n. sp.

The specimens brought together under this name are perhaps identical with one described by Joubin as a variety of *T. dorsale*. From this species, however, they differ at least as much as many species (which are regarded by every one as distinct) do from each other. I am, moreover, inclined to regard them as constituting a distinct species, because in spite of the variability of *T. dorsale* I have met with no variations which in any way approach them in

colour and marking, and they, on the other hand, are singularly invariable.

The length ranges from 5 mm. to 1 cm. The body is rounded, and ends abruptly both anteriorly and posteriorly as in *T. dorsale;* the head, however, is more apparent than in the latter, owing to the slight amount of pigment there distributed. The ground colour is yellow, with a sprinkling of orange-red granules, which are strongly concentrated in the median dorsal line, forming a stripe of chocolate colour, beginning just in front of the anterior pair of eyes, and passing backward to the posterior end of the body.

The eyes are black, and similarly situated to those of *T. dorsale.* Many specimens have been found in the coralline pools at Wembury Bay, and they are also met with among the weeds in the second and third zones, and dredged at the Duke Rock. In all these places they are associated with other species of *Tetrastemma,* including *T. dorsale.*

15. T. CANDIDUM, *O. F. Müller, Oersted.*

Agrees with the remaining species of this genus, and differs from the last three in its more or less flattened body, in marked contrast to the rounded body of *T. dorsale* and its allies, and in its sharply separated spathulate head. The species now to be considered are also characterised by their excessive variability. Only one specimen resembling the type form of McIntosh has been obtained; this was found by Mr. Garstang in sand between tide-marks at Rum Bay on the 21st of July.

The reddish and yellow varieties are not uncommon. They are found, though in small numbers, in Cawsand Bay among the weeds. Larger specimens are dredged in 5—20 fathoms, and they appear to be more numerous at the greater depth. Thus specimens have been dredged at the Duke Rock, and in Millbay Channel, but the majority have come from Stoke Point, where they seem to live associated with *Lepralia,* which they closely resemble in colour. The positive points characterising this species seem to consist in the shape of the head, which is more rounded than in the other members of the genus, in the definiteness of the cephalic grooves, which give the head a very characteristic appearance, and in the clearness and distinctness of the eyes, which are round and black. But in these as in other points there is great variation, and some varieties seem to form a series bridging the gulf separating this from the succeeding species. An interesting instance of this variation was exhibited by a Tetrastemma obtained in October, and which, while agreeing with the reddish variety of the present species in all other points, differed with regard to the anterior pair of eyes, which, instead of being

compact and round, were broken up into two little masses of minute specks, invisible except under the microscope. Immediately above these disintegrated eyes on each side was a slight aggregation of orange pigment granules which passed back towards the posterior pair, but ended just in front of the anterior grooves. In this and the following species there is a tendency towards the formation of a median dorsal white line, passing from the snout to the posterior extremity. In this specimen the white line was conspicuous, though somewhat interrupted in its course posteriorly, and on the snout it was continuous with an oval patch of the same white pigment.

In the slight development of pigment between the anterior and posterior eyes, the specimen just described exhibited a character which reappeared in another obtained from weeds collected at Redding Point. In this specimen, which was of a green colour and much resembled the type form, the anterior eyes were normal, and close behind them on each side was a little patch of orange pigment which, as in the last case, passed backwards towards the posterior eyes, becoming imperceptible behind the anterior grooves. A thin median dorsal white line passed backward from the snout, but came to an end just behind the posterior eyes. The shape of the head of this specimen, and the distinctness of the eyes, as well as the structure of the stylet region of the proboscis, clearly indicated that it belonged to this species. In this development of pigment between the anterior and posterior eyes, however, there is the suggestion of a transition to *T. vermiculatum*. This suggestion gathers force with the finding of varieties in which the characteristics of *T. vermiculatum* become more pronounced, and those of the present species less marked, until it becomes difficult to determine whether a given specimen shall be considered a variety of this or that species. One such specimen was obtained on the 21st November; it was 1 cm. long, and in colour resembled the yellow variety of this species; the anterior eyes were round and distinct; the posterior, though equally distinct, were much smaller and closer together; the anterior and posterior eyes of each side were connected by a band of bright orange pigment; the cephalic grooves were not so distinct as they usually are in this species, and the head was not so rounded. In this particular specimen the proboscis stylet resembled neither that of this nor any other species in particular; but in another, which exhibited all the above-mentioned characters, the stylet was like that of *T. vermiculatum*, the handle being much swollen at its base.

A still nearer approximation to *T. vermiculatum* was reached by an individual dredged from Millbay Channel on the 25th of November, which should perhaps be regarded as a variety of that species. This specimen, a ripe male 15 mm. long, was of a brighter

yellow than the last, the colour being intensified by the presence of scattered granules of orange pigment; the head was somewhat narrow and elongated, the eyes very distinct, the posterior being very slightly smaller than the anterior, and the four forming a rectangle. The cephalic grooves were very distinct; the anterior and posterior eyes on each side were united by a band of dark brown pigment; there was a median dorsal white line on the head passing from the snout to a point just behind the posterior grooves; the proboscis stylet resembled that of *T. vermiculatum*.

According to McIntosh this species breeds in April and May as well as in the autumn. I have only found ripe specimens in autumn.

16. T. VERMICULATUM, *De Quatr., McIntosh.*

This is a fairly common species, living in weeds between tide-marks, and also in water of 5 to 20 fathoms, being frequently dredged with stones at the Duke Rock and Millbay Channel. Joubin finds that the young forms are without the pigment uniting the anterior and posterior eyes, and observes that the dorsal white line is a preferable character in distinguishing this species. On this point I cannot agree with him, as, on the one hand, I have obtained many specimens which are without the median dorsal white line; and on the other, such a line, as I have already said, appears in an erratic manner on individuals of all these species, sometimes extending from snout to tail, sometimes limited to the head, and sometimes being a mere row of white dots. With his other remark, that the oval head "est assez caractéristique," I quite agree. As in the case of the other members of this genus, the breeding period is late autumn and early winter, but, as in the last species, McIntosh found ripe specimens in spring and early summer.

17. T. MELANOCEPHALUM, *Johnst.*

T. MELANOCEPHALUM, *Hubrecht.*
T. CORONATUM, *Hubrecht.*

I agree with Joubin in regarding Hubrecht's two species, *T. melanocephalum* and *T. coronatum*, as really forming one, and I shall be surprised if his *T. diadema* does not turn out to be a variety of this species also. I have not found any specimens that perfectly agree with Hubrecht's description of the last-mentioned species, but the description given by Joubin of *T. diadema* is quite applicable to what I regard as a variety of *T. melanocephalum*. That the specimens to which I refer really belong to this species there can be little doubt, the variations by which they are connected to the type form being so numerous.

This species lives under the same conditions as the other members of the genus, and is found associated with them among weeds between tide-marks and on stones dredged in 20 fathoms.

The greater number of specimens are various shades of yellow, but a bright green variety is found in the coralline pools of Bovisand Bay. It is this variety which I think Joubin describes as *T. diadema*.

The green specimens are the longest of this species I have yet met with, commonly reaching 3 cm. in length. The pigment patch is dark brown and quadrangular in shape, with a slight tendency to concavity in front and convexity behind. There are three pronounced patches of white, two in front of the dark patch, one on each side of the head and somewhat triangular in outline, and one behind it stretching across the breadth of the posterior part of the head. I have not determined whether the white patches are pigment patches, or whether they are due to the aggregation of fatty particles, as Hubrecht suggests. The eyes are approximately of the same size, and are very distinct, the anterior pair being situated just in front of the dark patch, within which, however, they are in some specimens included.

Many specimens of the yellow variety are met with agreeing generally with the above, the majority not reaching more than 15 mm. in length (though a single specimen was found as long as 4 cm.), and exhibiting great inconstancy in the amount and distribution of the white patches, which are sometimes absent altogether, as well as in the size and intensity of the dark patch.

A common variety is that in which the pigment patch is represented by a sprinkling of brown granules over a roughly quadrilateral area situated between the two pairs of eyes. Before this pigment are two small white patches, and behind is a transverse white patch, behind which again the posterior eyes are placed. In this variety the white granules which exist, distributed irregularly over the body of most specimens, become regularly arranged along the median line, forming a series of disconnected transverse bars passing from the posterior white patch on the head to the fan, composed of radiating white lines, which is found at the tail of nearly all the yellow varieties. In one specimen I have met with a still further stage of this tendency for the white particles to aggregate along the median line. In this, which had the broad dark patch of the type form, in front of and behind which some white granules were scattered, there was a very definite and conspicuous thin white median line passing from just behind the posterior eyes to the tail.

In many, if not most specimens with a broad, well-defined, dark pigment patch on the head, those portions of the pigment which are situated in the line uniting the anterior and posterior eyes are con-

spicuously darker than the median portion. This tendency is expressed more strongly in some specimens than in others, until a condition is reached in which the median portion has almost entirely disappeared, leaving only a thin bridge which joins the posterior ends of two masses of pigment which extend from the anterior to the posterior eyes. Behind the pigment bridge there is a band of white separating it from the posterior eyes, but there is no white on the anterior portion of the head. A median aggregation of granules is present on the body, forming a white dotted line passing from the white head patch to the tail fan.

A specimen which was dredged in the Hamoaze near the "Royal Adelaide" on December 14th represents the final term of the series, and follows the last very closely. In this individual the pigment bridge has completely broken down, so that in this case the head is characterised by two dark patches passing from the anterior to the posterior eyes, one on each side. Between the posterior eyes there is a patch of white, but this is much smaller than in the last specimen. The posterior eyes are slightly smaller than the anterior (which was the case in the last variety), and are slightly closer together. This individual undoubtedly belongs to this species, both on account of the fact that it belongs to an entire series reaching up to the type form, and also because in the presence of the white patch between posterior eyes, in the shape of the head and the condition of the stylet region of the proboscis, it exhibits most characteristic melanocephalous features. Nevertheless this arrangement of pigment is certainly suggestive of a transition towards *T. vermiculatum*, and especially recalls varieties described as intermediate between *T. candidum* and *T. vermiculatum*.

Only one case has come under my notice in which any relation could be detected between the colour of the animal and that of its surroundings. It was that of a specimen found among red weeds. The colour of this individual was remarkable, differing entirely from any other met with. The ground colour was a greenish yellow, but this was covered superficially by minute red-brown pigment granules, the result being the production of a colour remarkably similar to that of the weeds in which it was found. The red-brown granules were concentrated on the head to form the usual quadrate patch, the edges of which were not sharply defined, and the patch itself was reddish, not black. This animal, which was 1 cm. long, was a female containing ova.

18. T. AMBIGUUM, n. sp.

Under this name I include a few specimens found in November which have many points of agreement with *T. Robertianæ*, as a

Not uncommon. Almost restricted to the Breakwater, where it is found at low tide among the roots of Laminaria and in the cavities of stones. It has a wide distribution, ranging from the north of England to Madeira.

variety of which species I was at first inclined to regard them. I am induced to separate them, however, because of the absence of the peculiar marking which is so characteristic of that species.

The length is about 1 cm. The head, which is very distinct from the body, is very broad at the level of the entrance to the side organs, and in shape resembles that of *T. melanocephalum*. The anterior eyes are at least twice as large as the posterior. All four are of a brown colour, of irregular shape and not well defined. The ground colour is a pale yellow. On the dorsal surface there is a considerable development of reddish-brown pigment, which covers the whole of this surface of the body from just behind the posterior grooves to the tail.

The proboscis stylet handle is of the shape described by McIntosh as characteristic of *T. Robertianæ*.

I also refer here a specimen which I found the same month, which exhibited some differences from those above described. The length was 15 mm., the colour a uniform pale yellow. The general shape and the relation of head and body was the same as in the type form. The eyes were black and fairly distinct, the anterior being nearly twice the size of the posterior. The stylet handle resembled that of *T. vermiculatum* rather than that of *T. Robertianæ*.

All these specimens had ripe generative organs.

Genus PROSORHOCHMUS, Keferstein.

McIntosh characterises this genus as follows:—"Eyes four, not forming a rectangle; snout dimpled, and furnished with a transverse superior lobe. Ovo-viviparous." Of these three characters the first is scarcely available, as there is a general tendency towards this condition in the genus *Tetrastemma*, a tendency so great that in almost every species there are many individuals with the posterior eyes closer together than the anterior. McIntosh himself is not inclined to attach much value to the third character, as he says "it is a condition which further investigation will probably extend to many genera." The only character which is left is the second, and it appears to me questionable whether, on account of such a feature, a single species in all other respects *Tetrastemma*-like should be raised to the rank of a separate genus.

19. Prosorhochmus Claparedii, *Keferstein*.

Several specimens have been dredged, some from the Millbay Channel, others from the Duke Rock. None of these specimens

agreed with the figure given by McIntosh either in colour or in general appearance.

The length varied from 8 mm. to 3 cm. The ground colour was a yellowish brown. This on the dorsal surface was covered by a thick uniform sprinkling of reddish-brown grains of pigment. The cephalic grooves were very pronounced. The region included between the anterior and posterior grooves was rendered conspicuous dorsally by the strong development of the reddish-brown pigment, which was here in the form of thick lines radiating forwards in all directions from a median and posterior point. The head, which was broad and conspicuous, in front of the anterior grooves was covered superficially on each side by large flakes of white pigment, which reappeared at the posterior end of the body, covering the tail. The anterior eyes were red, large, and irregularly triangular; the posterior were much smaller and rounder, and were generally closer together than the anterior, though there was sometimes little difference in this respect. The right and left lobes of the snout were very conspicuous, but the transverse dorsal lobe was more difficult to make out.

The stylet region of the proboscis, which is very characteristic, entirely agreed with the figure given by McIntosh.

The shape of the body renders this species at once recognisable. It is constricted behind the posterior grooves, gradually increases in girth up to the middle of its length, and from thence tapers to the tail.

Ripe specimens have been met with in the spring, but I have never seen a female with developing eggs.

Hubrecht did not find this species at Naples, but it was found at Trieste by Dewoletzky. It is rare at Roscoff (Joubin).

Family NEMERTIDÆ, *Hubrecht.*

Genus NEMERTES, Cuvier.

20. N. GRACILIS, *Johnston.*

Not uncommon. Almost restricted to the Breakwater, where it is found at low tide among the roots of Laminaria and in the cavities of stones. It has a wide distribution, ranging from the north of England to Madeira.

21. N. NEESII, *Oersted, McIntosh.*

Like the last, this species abounds on the Breakwater, and is scarcely found elsewhere.

The generative organs are ripe from March to October. Large numbers of eggs have been laid in my dishes, but they have always died without segmenting, though numbers of ripe males were present. Artificial fertilization has been equally a failure.

Like the last, this species is widely distributed, ranging from Iceland to the Mediterranean. It is rare at Naples according to Hubrecht.

Family MALACOBDELLIDÆ, *v. Kennel.*

Genus MALACOBDELLA, Blainv.

22. M. GROSSA, *Blainv.*

Several specimens of this interesting parasite have been obtained. In all cases they have been found in the branchial cavity of *Cyprina islandica.* In only one case have I examined one of these molluscs without finding a specimen, and in no case has more than one been found in a single Cyprina.

This species lives well in captivity in spite of its parasitic habits. One specimen has lived in a vessel of water submerged in a tank for more than three months, and is still apparently healthy. It moves slowly about the sides of the vessel, to which it adheres by its sucker.

In the autumn many ripe females were found, which subsequently laid unfertilized eggs, but no ripe males have been seen.

Order 4.—HETERONEMERTINI, *Bürger.*

The lateral nerves situated, as in the Protonemertini, outside the circular muscular layer. Their apparent position, however, is different, owing to the appearance of a new muscular layer (longitudinal) which has inserted itself between the basement membrane and the circular layer. The lateral nerves are situated between this layer and the circular layer.

The body-wall consists of epidermis, cutis, outer longitudinal muscular layer (new), a circular muscular layer, and an inner longitudinal muscular layer.

Mouth situated behind brain.

Proboscis without a stylet.

Family LINEIDÆ, *McIntosh.*

A. *AMICRURÆ, Bürger.*

Caudal process absent.

Genus LINEUS, Sowerby.

23. L. LONGISSIMUS (*Gunn, Sowerby*).

L. MARINUS, *McIntosh.*

Not very abundant. Occasionally dredged at the Yealm among Phallusia and other Ascidians, and in the deeper water outside the Breakwater. Sometimes found shore-hunting during very low tides among the roots of Laminaria. No specimens have been met with of the size given by McIntosh, the largest not being more than six feet long, while the majority are very much less. Apparently a northern form, as it occurs on the coasts of Norway and Belgium and the Atlantic coasts of France, but not in the Mediterranean.

24. L. OBSCURUS, *Desor.*

L. GESSERENSIS, *McIntosh.*
L. SANGUINEUS, *McIntosh.*
L. GESSERENSIS, *Joubin.*

By far the commonest Nemertine in the Sound. It is to be found everywhere between tide-marks. Joubin describes five colour varieties: (*a*) deep blue and black; (*b*) deep olive-green; (*c*) pure green; (*d*) green and red; and (*e*) red. All these varieties, with the exception perhaps of the third, I have met with in the Sound, but I have not noticed that any particular habitat is characteristic of any individual variety. In common with Hubrecht and Joubin, I regard the *L. gesserensis* and *sanguineus* of McIntosh as varieties of the same species.

Neither Hubrecht nor Bürger has found this species in the Mediterranean, but Joubin appears to have obtained it at Porte Vendres, and Dewoletzky at Trieste. It is, however, like *L. longissimus*, a northern form, though it has a greater southern extension than the latter.

According to McIntosh the breeding season lasts from January to May. Mr. Garstang tells me that during the present year he has found eggs and ripe specimens as early as January, and they are still (March) to be obtained.

25. L. LACTEUS, *Montagu.*

This species seems commoner in the Mediterranean than on the Atlantic shores; at least Joubin states that it is commoner at Banyuls than at Roscoff, and Bürger describes it as "tolerably common" at Naples, though Hubrecht does not seem to have found it there. I have not obtained many specimens. The north side of Drake's Island, between tide-marks, seems the most favorable locality, though isolated specimens have also been obtained in Cawsand Bay. All the individuals were small, measuring only from 5 to 10 cm. in length, whereas those described by McIntosh were one or two feet. I have not met with either ripe specimens or eggs. At Banyuls they are said to breed towards the end of May.

26. L. BILINEATUS, *Renier.*

CEREBRATULUS BILINEATUS, *Hubrecht.*
LINEUS BILINEATUS, *McIntosh.*

Fairly common in from 5 to 20 fathoms. It is especially abundant at the Duke Rock among the shells and stones, though numbers of individuals have been obtained from the west channel and elsewhere. One small specimen was obtained among corallines in tide-pools on the east side of Drake's Island. It is the dark-coloured specimen mentioned below. The greater number of the specimens which I have seen are small, being only from 3 to 5 cm. long. Only one was a fair size. This was dredged at the Duke Rock on May 14th. Its length could not be determined, as its tail was missing, but its breadth was 0·5 cm., so that its length when complete must have been at least 12 to 15 cm.

This species is very variable in colour. The majority of individuals were of a creamy white, inclining to reddishness. In some the brown-red pigment granules were localised in patches here and there. As the larger specimens almost invariably showed more colour than the smaller, I was inclined at first to think that these differences indicated merely stages in development. The finding, however, of a very small specimen between 2 and 3 cm. long, which was of a dark uniform chocolate-brown, seems to point rather to colour variation as the explanation, and this is strengthened by the fact that I have found specimens 4 cm. long perfectly white. The colour of the single large specimen was a beautiful dark purple.

In all the specimens I have seen the dorso-median line is double, being divided by a thin line of the same colour as that diffused over the body. Those described by Bürger from Naples are without the median dividing line, though Hubrecht has found there specimens

quite typical in this respect. According to Chapuis this is a viviparous species. Dalyell, however, states that his specimens laid vast quantities of eggs in June. Unfortunately I have been unable to make any observations on this point.

B. *MICRURÆ, Bürger.*

A caudal appendage present.

Genus MICRURA, Ehrenberg, Bürger.

Includes small forms with tapering head not marked off from body. Progression by crawling, not swimming. Usually knotted in heaps or strongly contracted. Provided with a caudal appendage.

27. M. PURPUREA (*Dalyell*), *J. Müller.*

CEREBRATULUS PURPUREUS, *Hubrecht.*

A common species, dredged in 5 to 20 fathoms. The Duke Rock appears a specially favorable locality. All specimens so far met with are rather small, the largest not exceeding 5 cm. I have never found a specimen with eyes, but Joubin says that a large specimen which he obtained had a dozen extremely small eyes, which were situated on the yellow band across the snout. The ground colour is very variable, all shades of red and brown being represented as well as purple. A single light green specimen was dredged outside the Breakwater on November 7th. I have not as yet met with any ripe specimens, but Joubin records the capture of one containing eggs in June, and McIntosh in April. The voracity of this species is mentioned by McIntosh ; I met with a striking instance of it in May last. A specimen of about 3 or 4 cm. was placed in a dish with a *Nemertes Neesii* of quite 20 cm. length. Some little time after I was astonished to find the Micrura busily engaged in swallowing the Nemertes. The posterior one fifth of the latter had already disappeared into the mouth of the former when I noticed them, and still the assailant was struggling to gulp down more of its prey. In the meantime the victim glided round the dish, apparently not suffering the smallest inconvenience from the attack upon its posterior extremity. Ultimately both attacker and attacked became quiescent, the former having become more than twice its previous girth. The portion of the Nemertes in the gut of the Micrura still remained in continuity with the rest of the body, though apparently undergoing digestion.

28. M. AURANTIACA, *Grube.*

CEREBRATULUS AURANTIACUS, *Hubrecht.*

One individual only has been obtained. This was found between tide-marks at Wembury Bay on June 10th. The length was only from 3 to 4 cm., the colour bright vermilion dorsally, ventrally pale pink. Dorsally the vermilion was interrupted on each side of the middle line over a region corresponding to the hinder quarter of the cephalic slits, in such a way as to cause the appearance of a neck, the pale unpigmented edges being almost invisible in comparison with the median strongly pigmented portion. Two white patches were present, one on each side of the snout, of considerable vertical depth, as when the worm was examined laterally the white patches were seen to pass from the dorsal to the ventral lips of the cephalic slits. In the figure given by McIntosh of this species there is a single crescentic white patch, and the region in front of the crescent is pigmented like the body. In my specimen, however, not only is the patch double, but there is no pigmented region in front of it, the snout being anteriorly devoid of pigment. Eyes absent. Cephalic slits elongate and deep.

No caudal appendage was observed in this individual. This was, curiously enough, the case in the specimen described by McIntosh, for though the caudal appendage was figured by the artist, the writer states that he did not himself observe it.

Although many colour varieties of this species have been recorded, none, I believe, have been found with the anterior white patches distributed in the way above described.

This species is new to the British coast, not having been recorded further north than the island of Herm.

29. M. FASCIOLATA, *Ehrenberg.*

CEREBRATULUS FASCIOLATUS, *Hubrecht.*

This very pretty species is common in the Sound, great numbers being dredged, especially at the Duke Rock. Many varieties of different shades of red have been collected, but no green varieties, which seem to be the most abundant at Naples.

One specimen from the Duke Rock was interesting as an example of the regenerative power of this species. The whole animal was twice as long as its own cephalic slits; one transverse white band was present in the usual position of the first band, and accurately marked the middle of the animal. The head was of the size of that of a specimen of 3 or 4 cm. Just before the posterior termination

of the body there was a sudden reduction in girth, followed by the usual caudal appendage.

Ripe individuals are found from October to the end of the year.

30. M. CANDIDA, *Bürger.*

NEMERTES LACTEA.

CEREBRATULUS LACTEUS, *Hubrecht.*

I refer to this species a Nemertine which was dredged at Stoke Point on the 10th of November. It was 1·5 cm. long, of an opaque white colour, and possessed a caudal appendage. Eyes seemed to be absent. Unfortunately while under observation the animal died, its body rupturing in an extraordinary manner, and from no ascertainable cause, and emitting clouds of spermatozoa.

This species has not previously been recorded in Great Britain; it is common at Naples, and occasionally found at Banyuls and Roscoff, but the absolutely white variety seems to be rare on the French coast.

Genus CEREBRATULUS, Renier, Bürger.

Relatively broad, powerful forms, which roll themselves spirally and do not tie themselves in knots. They are excellent swimmers, cutting through the water in an eel-like manner. In transverse section the body forms a long ellipse. The lateral edges of the body stand out like longitudinal folds. Head lancet-shaped. All have a caudal appendage.

31. C. FUSCUS, *McIntosh, Hubrecht.*

MICRURA FUSCA, *McIntosh.*

A few specimens only have been obtained. The first was dredged in 4 or 5 fathoms in Jennycliff Bay on November 30th, a few others were dredged between the Mallard and Cobbler Rocks. Of these specimens the smallest was 2 cm. in length, and the largest 5 cm., the latter being 3 mm. broad at the tail, and the caudal appendage reaching the length of 2·5 mm.

There is much variability in the disposition of the brown flakes of pigment on the yellow ground colour. In some specimens the brown pigment was limited to the head, in others it was present over the whole dorsal surface of the body, but in all cases it was very sparsely if at all distributed on the ventral surface.

The disposition of the eyes is very irregular. In one specimen I counted eight eyes. Two of these were situated in corresponding

positions on each side of the snout, and were about four times as large as the rest. Of the remainder two were placed on the left side and four on the right, but there was no kind of regularity in their arrangement.

Joubin's figure (Pl. XXX, fig. 3) shows well the peculiar posterior end so characteristic of this species. The nervous system is conspicuously red.

32. C. PANTHERINUS, *Hubrecht.*

C. MARGINATUS (pars), *Joubin.*

I assign to this species a Cerebratulus dredged off Stoke Point on September 4th.

In colour it agreed with the last species, from which it differed in the shape of the head, the absence of eyes, and in the posterior termination of the body. The anterior end was much swollen, and waves of contraction continually passed along the whole length of the animal. When it reached me it was extremely sluggish, exhibiting no other sign of life than these contractions. The snout was very pointed, and the cephalic slits were deep with closely opposed lips. Posteriorly the lips were opened, exhibiting deep pits leading to the side organs. At this point the slits were red. The animal, which was 4 cm. in length, was a ripe male. The testes were present in a series from the blunt tail to the anterior fifth of the body. The mouth was a large corrugated slit just behind the cephalic slits. The brain, which was situated just in front of the region where the cephalic slits widen out, showed through the ventral wall of the body and through the slits, laterally, as a bright red body.

Joubin regards this species as a variety of *C. marginatus*, but Bürger, who has obtained many specimens of both, is convinced of its validity, stating that all the forms which are pigmented in the manner characteristic of this species differ from *C. marginatus* in the structure of the brain.

I am not sure whether this species is included by McIntosh as a variety of *C. angulatus*. If not, this is its first record in Great Britain.

This is another of the deep water species, which are, no doubt, more common than they seem, but which are at present nearly inaccessible to us.

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The Turbellaria of Plymouth Sound and the Neighbourhood.

By

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I PROPOSE in this paper to furnish a list of the marine Turbellaria of Plymouth Sound and the neighbourhood, including all species that have hitherto been recorded from this locality. That such an attempt is in some respects premature I am only too well aware, but I have written it for the convenience of those who are working at, or are interested in, the fauna of Plymouth, and it may serve as a starting-point in our knowledge of the Turbellaria of the Sound. The synonymy and descriptions of the species are given by v. Graff, Lang, Jensen, and recently, together with figures of the new species and the literature, by myself.*

During August and September of 1892 I occupied a British Association table at the Laboratory, Plymouth, and commenced an investigation into the Turbellaria of the Sound. This was practically an unworked field. Montagu had indeed discovered *Prostheceræus vittatus* in Kingsbridge Estuary, South Devon, in 1815 : the Channel Islands have been partially explored with regard to the Turbellaria : St. Malo and St. Vaaste-la-Hogue have been still more carefully explored by Quatrefages, Keferstein, and Claparède. These researches, however, deal almost exclusively with the Polycladida. Hence it is only recently, through the investigations of Professor Hallez, that the Rhabdocœlida have received due attention at Wimereux and in the Strait of Dover. Professor Hallez's results are not yet quite complete, and I much regret my inability to consult the original papers.†

The general results of my observations may be here briefly summarised. As one might have expected, a number of Mediterranean forms were noticed (about 18 per cent.). These, together with certain Scandinavian and a few new species, form the additions to

* *British Marine Turbellaria*, Quart. Journ. Micros. Sci., April, 1893.

† Revue biologique du nord de la France, Lille, 1890–2.

the fauna. I should state that for several reasons my attention was directed more particularly to the Rhabdocœlida, consequently the number of Polycladida here recorded will, in all probability, be increased by future investigation.

As regards the methods of collecting the Turbellaria, it is necessary to bear in mind that almost all the Rhabdocœlida are so minute (rarely more than 2 mm. in length) as to render it a matter of the greatest difficulty to isolate them from the tangled masses of seaweed in which they are usually found. My method of working the area between tide-marks was twofold. I collected the *Ulva, Ptilota, Bryopsis,* and other weeds, and placed them in vessels of sea water in the Laboratory. The Rhabdocœles emerged in great numbers, especially towards night, and could be picked out with a pipette. Stones richly coated with ascidians, polyzoa, sponges, &c., and the sand- and shell-débris at the base of *Corallina,* treated in a similar manner, were very productive. The drawback to this method is that the real habitat of any particular species cannot thus be determined; and although I attempted to isolate the various kinds of seaweeds I was not successful in establishing a constant relation between a Turbellarian and the plant on which it is found.

My second method was that proposed to me by David Robertson, Esq. It consisted in the use of a hand-net, in the mouth of which a sieve was placed to prevent the entrance of bulky weeds. Such a net was used from the dinghy at low water among the *Laminaria, Halydris,* &c., which border the creeks in Wembury Bay, the Breakwater, and other places. Tide-pools were also explored by its help. The dredge brought up a large number of interesting forms. Millbay Channel, the Hamoaze, the Duke Rock, and the New Grounds are especially productive in infra-littoral forms. Examination of dredge-material at night gives one a vivid idea of the activity and voracity of this group. Pelagic forms were rare, and chiefly represented by the larvæ of Leptoplana and Müller's larvæ. The latter were specially abundant in October.

Distribution of Turbellaria in Zones of Depth.

First Zone.—This zone is usually uncovered for one to two days during neap-tides. *Monotus fuscus* is here the characteristic form, although it ranges throughout the tidal zone. It appears to derive moisture from Balani into which it creeps during ebb-tide. Other interesting devices for gaining moisture are recorded by Hallez and v. Graff. Towards the lower portion of this zone *Convoluta paradoxa* occurs.

Second or Mid-tidal Zone.—This zone, daily covered by the tide, is characterised by the two species already mentioned, and also the following :—*Aphanostoma diversicolor, Byrsophlebs graffi, Provortex balticus, Macrorhynchus naegelii, Plagiostoma vittatum,* and *Vorticeros auriculatum.* Almost all these are provided with adhesive cells (Haftpapillen) at their posterior end, enabling them to retain their position during the wash of the tide.

Third Zone.—Exposed during spring-tides. *Cylindrostoma quadrioculatum, Convoluta flavibacillum, Hyporhynchus armatus, Acrorhynchus caledonicus, Leptoplana tremellaris.* This zone marks the lower limit of the Acœla, and of the great majority of Rhabdocœla.

Fourth Zone.—Depths up to 20 fathoms. *Promesostoma solea, Provortex rubrobacillus, Cylindrostoma inerme, Plagiostoma girardi,* species of *Enterostoma, Stylostomum variabile, Oligocladus sanguinolentus, Eurylepta cornuta.*

This sketch of the zones must be regarded as purely tentative, since my stay was not sufficiently prolonged to enable me to test these results. I was led to attempt such a classification from the striking absence of Acœla and most Rhabdocœla below the Laminarian zone. On this subject there appears to be very little published work, and it would be a matter of some interest to ascertain the alterations in the vertical distribution of Turbellaria according to the difference of surroundings and tidal conditions at various parts of the coast.

Local Distribution of Turbellaria.

Wembury Bay.

My work in this bay has been restricted to an examination of the well-known collecting-ground exposed at low water below Wembury Church. So far as my experience goes, this appears to be (for Turbellaria) the richest locality in the neighbourhood of Plymouth. Nineteen species have occurred between tide-marks excluding four doubtfully new forms, which were either too rare or too immature for exact and thorough determination.

It is not easy to define the characteristic Turbellarian features of Wembury Bay. The abundance of *Cylindrostoma quadrioculatum, C. inerme, Macrorhynchus naegelii,* and *Plagiostoma dioicum,* together with five species of the Acœla, and the apparent absence of Monotidæ, lend a provisionally distinctive aspect.

The splendid tide-pools abounding in such algæ as *Cystoseira ericoides, Codium tomentosum, Bryopsis plumosa,* are the best hunting-grounds. Among sand at the base of *Corallina officinalis,* curious

colour-varieties of *Leptoplana tremellaris*, specimens of *Aphanostoma diversicolor*, *Convoluta paradoxa*, *Plagiostoma girardi* (at low spring-tides), and an example of what appears to be *Fovia affinis* (a marine Triclad). In the tufts of matted Florideæ which hang from the under surface of rocks, *Cylindrostoma quadrioculatum* occurs in hundreds. Tow-netting in the narrow creeks that run in between the rocks produced young specimens of *Leptoplana tremellaris*, *Convoluta paradoxa*, *Plagiostoma vittatum*, and *Cylindrostoma inerme*. Working the Laminaria-fronds by a hand-net from the stern of the "Anton Dohrn" did not, however, add anything of interest.

There can be no doubt that many forms have been overlooked, and that if examined earlier in the year, Turbellaria differing from those occurring during the summer might be found. The following is a list of the species hitherto recorded:

Polycladida, *Leptoplana tremellaris.*

Tricladida, *Fovia affinis.*

Rhabdocœlida.

Acœla, *Proporus venenosus*, *Monoporus rubropunctatus*, *Aphanostoma diversicolor*, *Convoluta paradoxa*, *C. flavibacillum.*

Rhabdocœla, *Promesostoma marmoratum*, *Acrorhynchus caledonicus*, *Macrorhynchus naegelii*, *Hyporhynchus armatus*, *Provortex balticus.*

Allœocœla, *Plagiostoma dioicum*, *Pl. elongatum*, *Pl. vittatum*, *Pl. girardi*, *Enterostoma fingalianum*, *Cylindrostoma quadrioculatum*, *Cyl. inerme.*

Plymouth Breakwater.

Of the two faces of the Breakwater I have naturally paid most attention to the inner one, the stones and weeds of which afford good collecting-ground during low spring-tides. Many of the weeds on the inner face have, during the summer, an unhealthy, half-decayed appearance, which is associated with the occurrence of certain Turbellaria. *Pseudorhynchus bifidus*, however, which occurs typically in such a habitat in the Isle of Man and the east and west coasts of Scotland, has not yet occurred at Plymouth. *Macrorhynchus naegelii* and *Plagiostoma koreni* are the characteristic forms of the Breakwater. The number of adult examples of the former species diminished from the beginning of August onwards, and Mr. Garstang sent me the largest he could find in November, but all, without exception, were quite immature. Stones, the cavities of which were occupied by anemones, brought from the Breakwater and kept for some time (six weeks to two

months) in the Laboratory, produced a number of *Plagiostoma vittatum* and *Pl. koreni*. The pyriform stalked egg-capsules of the former were deposited in numbers in August. These and other species have the habit of creeping about under a covering of diatom-deposit which encrusts stones, weeds, &c. Protected in this way they are extremely difficult to find.

My method of examining the Breakwater was chiefly the use of a hand-net, which was worked vigorously among the weeds at low water from the dinghy. By this means the following fauna were obtained:

Polycladida, *Leptoplana tremellaris* (adult and young).

Rhabdocœlida.

Acœla, *Aphanostoma diversicolor.*

Rhabdocœla, *Macrorhynchus naegelii, Mesostoma* (?) *neapolitanum.*

Allœocœla, *Plagiostoma elongatum, Pl. koreni, Pl. vittatum, Vorticeros auriculatum* and *V. luteum, Allostoma pallidum, Monotus lineatus.*

Cawsand Bay.

There are here two distinct collecting-grounds—the rocks and tide-pools exposed at low water on the north side of the bay towards Picklecombe Fort, and the beds of Zostera that grow on the sandy bottom. In the former locality *Acrorhynchus caledonicus* is the prevailing species, as *Hyporhynchus armatus* is the chief feature of the Zostera bed. It was only toward the end of my visit that I discovered the tiny Rhabdocœles among the Crustacea and Nemertea which occur in great quantity in the Zostera, so that many forms will probably be added by a re-examination of the dredgings taken among the rich weedy ground indicated by Prof. Johnson (the Journal [N. S.], I, iii, pp. 297–8).

In the following list Z refers to species inhabiting the Zostera beds, N to forms occurring in the rock-pools on the north side of the bay.

Polycladida, *Oligocladus sanguinolentus* (Z).

Rhabdocœlida.

Acœla, *Proporus venenosus* (Z), *Monoporus rubropunctatus* (Z), *Convoluta saliens* (Z), *C. paradoxa* (N), *C. flavibacillum* (Picklecombe Fort).

Rhabdocœla, *Promesostoma solea* (Z), *P. agile* (Z), *Proxenetes flabellifer* (N), *Acrorhynchus caledonicus* (N), *Hyporhynchus*

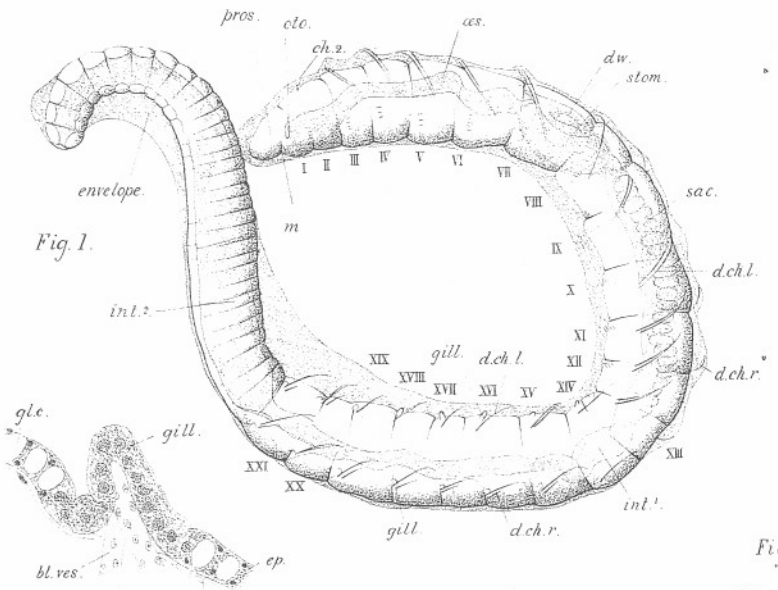

Fig. 1.

Fig. 5.

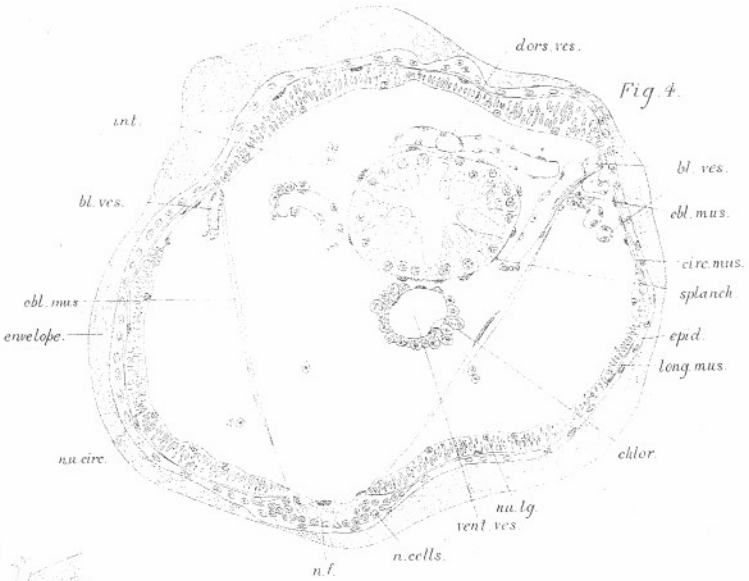

Fig. 4.

Fig. 2.

Fig 3. X 150

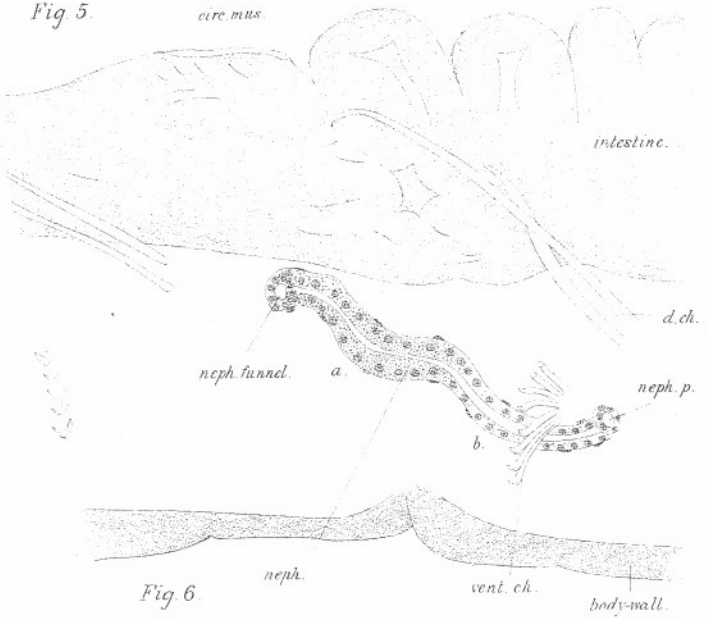

Fig. 6.

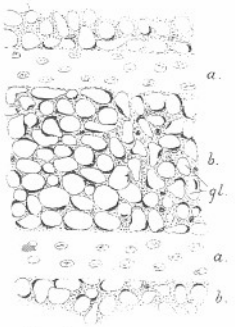

Fig. 7.

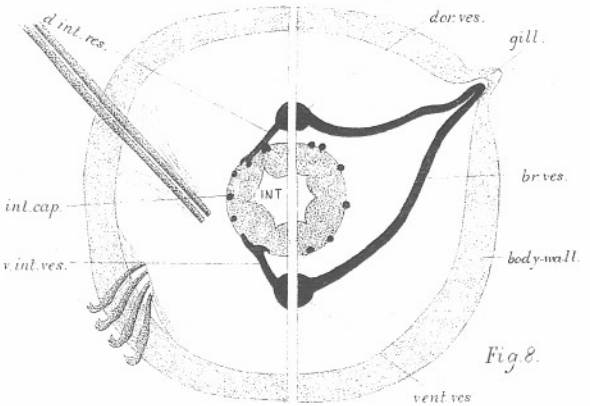

Fig. 8.

armatus (Z), *H.* (?) *penicillatus* (Z), *Provortex affinis* (N), *P. rubrobacillus* (Z).

Allœocœla, *Plagiostoma vittatum* (N and Z), *P. dioicum* (N), *P. girardi* (N), *Monotus albus* (N).

New Grounds.

The Turbellaria of this part of the Sound (north of the west entrance to the Sound), like the flora, is similar to that of the Duke Rock. There is, however, a characteristic form (*Provortex rubrobacillus*) that has not occurred elsewhere in the neighbourhood. *Macrorhynchus croceus* and *M. helgolandicus* will probably be found in other parts of the Sound, although at present this is the only known locality for them.

Polycladida, *Leptoplana tremellaris.*

Rhabdocœlida.

Rhabdocœla, *Promesostoma solea, Macrorhynchus naegelii, M. croceus, M. helgolandicus, Provortex rubrobacillus.*

Allœocœla, *Plagiostoma vittatum, Vorticeros luteum, Cylindrostoma inerme.*

Duke Rock.

The Duke Rock, situated in 7 fathoms at the east entrance of the Sound, forms one of a number of dredging-grounds inside the Sound, the Turbellarian fauna of which has a common general facies. The conditions of life in these localities are different from those in the tidal zone, and the difference is expressed in the Turbellaria as well as in other groups of animals and plants. Thus Acœla are, so far as my experience goes, quite unrepresented; the Allœocœla, on the other hand, are abundant.

The Turbellaria of the Duke Rock closely resemble those of the New Grounds, and this similarity is also borne out in the flora (see Johnson, "Flora of Plymouth Sound," loc. cit., p. 291). The most interesting form was a single specimen of *Monoophorum striatum* (Böhmig) (= *Enterostoma striatum*, v. Graff), which has hitherto only occurred at Trieste. Its carmine colour and the appearance of the muscles grouped in longitudinal bundles at once attract attention.

Species of the genus *Enterostoma* (perhaps at present the most unsatisfactory genus of all Allœocœla) are abundant here and elsewhere in the Sound. As, however, I have not completed my revision of the genus, the species recorded are only part of those that were

actually found. The following is a list of the Duke Rock Turbellaria:

Polycladida, *Leptoplana tremellaris, Eurylepta cornuta, Stylostomum variabile.*

Rhabdocœlida.

Rhabdocœla, *Promesostoma ovoideum, Pr. solea.*

Allœocœla, *Plagiostoma dioicum, Pl. girardi, Enterostoma austriacum, Cylindrostoma inerme, Monoophorum striatum, Automolos unipunctatus.*

Drake's Island.

The well-known collecting-ground on the north-eastern face of this locality has furnished the following fauna. The great belt of Laminaria extending in the direction of the Breakwater did not add anything of interest.

Polycladida, *Leptoplana tremellaris,* adult and young (3 mm. long).

Rhabdocœlida.

Acœla, *Proporus venenosus, Monoporus rubropunctatus, Convoluta paradoxa.*

Rhabdocœla, *Promesostoma marmoratum, Pr. solea, Pr. agile, Byrsophlebs intermedia, Byr. graffi, Acrorhynchus caledonicus, Macrorhynchus naegelii* (Claparède's variety with dorsal yellow streak), *Provortex affinis.*

Allœocœla, *Plagiostoma vittatum, Vorticeros auriculatum, Cylindrostoma quadrioculatum* (also on the S.E. face of the island).

Redding Point.

By this locality I include the shore from Redding Point to northward under Mount Edgcumbe Park. This area is prolific in littoral forms, the tide-pools and rocks being covered with a profusion of animal and vegetable life. *Promesostoma marmoratum, Monotus fuscus,* and *M. lineatus* are the prevalent forms, the two latter species being particularly abundant among the *Ulva* that covers the stones. The use of a hand-net in the tide-pools needs some discretion, since the crustacean *Virbius varians* swarms to such an extent as to exclude almost everything else. To get over this difficulty it is necessary to employ a fine sieve, as described in the introduction.

A comparison of the Turbellarian fauna with that of other parts

of the Sound cannot yet be made justly, as my investigations are not yet sufficiently complete. The Turbellaria appear to resemble those of the Breakwater, as a comparison of the accompanying tables tends to show. Specially interesting forms are *Aphanostoma elegans*, hitherto recorded from Bergen, and *Plagiostoma sagitta*, found by Uljanin in the Bay of Sebastopol. The occurrence of species from such widely distant localities shows how much still remains to be done before we can determine the geographical distribution of the species of this group.

The following list of species were taken at low water round Redding Point and northwards :

Polycladida, *Stylostomum variabile* (·75 mm. long).

Rhabdocœlida.

Acœla, *Convoluta paradoxa, Aphanostoma elegans.*

Rhabdocœla, *Microstoma grœnlandicum, Promesostoma marmoratum, Pr. solea, Acrorhynchus caledonicus, Macrorhynchus naegelii, Hyporhynchus armatus, Provortex balticus.*

Allœocœla, *Plagiostoma vittatum, Pl. koreni, Pl. sagitta, Vorticeros auriculatum, Monotus lineatus, M. fuscus.*

East Side of the Sound.

Under this heading I include the rocks below the Laboratory, Rum Bay, Batten Bay, and Bovisand Bay. As regards the Turbellaria of the first three there is little to be said. The same causes that have impoverished the flora and fauna probably account for the poor result in this group. Repeated attempts only resulted in *Convoluta paradoxa, Plagiostoma vittatum, Vorticeros auriculatum,* and *Monotus fuscus.* The last also occurs on the rocks below the ladies' bathing-place. In Bovisand Bay the tide-pools yielded *Convoluta paradoxa* and *C. flavibacillum.*

The Hamoaze.

A portion of this locality was explored by the help of the "Firefly." The stones and débris that are brought up are covered with the mud-tubes of *Polydora cæca,* tenanted, however, by an Amphipod, *Corophium Bonellii.* The great abundance of this Crustacean possibly in part accounts for the limited Turbellarian fauna.

Polycladida, *Leptoplana tremellaris.*

Rhabdocœlida.

Allœocœla, *Plagiostoma pseudomaculatum, Cylindrostoma inerme, Automolos* (?) *ophiocephalus, Aut. horridus.*

Millbay Channel.

This channel (varying in depth from 18 to 21 fathoms) is a recognised locality for certain animals, and I have found some species of Turbellaria peculiar to it. The allœocœlous fauna of this channel and the Hamoaze present an interesting species of the genus *Automolos*, apparently connecting the Allœocœla with the Tricladida. More observations are however needed, and an examination of these two localities will probably forward the solution of this problem. Species of *Cylindrostoma* and *Enterostoma* make up the bulk of the fauna. A specimen of what I take to be *Plagiostoma siphonophorum* (if confirmed) will prove to be another Adriatic form added to the Plymouth fauna.

Polycladida, *Leptoplana tremellaris* (abundant), *Oligocladus sanguinolentus, Stylostomum variabile* (young stages, ·5—1 mm., are not uncommon in September).

Rhabdocœlida.

Rhabdocœla, *Promesostoma solea.*

Allœocœla, *Plagiostoma siphonophorum* (*?*), *Pl. girardi, Enterostoma fingalianum, E. austriacum, Automolos ophiocephalus.*

SYSTEMATIC LIST OF THE TURBELLARIA.*

TURBELLARIA.

Sub-order 1.—RHABDOCŒLIDA.

A. *ACŒLA.*

Family PROPORIDÆ.

Genus 1.—Proporus.

1. Proporus venenosus (O. Schmidt).

This species is readily distinguished from all other Acœla by its elongate form, yellow colour, and large eyes. It is not uncommon at the base of the littoral zone at Wembury Bay and Drake's Island.

* A key for the determination of genera and species may be found in my "British Marine Turbellaria," loc. cit., pp. 514—522.

Genus 2.—MONOPORUS.

2. MONOPORUS RUBROPUNCTATUS (O. Schmidt).

Found in the same localities as the foregoing. Both are Mediterranean species.

Family APHANOSTOMIDÆ.

Genus 3.—APHANOSTOMA.

3. APHANOSTOMA DIVERSICOLOR Oersted.

In various localities between tide-marks. Not uncommon in the diatom-deposit on the sides of the tanks in the aquarium.

4. APHANOSTOMA ELEGANS Jensen.

A single specimen amongst *Ulva* at Redding Point.

Genus 4.—CONVOLUTA.

5. CONVOLUTA SALIENS v. Graff.

This species is apparently rather rare at Plymouth. Among Zostera from Cawsand Bay is the habitat for it. The curious mode of progression by sudden leaps, which co-exists along with the usual method of continuous movement, was first described by v. Graff in his "Monograph," and is apparently unique.

6. CONVOLUTA PARADOXA Oersted.

Widely distributed in the littoral zone; nowhere, however, very abundant, nor do the specimens attain the dimensions of Millport examples.

7. CONVOLUTA FLAVIBACILLUM Jensen.

Among sand in the creeks at Picklecombe Fort, Wembury Bay, and Bovisand Bay.

B. *RHABDOCŒLIDA.*

Family MICROSTOMIDÆ.

Genus 5.—MICROSTOMA.

8. MICROSTOMA GRŒNLANDICUM Lev.

Among Ulva, Redding Point.

Family MESOSTOMIDÆ.

Genus 6.—PROMESOSTOMA.

9. PROMESOSTOMA MARMORATUM (Schultze).

Variable in coloration and in the form and dimensions of the crosier-like copulatory organ. Not uncommon in tide-pools in Wembury Bay, Drake's Island, and Redding Point.

10. PROMESOSTOMA OVOIDEUM (O. Schmidt).

Occasionally dredged near the Duke Rock.

11. PROMESOSTOMA SOLEA (O. Schmidt).

Abundant in dredging taken from almost all localities.

12. PROMESOSTOMA AGILE (Levinsen).

Among *Zostera* in Cawsand Bay.

Genus 7.—BYRSOPHLEBS.

13. BYRSOPHLEBS GRAFFI Jensen.

Drake's Island, low spring-tide. Amongst algæ.

14. BYRSOPHLEBS INTERMEDIA v. Graff.

In the same locality as the foregoing.

Genus 8.—PROXENETES.

15. PROXENETES FLABELLIFER Jensen.

In tide-pools on the north side of Cawsand Bay.

Genus 9.—MESOSTOMA.

16. MESOSTOMA NEAPOLITANUM v. Graff (?).

A single specimen obtained among *Fuci* bordering the inner side of the Breakwater. This species hitherto recorded only from the Mediterranean.

Family PROBOSCIDÆ.

Genus 10.—ACRORHYNCHUS.

17. ACRORHYNCHUS CALEDONICUS (Claparède).

Found in abundance among Fucus, Halydris, &c., in tide-pools near Picklecombe Fort and Redding Point; less commonly in Wembury Bay.

Genus 11.—MACRORHYNCHUS.

18. MACRORHYNCHUS NAEGELII (Kölliker).

On the inner side of the Breakwater at low spring-tides this species was found plentifully during August.

19. MACRORHYNCHUS CROCEUS (Fabricius).

Dredged on one occasion on the "New Grounds."

20. MACRORHYNCHUS HELGOLANDICUS (Metschnikoff).

In the same locality as the foregoing. Probably a search instituted earlier in the year would reveal more localities for these two species. Only a few adults were found, usually each with a single egg-capsule.

Genus 12.—HYPORHYNCHUS.

21. HYPORHYNCHUS ARMATUS (Jensen).

Abundant among *Zostera* in Cawsand Bay and in tide-pools at Redding Point.

22. HYPORHYNCHUS PENICILLATUS (Schmidt).

A single specimen among Zostera, Cawsand Bay.

Family VORTICIDÆ.

Genus 13.—PROVORTEX.

23. PROVORTEX BALTICUS (Schultze).

This species is apparently not common at Plymouth during August and September. It occurs between tide-marks, most commonly in Wembury Bay.

24. PROVORTEX AFFINIS (Jensen).

Among algæ on the north- and south-eastern faces of Drake's Island.

25. PROVORTEX RUBROBACILLUS, Gamble.

This form is figured and described in my "British Marine Turbellaria," pp. 470–1, pl. xxxix, fig. 8, and pl. xl, fig. 12. The constant presence of red, rod-like concretions in the intestinal cells and the form of the copulatory organ are diagnostic features.

C. *ALLŒOCŒLA.*

Family PLAGIOSTOMIDÆ.

Genus 14.—PLAGIOSTOMA.

26. PLAGIOSTOMA DIOICUM (Metschnikoff).

Duke Rock and Wembury Bay.

27. PLAGIOSTOMA ELONGATUM Gamble ("British Marine Turbellaria," p. 473).

A single specimen among sand, Wembury Bay. Mr. Garstang sent me two from the Breakwater in November.

28. PLAGIOSTOMA PSEUDOMACULATUM Gamble (loc. cit., p. 474).

Among the weed-tubes of *Polydora cæca* in the Hamoaze.

29. PLAGIOSTOMA SAGITTA Uljanin.

Among weeds in a tide-pool, Redding Point.

30. PLAGIOSTOMA CAUDATUM Levinsen.

A single specimen dredged in Cawsand Bay among *Zostera*.

31. Plagiostoma vittatum (Frey u. Leuckart).

An abundant littoral species in all localities. The variations in colour are great, and are discussed by v. Graff and myself. Egg-capsules were obtained from the Breakwater in September.

32. Plagiostoma koreni Jensen.

Among algæ on the Breakwater and at Redding Point, also among diatom-deposit in the tank-room of the Laboratory.

33. ? Plagiostoma siphonophorum (Schmidt).

A specimen in the Millbay Channel. (See "Brit. Mar. Turbellaria," p. 477.)

34. Plagiostoma girardi (Schmidt).

At extremely low spring-tide, Wembury Bay, and in tide-pools on the north side of Cawsand Bay. Not uncommon on the Duke Rock and in Millbay Channel.

Genus 15.—Vorticeros.

35. Vorticeros auriculatum (O. F. Müller).

Found in the same localities and under the same conditions as *Plagiostoma vittatum*.

36. Vorticeros luteum v. Graff.

A single specimen dredged off the New Grounds; another obtained on the inner side of the Breakwater.

Genus 16.—Enterostoma.

37. Enterostoma austriacum v. Graff.

Specimens referable to this species occurred commonly in the Sound at depths below 5 fathoms.

38. Enterostoma fingalianum Claparède.

Among *Florideæ*, Wembury Bay.

Genus 17.—Cylindrostoma.

39. Cylindrostoma quadrioculatum (R. Leuckart).

Abundant in the same locality as the preceding.

40. Cylindrostoma inerme (Hallez).

In dredgings taken from the Duke Rock, Millbay Channel, and the Hamoaze.

41. Cylindrostoma elongatum Levinsen.

Tide-pools, Wembury Bay.

Genus 18.—Monoophorum.

42. Monoophorum striatum (v. Graff).

A single specimen of this characteristic species was dredged off the Duke Rock.

Family MONOTIDÆ.

Genus 19.—Monotus.

43. Monotus lineatus (O. F. Müller).

Not uncommon amongst *Ulva* in the neighbourhood of Redding Point.

44. Monotus fuscus (Oersted).

Abundant among *Balani*, *Ulva*, and generally throughout the littoral zone.

45. Monotus albus Levinsen.

In tide-pools below Picklecombe Fort.

Genus 20.—Automolus.

46. Automolus unipunctatus (Oersted).

Rarely amongst algæ, Duke Rock.

47. Automolos horridus Gamble ("British Marine Turbellaria," p. 491).

A single specimen in the Hamoaze.

48. (?) Automolos ophiocephalus (Schmidt).

Millbay Channel. For a discussion of the probable relations of this form see my paper, pp. 492–3.

Sub-order 2.—TRICLADIDA.

Family PLANARIIDÆ.

Genus 21.—FOVIA.

49. FOVIA AFFINIS Stimpson.

In a sandy creek, Wembury Bay.

Sub-order 3.—POLYCLADIDA.

A. *ACOTYLEA.*

Family PLANOCERIDÆ.

Genus 22.—LEPTOPLANA.

50. LEPTOPLANA TREMELLARIS (O. F. Müller).

I have recently ascertained that many examples grouped under this species, on the ground of their general agreement with the type in form, colour, and the number and position of the eye-groups, in reality belong to the next species. The subject requires further investigation, which, owing to the pressure of other work, I am unable to undertake at present. The specific characters and synonymy of this form are given fully by Lang in his "Polycladida," and the previous records on our coast in my "British Marine Turbellaria."

Adult examples occur generally at Plymouth, under stones and shells from the littoral zone down to 15 fathoms. They are plentiful during July and August, becoming scarcer in September. Mr. Garstang informs me that the species during February is difficult to discover even in its summer haunts. It is tolerably certain that, like the majority of littoral animals, the adults die in the autumn, and the young probably attain sexual maturity in the following summer.

Copulation in this species has not hitherto been observed. The eggs are laid in successive batches, surrounded by an albuminous substance. They adhere to stones, algæ, &c., between tide-marks, and after a period varying from a fortnight (Keferstein) to two months (Hallez) the larvæ hatch out. Specimens 1 to 3 mm. in length, and having the outline of a spherical triangle, were fairly abundant in the littoral zone in September. Thus at Wembury Bay and inside the Breakwater many specimens were obtained with the aid of the

hand-net among *Laminaria, Corallina,* &c. A few specimens also occurred in tow-nettings taken close inshore and also in mid-channel, outside the Breakwater. At present I am unable to state whether these young *Leptoplana* belong to either or both of the species here recorded. The genital ducts afford the only secure diagnostic features, and naturally these are wanting in the present instance.

51. Leptoplana Dræbachensis Oersted.

In my paper previously cited I have discussed the possible identity of this species with the older *L. atomata,* O. F. M.

Recently, specimens from Plymouth Sound have reached me which agree in almost every particular with *L. Dræbachensis,* Oe., as described by Jensen, and it appears probable that this species has hitherto been confused on our coasts with *L. tremellaris.* The old species, *L. atomata,* O. F. M., whose relations with other species of the genus are totally obscure, might perhaps be dropped altogether.

B. *COTYLEA.*

Family EURYLEPTIDÆ.

Genus 23.—Prosthecereæus.

52. Prosthecereæus vittatus (Montagu).

This fine species, discovered by Montagu in the estuary of Kingsbridge, has occurred off Stoke Point on *Diazona* in 15 fathoms (Mr. Cunningham), and also in the Sound (Mr. Garstang).

Genus 24.—Cycloporus.

53. Cycloporus papillosus Lang.

Infra-littoral specimens have occurred on ascidians and sponges (*e. g. Hymeniacidon sanguinea*) dredged in the Cattewater, and also outside the Sound. The variety *lævigatus* occurred along with *Stylostomum variabile* (to which it bears no little resemblance) in the river Yealm in October. The relations which appear to exist between this species and the substratum in which it lives are discussed by me in the forthcoming number of the Transactions of the Liverpool Biological Society.

Genus 25.—EURYLEPTA.

54. EURYLEPTA CORNUTA (O. F. Müller).

Occasionally dredged on the Duke Rock and in the estuary of the Yealm.

Genus 26.—OLIGOCLADUS.

55. OLIGOCLADUS SANGUINOLENTUS (Quatrefages).

Adult specimens were dredged off the Duke Rock, Millbay Channel, Cawsand Bay, and Stoke Point.

Genus 27.—STYLOSTOMUM.

56. STYLOSTOMUM VARIABILE Lang.

Estuary of the Yealm, Duke Rock. Young stages were found between tide-marks at Redding Point and round the Mallard Buoy in September.

The Post-larval Stage of Arenicola marina.

By

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With Plate I.

By "post-larval stage" I wish to indicate that stage in the developmental history of *Arenicola* at which the full adult number of somites has appeared, and the body is already distinguishable into (*a*) an anterior chætigerous region, and (*b*) a posterior achætous region or tail, but in which the gills are not yet completely formed or have not yet even made their appearance.

Such a stage was sent to me early in March, 1893, by Mr. Garstang, with a suggestion, which turned out to be perfectly well founded, that the worms were the young of *Arenicola*.

My hearty thanks are herewith accorded to him for his kindness in giving me the opportunity of studying them.

Two of these small worms were collected, one on February 22nd, the other on the 23rd of the same month, and he sent them to me preserved. One was stained and mounted entire, the other was cut into sections, partly longitudinal, partly transverse. An unfortunate accident to the longitudinal sections deprived me of investigating the anterior end of the worm as thoroughly as I could have wished, and though Mr. Garstang has been constantly on the look-out for more specimens, success has not crowned his efforts.

Mr. Garstang gives me the following information as to these larvæ :—"Each was inhabiting a perfectly colourless and transparent gelatinous tube, obviously secreted by itself. The body of the *Arenicola* larva was very flexible when alive, enabling it to wriggle actively in an eel-like manner in the water—generally near the surface—when placed in a tall clear glass jar."

"The two extremities of the body were in each of the larvæ yellow. This yellow colour was due to a number of yellow bodies or cells apparently situated in the epidermis. The blood was distinctly reddish."

"The gelatinous tube seemed to invest the body closely, and was certainly no impediment to the animal."

These two specimens are practically identical.

The worm is about 6·8 millimetres in length. It consists of a prostomium, without eye-spots, but with a light area or depression on each side in which is lodged the otocyst, followed by a peristomium and twenty chætigerous somites forming the anterior region, with a tail of a greater number of somites—some thirty or more—terminating in a small pygidium or anal somite.

These tail somites are difficult to enumerate, as the septa are not well developed, but each segment is surrounded by a band of gland-cells, which serve for their demarcation.

The worm is surrounded by a structureless gelatinous-looking envelope or tube (figs. 1, 4), probably secreted by these gland-cells, which are not confined to the tail, but occur in every somite; in fact, they are more abundant in the anterior somites, and here occur in two bands per somite, separated by a narrow non-glandular band (see fig. 7). This closely investing gelatinous tube seems, when taken in connection with sundry internal arrangements, such as nephridia, septa, &c., to point to an affinity with the *Chlorhæmidæ*.

As will be seen from the accompanying figures (fig. 1), the dorsal bundle contains two long capillary chætæ, of which one is longer than the other.

The peristomium is achætous; the first dorsal bundle is represented by a minute dorsal chæta (*Ch.* 2), scarcely protruding from the body, in Somite 2. At first sight the entire region between the prostomium and the first long chæta appears to be achætous, but this region is divided into two portions by a slight groove ventrally, and careful observations showed this small chæta (*Ch.* 2, fig. 1), demonstrating the composition of this region. In the adult *Arenicola* the achætous region following the prostomium has been regarded on other grounds—to wit, the existence of two septa anterior to the first bundle of chætæ—as being composed of two somites.

This small chæta, then, probably disappears in the adult, as has been shown to be the case with the anterior chætæ in some other Polychætes.

The ventral chætæ commence in Somite 3; they are much shorter than the capillary chætæ, being only about twice the length of the thickness of the body-wall. Each chæta is a sigmoid hook, with a small but distinct notch (fig. 2), the lower prong being the larger.

In the first few bundles there are only three chætæ; the number increases as we pass backwards, till in the hinder somites eight or nine chætæ constitute a bundle. Both the dorsal and ventral chætæ differ from those occurring in the adult, in which the dorsal chætæ present a series of small processes on each side (see Cunningham, Trans. Ed. Roy. Soc., xxxiii, 1888); whilst the ventral ones, as my fig. 3 shows, are without the smaller prong. Naturally the size of the chætæ differs, some idea of which difference will be conveyed by a comparison of figs. 2 and 3.

Of the thirteen pairs of gills in the adult, the present post-larval stage shows in profile only six pairs, situated on Somites 14—18. But I believe I can detect other gills on succeeding somites in the mounted specimen; however, it is difficult to be certain of the number. In the adult the first gill, which is quite small, occurs on the ninth somite (seventh chætigerous), and the last in the nineteenth chætigerous (*i. e.* the twenty-first somite). Thus the gills make their appearance from behind forwards. Each gill is at present merely a small somewhat conical papilla or eversion of the epidermis, containing a potential cavity entirely occupied by a looped blood-vessel (see fig. 5). The appearance suggests that these gills of *Arenicola* are special structures, and not, as in *Eunice* and other free-living Polychætes, modifications of the dorsal cirrus, as there is no trace of sensory hairs, which are present even in quite early stages in the development of cirri—for instance, in *Polydora*.

The epidermis is at this stage a single layer of cells, and varies, as it does in the adult, in different parts of the somite. In the non-glandular band (figs. 4 and 7) the cells whose outlines are not recognisable are flattened, and the nuclei are oval with their long axes parallel with the surface of the body. In the glandular band, however, the epidermis is thicker (fig. 5), and consists of narrow, deeply staining cells, compressed between large gland-cells. The nuclei of the former are small and circular, and of the latter compressed against the side of the cell. Viewed from above, the epidermis presents the appearance of fig. 7.

Wirèn (Kongl. Svensk. Vet. Akad. Handlingar, 22, pl. i, figs. 1—23) has described a similar difference in the epidermis cells between the ridges and those constituting the ridges in the adult. Probably these glandular bands of the post-larval stage become broken up into the polygonal areas or ridges of the adult.

I would here call attention to the strongly marked grooves, each followed by a distinct ridge, in the anterior somites; in this ridge the chætæ are inserted. This is true of both the post-larval stage and of the adult, and one would at first sight regard these grooves as intersegmental grooves, so that the chætæ appear to have the rather

abnormal position of the anterior margin of the somite. But such is not in reality the case; dissections of the adult, as well as observation of the nephridia of this present stage, indicate that the chætæ, and thus the ridge and groove, are in the middle of the somite, for in the anterior regions of the adult are certain complete septa, the last of which is placed midway between the third and fourth bundles of chætæ, the next anterior midway between the second and third bundles. The anterior end of the nephridium in the somites containing these organs lies about midway between consecutive bundles of chætæ—where, in fact, the septum would occur. I am unable to distinguish the septa in the present mounted specimen.

Of internal structures I will draw attention more particularly to the vascular system. Wirèn (loc. cit., p. 38, et seq.) has shown that in the adult *Arenicola* the dorsal and ventral blood-vessels are merely local enlargements of a continuous perienteric sinus, from which the axial portions are slightly nipped off. *Now at this post-larval stage I find no sinus.* Both the dorsal and the ventral vessels are quite distinct from the wall of the gut, as the camera drawing (fig. 4) shows. From these axial vessels branches pass right and left to the wall of the gut (diagrammatically shown in fig. 8), where they subdivide to a slight extent, and give rise to a but feebly developed plexus below the cœlomic epithelium.

I have already, in discussing the perienteric blood-sinus of certain earthworms,* referred to the improbability of its being a primitive feature, as is sometimes held. Here in *Arenicola*, at any rate, we have a network preceding ontogenetically the sinus of the adult.

Other vessels pass to the gill as shown; the dorso-branchial vessel passes straight to the gill, curves round at the apex of the latter, and after two or three twists passes to the ventral vessel. Another vessel passes to the nephridium, but I have not traced its origin. The blood-vessels are covered by cœlomic epithelium, which, in the case of the ventral trunk and the ventro-branchial vessel, consists of rounded cells with brownish granular contents and a round nucleus; they are, in fact, chloragogic cells: elsewhere the cœlomic epithelium is flat.

In the body-wall the circular muscles are already present, and the epidermis rests directly upon them—the subepidermic tissue described by Wirèn has not yet made its appearance.

The longitudinal muscles are interrupted at three points, ventrally at the nerve-cord and dorso-laterally at the level of the dorsal chætæ. The oblique muscles so characteristic of Polychæta are attached at these same points (see fig. 4).

* Quart. Journ. Mic. Sci., xxxiv, *A New English Genus of Aquatic Oligochæta* (Sparganophilus).

As to the separate existence of a somatic cœlomic epithelium I feel some doubt; apparently the inner ends of the cells giving rise to the longitudinal muscles are themselves the lining of the cœlom, so that these cells are *myocœlomic*.

The *nephridia* are confined to Somites 6—10, though there may be traces of them in other somites. I believe I can distinguish a small one, for instance, in Somite 5. They have thus the same position as in the adult, where they occur in the fourth to eighth chætigerous somites, *i. e.* Somites 6—10.

But though they have the same position, they are very different in shape. I have previously figured this organ in the adult (Quart. Journ. Mic. Sci., xxxii, pl. xxv, *The Nephridium of Lumbricus, &c.*), and the present fig. 6 may be compared therewith. In place of the great wide sac there is in the post-larval stage quite a simple narrow tube, running nearly in a straight line from the nephridial pore, situated behind the ventral bundle of chætæ, forwards to the nephrostome, about midway between that bundle and the preceding one. The tube is, however, divisible into two regions, according to the presence or absence of concretions. The former (fig. 6, *a*) forms rather more than half the whole length of the tube. The organ is ciliated throughout.

The nephrostome is perfectly simple, so far as I can judge; is without lips, so that we cannot speak of a "funnel" in the usual sense of the word.

With regard to the alimentary tract, it presents exactly the same regions as in the adult. The narrow œsophagus passes back from the pharynx (? if this is eversible) into a wide "stomach," occupying Somite 7 and part of 8. Into the hinder part of this a pair of cone-like diverticula open, each diverticulum being longitudinally ridged internally. Immediately after the stomach the gut presents a series of pouches on each side, as in the adult. This sacculated region extends through four or five somites, and is succeeded by the narrow intestine, which suddenly dilates in the "tail," and here occupies nearly the whole cavity of the body.

DESCRIPTION OF PLATE I,

Illustrating Mr. Benham's paper on "The Post-larval Stage of *Arenicola marina*."

FIG. 1.—View of the larva mounted whole (from a camera drawing, under Zeiss *aa*, occ. 2). × 38. The animal is lying on its right side anteriorly, but is twisted in Somite 13, so that it presents its dorsal surface upwards. The dorsal chætæ of the right side are seen as far forwards as Somite 8. The ventral chætæ are seen anteriorly, but have not been represented after Somite 13. The rudimentary gills are seen in Somites 14 to 21. The somites in the "tail" are indistinct except towards the anus. The dark shading round the animal represents the structureless envelope secreted by it. *Ch.* 2. Rudimentary dorsal chæta of Somite 2. *div.* The diverticulum of stomach of the left side. *d. ch. l.* The dorsal chætæ of the left side. *d. ch. r.* The dorsal chætæ of the right side. *int'.* Narrow intestine. *int*^{2}. Wide intestine. *m.* Mouth. *œs.* Œsophagus. *oto.* Area deprived of pigment, below which is situated the otocyst. *Pros.* Prostomium. *sac.* Sacculated region of intestine. *stom.* Stomach.

FIG. 2.—One of the ventral chætæ from a transverse section. (Camera, Zeiss D. 4.) × 500.

FIG. 3.—One of the ventral chætæ of an adult *Arenicola*. (Camera, Zeiss B. 4.) × 150.

FIG. 4.—Transverse section through middle region of the body, about Somite 16. (Camera, Zeiss D. 2.) × 200. [The intestine has probably shifted a little from its natural position. The oblique muscles are not cut through in the section drawn, but I have added them from neighbouring sections.] *Bl. ves.* Blood-vessels passing to and from the gill (which is not represented in the section). *chlor.* Chloragogen cells around the ventral blood-trunk. *circ. musc.* Circular muscle of the body-wall. *dors. v.* Dorsal blood-trunk. *epid.* Epidermis. *int.* Intestine. *long. mus.* Longitudinal muscles of the body-wall. *n. cells.* Nerve-cells. *n. fi.* Nerve-fibres. *nu. circ.* Nuclei of circular muscles. *nu. long.* Nuclei of longitudinal muscles. *obl. mus.* The oblique (or transverse) muscle. *splanch.* Nuclei of visceral cœlomic epithelium. *vent. ves.* Ventral blood-trunk.

FIG. 5.—A section through a gill. *ep.* Epidermis, in which is a number of gland-cells (*gl. c.*). *circ. mus.* Circular muscles of the body-wall. *Bl. ves.* Branchial vessels.

FIG. 6.—A portion of Fig. 1 more highly magnified. It represents one of the somites containing a nephridium. (Camera, Zeiss D. 2.) × 200. The body-wall and the intestine are represented by the shading. The chætæ of two neighbouring somites are included in order to show the relative position of the nephridial pore and funnel. *a.* The excretory region. *b.* The "duct."

FIG. 7.—A portion of the body-wall viewed from the surface; it shows one of the glandular bands (*b*) bounded by the narrow non-glandular rings (*a*, *a*) which occur in each somite. *gl.* Gland-cells.

FIG. 8.—Diagrammatic transverse sections of the body to show vascular system in the branchial region on the right side, and the intestinal vessels on the left side. *Br. ves.* Branchial vessel. *Dor. ves.* The dorsal trunk. *Vent. ves.* Ventral trunk. Both are quite separate from the wall of the intestine (see Fig. 4). *d. int. ves.*, *v. int. ves.* Vessels passing from these trunks to and from the plexus in the wall of the intestine (*int. cap.*).

The Immature Fish Question.

By

J. T. Cunningham, M.A.,

Naturalist to the Association.

I. STATISTICS.

It is only eight years since the Royal Commission on beam trawling issued its report, and already a Select Committee of Parliament has been appointed to make a new inquiry into one of the principal subjects investigated by that Commission, namely, the decrease of the fish supply and the advisability of remedial measures. Among the conclusions of the Commission was this one :

"That in the absence of a proper system of fishery statistics and scientific observations, it is impossible to measure the fluctuations of the fisheries or to discover their causes."

In consequence of this statement the Board of Trade began the collection and publication of fishery statistics in 1886. Before that time only a return of the quantity of fish conveyed inland by rail had been issued; and although the Scottish Fishery Board had for many years obtained some statistics of the fish caught and landed in Scotland, none had been recorded in England, Wales, or Ireland. The Fishery Statistics are now annually issued in a series continuous with the old return of rail-borne fish, which is still included among the tables. The return now gives the total quantity and value of the different kinds of fish landed, the average price, the quantities for the different coasts of England and Wales, the quantities for the different months, and the totals for each port or district.

Within the last few years an agitation has developed among those engaged in the fishing industry on the east coast of England, concerning the capture of immature or undersized flat-fish, and the decrease in the supply of the more valuable kinds of these fish, namely, soles, turbot, brill, plaice, and lemon soles. The conclusion of the Commission of 1883–5 on this subject was as follows :

After carefully considering the whole evidence on the question of the decrease of fish, we are of opinion that—

As regards territorial waters:

(1) On many fishing-grounds, from the Moray Firth to Grimsby, there has been a falling off in the takes of flat-fish, both as regards quantity and quality.

(2) There has also been a decrease in the takes of haddock in certain places, chiefly in bays and estuaries.

As regards off-shore waters:

(3) No decrease, except in the case of soles, has been proved in the total takes of the North Sea.

Now let us turn to the statistics that have since been collected. The return for the year 1892 is not yet issued,* so that we have only six years to compare altogether; and this is a very short period to draw conclusions from, even if the statistics furnished all the particulars that were required to show the increase or decrease of the supply. The table below shows the total quantities in cwts. of the

England and Wales—all Coasts.

	1886	1887	1888	1889	1890	1891	1892
Brill	—	—	—	—	15,403	16,571	17,740
Turbot	59,850	63,166	55,041	53,576	51,879	56,875	62,630
Soles	98,078	85,316	72,522	74,143	72,129	82,688	72,821
Other prime fish	370,014	115,850	113,415	35,982	46,771	38,754	50,655
Total prime fish	527,942	264,332	240,978	163,701	186,182	194,888	203,846
Plaice	—	—	698,142	594,307	622,577	711,322	696,227
All fish except shellfish	6,412,433	6,029,481	6,348,072	6,464,564	6,100,630	5,966,076	6,485,699
Total, excluding salmon	6,397,367	6,012,371	6,340,774	6,460,064	6,095,512	—	—
Total value, excluding shellfish £	3,688,079	3,778,958	3,948,013	3,862,389	4,368,552	4,491,018	4,628,705
Drift-net fish	2,740,579	2,080,435	2,299,383	1,428,118	1,291,661	1,789,561	2,059,062
Bottom fish	3,671,854	3,949,046	4,048,689	5,036,446	4,808,969	4,176,515	4,426,637

more valuable flat-fish landed on the coasts of England and Wales, and includes certain other items from the official tables. It will be seen

* See postscript.

from this table that the total quantity of all fish exclusive of shell-fish shows fluctuations, but not steady increase or decrease. It is true that the quantity for 1891 is the least of the six totals, but the difference is not great, and the fluctuations in the other five years show that no definite importance can be attached to it. The inclusion or exclusion of the item salmon makes no appreciable difference in the result, but it is puzzling to find that there is no separate item for salmon in the year 1891, and no explanation of the omission is to be found in the memorandum which precedes the tables.

It will be seen that the figures under the item "Prime fish not separately distinguished" are so irregular that it is quite impossible to understand them. The cause of the irregularity lies evidently in changes in the method of classifying and estimating the fish followed by the returning officers. We cannot believe that certain kinds of fish constantly included under this item have fallen off to such an extent. We must conclude that this item has been enormously diminished by the abstraction from it of increasingly greater quantities which have been included under the special items. For practical purposes, then, this item is useless. If we look at the item soles, we find that the quantity for 1891 was greater than for any year except 1886 and 1887, so that on the whole there has been no very great decrease. Exactly the same is true of turbot. Assuming the figures to be reliable, however, there is a decrease in these items since 1886. Plaice has only been separately distinguished since 1888, and the annual total shows an increase, the figures for 1891 being the maximum. Brill has only been separately distinguished for two years, and nothing can therefore be said about it. It is a remarkable fact that there is no mention of lemon soles as a separate item, although these fish are sold separately at most of the fishing ports, and form an important proportion of the total catch of the deep sea trawlers. Moreover the fishing industry includes lemon soles among the flat fishes for which protection is demanded. We may note that the total value of the fish landed has increased enormously in the six years, the value in 1891 being three quarters of a million pounds greater than in 1886.

As it is trawl-fishing which is chiefly concerned in the present agitation I have added together the quantities under the items mackerel, herrings, pilchards, and sprats, and given the result separately as the total of drift-net fish, and given the remainder of the whole quantity as the total of bottom fish. The latter item includes certain other fish which are not bottom fish, such as salmon and mullet; but the quantities of these are relatively small, so that the figures I have obtained as bottom fish probably represent fairly well the total catch of deep sea trawlers. It will be seen, then, that there

has been a much greater falling off in drift-net fish than in bottom fish, considering all the coasts of England and Wales together. The item bottom fish increased greatly till 1889, but has fallen off in the following two years.

If we examine the various coasts separately, we find that the results for the east coast are closely similar to those for all coasts together. In the total quantity of fish landed, there was practically no decrease until 1889, but a decrease in 1890 and 1891. The total

England and Wales—East Coast.

	1886	1887	1888	1889	1890	1891	1892
Brill . . .	—	—	—	—	11,746	13,531	14,590
Turbot . . .	55,524	57,561	48,760	44,272	40,763	47,594	52,780
Soles . . .	82,677	67,874	52,151	47,747	46,187	61,287	52,934
Other prime fish .	364,557	109,424	105,057	25,848	34,391	30,197	40,265
Total prime fish .	502,758	234,859	205,968	117,867	133,087	152,609	160,569
Plaice . . .	—	—	628,658	518,688	548,784	647,915	620,951
Total except shellfish	5,321,656	5,157,678	5,260,350	5,223,635	4,719,237	4,670,646	5,105,814
Drift-net fish . .	1,965,657	1,628,102	1,664,854	1,790,350	1,307,410	1,100,410	1,388,937
Bottom fish . .	3,355,999	3,529,576	3,595,496	3,433,285	3,411,827	3,570,236	3,716,877

quantity of soles was greater in 1891 than in any other year except 1886 and 1887. The quantity of turbot was less than in 1886, 1887, and 1888, but greater than in 1889 or 1890. The quantity of plaice is at a maximum in the last year of the series.

On the south coast the total quantity of all fish except shellfish has greatly decreased, but the decrease has been in drift-net fish, not in flat fishes or trawled fish generally. The quantities of turbot and soles landed has greatly and steadily increased, although there was a slight falling off in 1891. Plaice, on the other hand, has decreased.

The west coast shows an enormous and steady increase in the total quantity of fish landed, the amount in 1891 being more than three times that of 1886. The increase has been largely in mackerel. With regard to flat-fish, turbot and soles have very

greatly increased, with a slight falling off in 1891; and plaice, as on the south coast, has decreased.

South Coast.

	1886	1887	1888	1889	1890	1891	1892
Brill . . .	—	—	—	—	2,822	2,070	2,070
Turbot . . .	3,211	3,582	4,408	5,838	6,733	5,392	6,231
Soles . . .	9,555	9,314	11,256	12,709	12,159	10,808	9,126
Other prime fish .	5,457	6,426	8,358	10,134	12,380	8,557	10,390
Total prime fish .	18,223	19,322	24,022	28,681	34,094	26,827	27,817
Plaice . . .	—	—	55,788	52,360	46,588	44,378	47,207
Total except shellfish	871,041	642,914	605,808	652,471	586,501	595,705	599,749
Drift-net fish . .	638,479	349,464	307,188	312,834	227,808	319,353	319,275
Bottom fish . .	232,562	293,450	298,620	339,637	358,693	276,352	280,474

When we separate the quantities of drift-net fish, as was done for all the coasts together, and describe the remainder as bottom fish,

West Coast.

	1886	1887	1888	1889	1890	1891	1892
Brill . . .	—	—	—	—	835	970	1,080
Turbot . . .	1,115	2,023	1,873	3,466	4,383	3,889	3,619
Soles . . .	5,846	8,128	9,115	13,687	13,783	10,593	10,761
Other prime fish .	—	—	—	—	—	—	—
Total prime fish .	6,961	10,151	10,988	17,153	19,001	15,452	15,460
Plaice . . .	—	—	13,696	23,259	27,205	19,029	28,069
Total except shellfish	219,736	228,889	481,914	588,458	794,892	699,725	780,136
Drift-net fish . .	136,443	102,869	327,341	324,934	465,426	369,798	350,850
Bottom fish . . .	83,293	126,020	184,573	263,524	329,466	329,927	429,286

we find that on the east coast the latter item has varied but little. It was greatest in 1888, and the next highest figure is that for 1891. On the other hand, the total of drift-net fish has decreased steadily since 1886. On the south coast the annual quantity of drift-net fish has been pretty steady for four years out of the six, but the total for 1891 is only half that for 1886. Bottom fish on the south coast increased greatly to a maximum in 1890, but fell back considerably in 1891. On the west coast both drift-net fish and bottom fish have enormously increased.

These results are chiefly, perhaps entirely due to the fact that in recent years a large number of east coast boats of the largest size, both trawlers and drifters, have annually spent a portion of the year in fishing on the more distant grounds on the south and west coasts of England and the south coast of Ireland. Sailing and steam trawlers have fished on the grounds to the south and west of the Wolf Rock between the Scilly Isles and Mount's Bay, off the north coast of Cornwall and in the British Channel. Every spring a large fleet of mackerel boats from Lowestoft make Plymouth their headquarters, and land their fish at that port. The effect of this recent movement in the fishing industry is plainly indicated by the figures in the official return of the total quantities of fish landed at the principal ports on the several coasts (Table below). Thus we see that the quantity landed at Grimsby has slightly decreased, at Lowestoft has varied but little, at Plymouth has steadily increased, and also at Brixham; at Tenby there has been a decrease, while Milford (including Neyland) has sprung from nothing to be as important a port in relation to landing fish as Lowestoft.

	1886.	1887.	1888.	1889.	1890.	1891.	1892.
	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.	cwt.
Grimsby . .	1,363,595	1,342,240	1,401,270	1,350,430	1,297,560	1,258,840	1,377,640
Lowestoft . .	502,097	476,947	476,718	599,946	417,373	572,777	627,578
Plymouth . .	141,712	150,157	132,087	164,864	163,884	179,353	135,241
Brixham . .	48,280	59,863	62,891	81,317	95,612	61,460	59,103
Tenby . .	10,232	9,451	10,363	8,791	6,910	6,349	4,201
Milford and Neyland . . .	—	5,690	157,419	270,576	484,006	403,657	370,687

Now it is clear that an increase in the quantity of fish landed may very well be produced by an increase in the size and number of boats, and the fact that they visit new and distant grounds, at the same time that the productiveness of grounds formerly used is declining. The most rigid and reliable test of the productiveness of a given fishing-ground would be to compare the average quantity of

fish caught in a given time by the same or a similar boat in successive years. The Fisheries Department of the Board of Trade has not yet attempted this. Indeed, it has not attempted anything in relation to this subject beyond the collection of the quantities of fish landed, distinguishing certain kinds of fish, different coasts, and different ports. There is absolutely nothing in the statistical tables and memorandum concerning the number of men and boats or the size and character of the boats employed in the fisheries, if we except a brief reference in the memorandum of the first return, that for 1886. In this memorandum the number of boats and men was quoted from the Annual Statement of Navigation for 1885, and the *value* of fish landed was calculated per boat and per fisherman. In order, then,

Boats registered in England and Wales under Sea Fisheries Act, 1868.

	Total number of 1st class boats.	Total tonnage 1st class.	Total number all classes.	Total tonnage all classes.	Total number of regular fishermen.	Number of men required for boats.
1871	2,582	90,224	15,615	131,092	—	—
1872	2,778	100,332	15,331	140,535	—	—
1873	2,851	104,642	15,049	145,134	—	45,398
1874	2,934	110,500	15,029	150,268	25,576	46,525
1875	2,979	111,784	14,830	151,041	26,245	44,142
1876	3,142	121,445	14,809	160,332	28,238	43,399
1877	3,425	137,768	13,294	174,174	30,408	35,883
1878	3,637	149,343	10,786	182,415	30,480	31,277
1879	3,767	155,941	10,639	189,006	29,408	31,375
1880	3,840	161,450	10,524	194,532	28,835	28,085
1881	3,870	162,417	10,357	195,348	29,141	27,792
1882	3,931	170,367	10,373	203,355	30,802	27,512
1883	3,743	161,830	8,880	190,517	31,810	30,152
1884	3,840	169,161	8,622	197,300	32,631	28,020
1885	4,040	183,694	8,826	212,176	33,422	28,520
1886	4,011	189,375	8,447	216,349	34,080	32,086
1887	4,014	190,464	8,390	217,346	34,526	30,914
1888	3,982	189,292	8,417	215,725	33,509	32,823
1889	3,928	187,724	8,271	213,542	33,474	33,429
1890	3,879	183,910	8,050	208,389	32,503	30,330
1891	3,873	183,421	8,063	207,515	33,044	28,885
1892						

to ascertain the number or particulars of boats and men employed in our fisheries in successive years we have to examine the Annual Statements of Navigation and Shipping. We find there the number of boats registered under the Sea Fisheries Act of 1868, arranged in three classes. The Navigation Statement has, since 1876, been prepared by the Commercial Department of the Board of Trade, and, since it is signed only by the Assistant Secretary of that department, it appears that the Fisheries Department has nothing to do with it. So that, notwithstanding the organisation of the Fisheries Depart-

ment in 1886 to take over all fisheries business, the Act of 1868 is not administered by that department. The first class of fishing-boats includes those of fifteen tons and upwards; the second class, those less than fifteen tons not navigated by oars only; the third class, boats navigated by oars only. The table on the preceding page shows the boats on the register in successive years from 1871 to 1891. I have also extracted the number of men and boys constantly employed in fishing, compiled from estimates made by the collectors of customs, omitting the figures of those occasionally employed, and I have given the number of men and boys required to work the boats whose certificates were produced and endorsed. But both these sets of figures are only approximations, for the production of certificates every year is not everywhere rigidly enforced. The important points brought out by these figures concerning boats and men are the following.

The total number of first-class boats increased steadily from 1871 to 1885—namely, from 2582 in 1871 to 4040 in 1885. Since the latter year the number has slightly decreased down to 3873 in 1891. The total number of boats of all classes steadily decreased from 15,615 in 1871 to 8063 in 1891. The total tonnage of all classes included increased steadily from 131,000 in 1871 to 217,000 in 1887, since when it has slightly decreased to 207,000 in 1891. The total number of regular fishermen increased from about 25,000 in 1874 to 34,526 in 1887, since when it has decreased to 33,044.

Now, logically to pursue the inquiry into the increase or decrease of the fish supply, in particular of the supply of various kinds of trawled fish, and of all kinds together, it would be necessary to be able to compare the catch obtained by equal catching power in a series of years. This has recently been attempted by the Fishery Board for Scotland, which, having adequate powers, has been able for the past three years to collect statistics of the tonnage and value of trawlers fishing on the Scottish coast, and the quantities of fish landed by these trawlers, apart from the fish landed by other boats. This has not been done for England and Wales, and could not be done by the present defective organisation of fishery authorities in this part of the kingdom. The Scottish Board has an efficient scientific department managed by competent scientific men, who have devoted their trained powers and scientific methods to the problems of sea fisheries. They have also the whole coast divided into districts, each provided with a competent fishery officer who has complete knowledge and experience of the fisheries, but no pecuniary interest in them. The scientific authority can thus without difficulty obtain any information it requires.

The statistics thus obtained by the Scottish Board are discussed

in detail by Dr. Fulton in the Board's tenth report, 1892. He finds that the tonnage of Scottish trawl-vessels has increased from 2004 in 1883 to 6484 in 1891. The separate particulars of steam trawlers, which make up the greater part of this tonnage, have only been obtained since 1889. The fish landed by trawlers in Scotland has been separately recorded since 1888, and Dr. Fulton states that the total quantity has increased from 250,000 cwt. in 1888 to 323,046 cwt. in 1891. But, on the other hand, the quantity of fish per ton of the vessels' tonnage has decreased from 92·9 cwt. to 49·8 cwt. He is able further to give the quantity of round-fish and flat-fish per ton of the vessels' tonnage separately, and also the proportional quantity of several single kinds of fish. He finds in all except in skates a great falling off.

However, it must be pointed out that, in the first place, it is not safe to rely upon conclusions drawn from a series of statistics extending over so short a period; and in the second place, that the Scottish trawlers have been greatly handicapped by the closure of such extensive areas as the Firth of Forth and other territorial waters where they formerly fished.

In the following table I have indicated all that can be done in the way of comparing the statistics of fish caught, and boats employed,

	Cwt. soles per 1st-class boat.	Cwt. soles per ton 1st class.	Cwt. total fish per ton total tonnage.	Cwt. turbot per 1st-class boat.	Cwt. turbot per ton 1st class.	Total value per ton total tonnage.
1886	24·45	·51	29·63	14·92	·31	£17
1887	21·25	·44	27·74	15·73	·33	17
1888	18·21	·38	29·42	13·82	·29	18
1889	18·87	·34	30·27	13·63	·28	18
1890	18·59	·33	29·22	13·37	·28	20
1891	21·34	·45	28·75	14·68	·31	21
1892	—	—	—	—	—	—

available for England and Wales. It will be seen that the hundredweights total fish per ton of total tonnage of fishing-boats shows slight fluctuations, but no continuous increase or decrease. There is no possibility of distinguishing trawlers and drifters among the boats registered. I have, therefore, compared the quantities of soles and turbot per first-class boat, and per ton of the aggregate tonnage of first-class boats; that is to say, I have supposed the number and tonnage of trawlers to be always in the same proportion to the aggregate numbers and tonnage of first-class boats—a supposition which may be correct or not. The results, however, are not without interest. Thus the quantities of soles per first-class boat for the several years follow almost exactly the same order as the total quan-

tities of soles landed. But whereas the absolute quantities in 1890 and 1891 are less than in the years 1888 and 1887 respectively, the quantities per first-class boat in the former years are greater. When we examine the quantities per ton of first-class boats we find a still greater difference from the absolute quantities, the proportion for 1891 being higher than for any other year except 1886. Taking next the turbot, we find that the quantities per boat follow the same order as the absolute quantities, and so also do the quantities per ton of first-class boats. The last column of the table shows that the annual earnings per ton of total tonnage have steadily increased in the six years, so that although the public are poorer on account of the increase in the price of fish, it would seem that the men and boats actually earn more money every year. But this result, again, requires qualification, for there has been especially on the north-east coast of England a great increase in the number of steam trawlers, and everywhere within the last six or seven years steam machinery has been more and more generally used on sailing vessels as well as steamers for hauling up the trawl. The steam trawler can make more hauls than the sailing vessel, and yet her tonnage is registered as less than that of a sailing vessel of the same size. For instance, a steam-vessel of fifteen tons gross is registered in the first class, but the tonnage entered for her is the net registered tonnage, which is less than fifteen tons. Taking these difficulties into consideration, it is not worth while to calculate the quantities of fish per boat or per ton for the several coasts separately.

Summary.—To summarise these results, then, the analysis shows that there has been no continuous decrease in the total quantity of fish caught, nor in the quantity of total fish per ton of the total tonnage of all kinds of boats. When we deduct the quantities of mackerel, herrings, pilchards, and sprats, we find there has been a considerable decrease in the total quantity of drift-net fish landed, and a corresponding increase in the total quantity of other kinds of fish. The total number of fishing-boats has steadily decreased since 1871, but the total tonnage reached a maximum in 1887. There has been a decrease, but not a continuous decrease in the quantity of soles and turbot landed, but an increase in the total quantity of plaice. The decrease in the quantities of soles and turbot has been confined to the east coast, and there no decrease in plaice has occurred. On the south and west coasts the quantities of soles and turbot landed have largely increased, and plaice also on the west coast ; on the south coast plaice have somewhat decreased.

Postscript.—After this paper was finished the statistical tables and memorandum for 1892 were published. I have therefore inserted the figures for this year in the tables, but time is not avail-

able to recast the paper and incorporate the returns for this year in it. It will be seen that my general arguments are confirmed by last year's figures. Soles for all coasts have fallen again, but turbot have nearly reached the maximum figures of 1887. The total fish excluding shellfish is greater than in any other year since statistics were collected, and so is the value. Drift-net fish have increased again, and the total of bottom fish is higher that in 1891. Similar remarks apply to the east coast considered separately.

A new feature in this return is Part III—A Statement of the Boats and Men for the years 1888 to 1891 inclusive. I have given these years among the whole series of years for which I have extracted these particulars from the Annual Statement of Navigation, and what I have said on this head requires no modification.

My hope and expectation that the extraordinary treatment of lemon soles in the tables would be remedied in this return are utterly disappointed. No change whatever is made. Lemon soles are placed in the Scotch tables as prime fish equivalent to soles in the English tables, while they are not mentioned at all in the latter, and English soles and Scotch lemon soles are added together to produce the total of soles for the United Kingdom. The official statistics of fish remind one of the French phrase, " Plus ça change, plus c'est la même chose."

II. SCIENTIFIC INQUIRIES.

1. At Plymouth.

Since last Christmas, in accordance with the Council's special instructions, I have been making systematic investigations into the question of the capture and destruction of immature or undersized fish at Plymouth. The following is my report on these investigations as far as they have yet gone. By immature fish in the tables I mean females in which there is no trace of yolk in the young eggs in the ovary when examined under the microscope. Immature males have been distinguished by the extremely undeveloped state of the testes. All the males registered as mature either contained ripe spermatozoa or were obviously spent.

Lemon Soles or Merry Soles.

Between January 1st and March 11th I examined 220 specimens of this species (*Pleuronectes microcephalus*) procured from the fish quay as landed for sale. The examination was carried out in the

Laboratory with the utmost minuteness and attention, and the results are shown in the following table.

Lemon (Merry) Soles, December 31st, 1892, to March 11th, 1893.

Length.	No. examined.	Males.		Females.	
		Mature.	Immature.	Mature.	Immature.
6 inches	0	0	0	0	0
7 „	10	7	0	3	0
8 „	14	10	0	4	0
9 „	26	16	0	10	0
10 „	50	34	0	16	0
11 „	54	31	0	23	0
12 „	28	17	0	11	0
13 „	26	12	0	14	0
14 „	9	2	0	7	0
15 „	1	1	0	0	0
16 „	2	0	0	2	0
17 „	0	0	0	0	0
18 „	0	0	0	0	0
	220	130	0	90	0

Under 11 inches—100.
Over 11 inches—120.

Not one specimen was immature. The period extended from just before the spawning period to the middle of that period, and every specimen was either ripe, or in such a condition that it would evidently have spawned this season if it had been left alive in the sea. All the males were actually ripe, yielding ripe milt when squeezed, or were nearly spent. The excess in the number of males over females is probably due to the fact that a disproportionate number of small fish were examined, and the males being smaller, a given number of small fish includes more males than females. It is probable enough that some of these fish were preparing to spawn for the first time in their lives, so that they were killed before they had actually been allowed to reproduce their kind; but it is not possible in such an examination of the fish as this with our present knowledge to ascertain whether a specimen is ripening for the first time or has spawned in previous seasons. But the evidence proves that in the period mentioned immature merry soles are not landed at Plymouth. At other times of the year immature specimens may be landed, but if so, I believe the proportion of such is small and unimportant. At the Conference convened by the National Sea Fisheries Protection Association in 1892, the limiting size adopted

for lemon soles was 11 inches in total length. Of the specimens included in the above table 100 were under that size and 120 over—that is to say, 45 per cent. of the number were under 11 inches in length. This, however, may not represent accurately the average proportion among all the fish of this kind landed. I will give, therefore, the results of observations which I made during a three days' trip on board a trawler at the beginning of March. We were trawling off Dodman Point in Cornwall, a ground where merry soles are usually abundant. We took 264 of these fish altogether. None of these were immature, and none were returned to the sea as unsaleable; the smallest was 7 inches long, 179 of these were over 11 inches in length, 85 were under that length. That is to say, 32 per cent. of the merry soles caught were under the proposed limit. Merry soles form a very important part of the total catch of a trawler fishing out of Plymouth, and they fetch a very good price. There would be the strongest opposition on the part of Plymouth trawlers to a proposal that they should be compelled to throw away 32 per cent. of the merry soles they catch.

The smallest merry sole I have ever obtained at Plymouth was 6·4 inches long, and this was a perfectly ripe male. As far as my experience goes, smaller specimens than this are never caught either by deep sea trawlers or any other kind of fishing-boats.

The merry sole or lemon sole is not a large fish. The largest obtained by Dr. Fulton on the east coast of Scotland was 18 inches long. I have not yet seen any at Plymouth over 17 inches in length, and no males over 16 inches.

On the south coast merry soles, large or small, are not captured by any boats, or very exceptionally, other than the deep sea trawlers, and they are only found in abundance at a considerable distance from the coast. The inshore waters, which yield often plenty of plaice, supply very few merry soles. Neither the full-grown nor the young of this species are taken in any numbers in territorial waters on British coasts. The evidence available shows that the young lemon soles when they first go to the bottom, instead of seeking the shore as young plaice do, travel in the opposite direction, and pass the first period of their lives at depths greater than those where the adults abound. Dr. Fulton, in his systematic search on the coast of Scotland, obtained only four specimens as small as 2 inches, although he obtained 64 out of a total of 195 under 8 inches. On the west coast of Ireland, the Irish Survey of 1890–91, obtained three specimens $1\frac{1}{4}$ inches long at depths of fifty-two to sixty fathoms. Mr. Holt has, however, recently found that young lemon soles 2 to 4 inches in length are not rare in the estuary of the Humber in autumn. But these were not in large numbers, the greatest number caught in one

haul of the shrimp trawl being sixteen. We may, therefore, practically confine our attention to the deep sea trawlers.

Mr. Holt has been investigating the question on the east coast for the North Sea since January, 1892. He says that the male lemon sole is sometimes mature at 6 inches, and that no specimen smaller than this could be procured. He says he has found immature females from 6 inches to 12 inches in length. But not all females are immature under 12 inches or under 11 inches. Many were mature at 10 inches, some at 9 inches, and one female even at 8 inches. Mr. Holt examined 424 specimens, the smallest he could procure, by far the greater number under 11 inches in length; and of these, 125 were immature—that is, 29 per cent. If we take only those under 11 inches examined by him, the numbers are these :— Total number examined, 263; immature, 101, or 38 per cent. Even this is not a very large proportion. I do not think it is large enough to justify any legislative interference with the capture of lemon soles. Mr. Holt states that young lemon soles are not taken on the eastern grounds.

It is certain, therefore, from the evidence reviewed that neither immature nor undersized lemon soles are captured by the deep sea trawls in excessive proportion on any particular grounds, and the question with regard to this particular fish is narrowed down to this :— Is it necessary or advisable to interfere in any way with the capture and sale of the smaller lemon soles, which the trawlers at present take on all ordinary off-shore fishing-grounds?

In the first place it must be noted that all the lemon soles taken are saleable and good for food. None are thrown overboard as useless, and all find a ready market. If a limiting size is enforced either the prohibited fish must be thrown overboard, or the fishermen must find a method by which they can avoid catching them. If they are forced to throw the small fish overboard, it is certain that they will not all be returned to the sea alive. It is doubtful if any or more than a very small proportion would survive if thrown overboard. According to my experience at Plymouth, it is seldom that the fish are sorted out and picked up as soon as they are emptied from the trawl on to the deck. In rough weather, and when the trawl contains a large quantity of stuff, the fish have been subjected to a good deal of mechanical violence before they reach the deck. Then the trawl is frequently torn, and it is mended and shot away before the fish receive any attention. Again, hauls are frequently made at night, when it would be troublesome and difficult to distinguish the smaller fish. In a great many cases the fish would not be thrown overboard until they were dead or beyond hope of recovery.

An enlargement of the mesh of the net has often been suggested;

but this will be considered in reference to the protection of immature fish generally. It is enough to state here that no enlargement of the mesh sufficient to allow lemon soles of 7 or 8 inches in length has yet been proved to be practicable.

It has been shown by my own observations at Plymouth, and Mr. Holt's at Grimsby, that practically no lemon soles are taken which are less than 7 inches in length. Now this length bears the same proportion to 18 inches, the maximum length of the lemon sole, as $10\frac{7}{8}$ inches does to 28 inches, the maximum length of the plaice. Therefore, since it is proposed to restrict the capture of plaice to those above 10 inches, the corresponding restriction with regard to lemon soles, as actually now enforced by natural conditions, is an established fact without the aid of law. To put this aspect of the matter in another light, if it is proposed to set up a limit of 11 inches for lemon soles, then the corresponding limit for plaice must be 17 inches, for 11 bears to 18 the same proportion as 17 to 28. I do not think the fishing industry would consent to a law which prohibited the landing or sale of plaice under 17 inches. The limiting sizes adopted by the conference of 1892 were for turbot and brill 12 inches, for lemon soles 11 inches, for plaice and soles 10 inches; and yet both the plaice and the sole grow to a larger adult and maximum size than the lemon sole.

My conclusion, then, is that no case has been made out for any interference with the capture, landing, or sale of lemon soles. Where it is found that a kind of fishing is practised which is diminishing or endangering the supply of a particular kind of fish without producing any great profit either to those engaged in it or to the community, then it is allowable to restrict or prohibit that kind of fishing. But the evidence at present available shows that any restriction of the fishing for lemon soles now carried on would be a hardship to the fishermen, a loss to the public, and of no certain benefit to the fishery.

It does not necessarily follow that if the supply of a certain kind of fish is diminishing, laws must be passed with the object of stopping the diminution. It may not be possible to improve the supply by special measures. When that is the case we must wait until the limit of diminution is reached; at a certain point the increase of the appliances for capture will also cease, because profits will be reduced to a minimum, and so an equilibrium will be established. But it is necessary to point out that in the case of lemon soles we have no sufficient evidence that the supply is diminishing or has diminished; scarcely any evidence at all on the question. For England and Wales we have no statistics of any kind with regard to lemon soles; as far as this fish is concerned no statistics have yet been collected. Trawlers

and fish traders at Plymouth unanimously maintain that in that neighbourhood the supply of merry soles has increased in recent years. They say that formerly, ten years ago, merry soles were not abundant enough to be sold separately; they were sold mixed with plaice as flat-fish. Now they are sold separately, and form an important item in the trade. The fishermen say that this is not due to an increase in the number of boats or an increase in the price of the fish, nor to the working of new grounds. They say that they get many more merry soles now on the same fishing-grounds than they did from five to ten years ago. What is the case in the North Sea I cannot say, but for the east coast of Scotland we have statistics. The gross quantity of lemon soles landed in Scotland is still increasing, while the total quantity of turbot, and of flounders, plaice, and brill together, appear to have reached a maximum about 1888 or 1889. Between 1888 and 1891 the quantity of lemon soles has increased from 12,667 hundredweight to 17,739 hundredweight. But, on the other hand, Dr. Fulton finds that the quantity of lemon soles caught by beam trawlers per ton of the vessels' tonnage decreased in the years 1889 to 1891. As I have mentioned before, no important conclusions can be drawn from statistics limited to three years. Thus it is shown that, on the one hand, there is no evidence at present of a statistical nature of a decrease in the supply of lemon soles, nor, on the other hand, any evidence from the natural history of the fish, or an examination of the fishery, that benefit could be obtained by imposing regulations or restrictions, or interfering in any way whatever.

Plaice.

The following table gives the results of examination of all the plaice examined in the period mentioned. It simply serves to show the relation of sexual maturity to size in this species at Plymouth.

The largest immature female was 14½ inches long, the smallest mature female 9 inches, so that from 9 inches to 14½ inches is the borderland within which some females are mature and others immature. The smallest mature male was also 9 inches long and the largest immature 12 inches.

Mr. Holt's results from observations on the east coast, as described in the preceding number of this Journal, are somewhat different. It is true he had examined a larger number of specimens. He once found a ripe male only 6 inches long, but this he rightly regards as quite exceptional. Apart from this, his smallest mature male was 9 inches long, and his largest immature 15 inches. Of females, his smallest mature was 13 inches long, and his largest immature 17 inches. These differences correspond closely with the

difference in maximum size of plaice on the east and south-west coasts of Britain. Dr. Fulton states (8th Report of Scottish Fishery Board) that the largest plaice found on the east coast of Scotland was 28 inches long. Mr. Holt tells me that he has never seen a North Sea plaice more than 27 inches long, although possibly one of 28 inches may occur occasionally. The maximum observed by me at Plymouth is 25 inches. There can be no doubt that the average

Length.	No. examined.	Males.		Females.	
		Mature.	Immature.	Mature.	Immature.
6 inches	1	0	0	0	1
7 „	26	0	10	0	16
8 „	13	0	4	0	9
9 „	4	2	0	1	1
10 „	8	4	1	0	3
11 „	6	3	1	1	1
12 „	8	4	1	1	2
13 „	12	5	0	5	2
14 „	10	4	0	3	3
15 „	3	1	0	2	0
16 „	9	1	0	8	0
17 „	1	0	0	1	0
18 „	2	0	0	2	0
19 „	1	1	0	0	0
20 „	1	0	0	1	0
21 „	2	0	0	2	0
22 „	0	0	0	0	0
23 „	0	0	0	0	0
24 „	1	0	0	1	0
25 „	1	0	0	1	0
	109	25	17	29	38

adult size corresponds to the maximum size. There is still some little uncertainty in distinguishing an immature fish from one that has recovered from spawning. Mr. Holt's discussion of this question in the preceding number of the Journal does not entirely exclude the possibility that some months after spawning the roe of a spawned fish may be similar to that of one which has never spawned at all. But among fish examined during the spawning season, as most of Mr. Holt's and all of mine were, there can be hardly any uncertainty from this cause. Therefore, if we take what Mr. Holt calls the biological limit, the length which will certainly exclude all immature fish, which is 18 inches for the North Sea, it is 15 inches for the south-west coast. So much for the biological question apart from the practical.

The fish included in the first table were partly samples of those landed by trawlers, deep sea trawlers, and partly samples of those

captured by small ground seines in the estuaries near Plymouth, chiefly in the estuary of the Tamar, called the Hamoaze. It is very instructive to exhibit the details concerning these two classes of fish separately, as I have done in the tables on this and the next page.

Plaice: January 1st to March 11th, 1893.

From Trawlers.

Length.	No. examined.	Males.		Females.	
		Mature.	Immature.	Mature.	Immature.
7 inches	1	0	0	0	1
8 „	2	0	2	0	0
9 „	3	2	0	1	0
10 „	8	4	2	0	2
11 „	5	3	1	1	0
12 „	8	4	1	1	2
13 „	12	5	0	4	3
14 „	10	4	0	3	3
15 „	3	1	0	2	0
16 „	9	1	0	8	0
17 „	1	0	0	1	0
18 „	2	0	0	2	0
19 „	1	1	0	0	0
20 „	1	0	0	1	0
21 „	2	0	0	2	0
22 „	0	0	0	0	0
23 „	0	0	0	0	0
24 „	1	0	0	1	0
25 „	1	0	0	1	0
	70	25	6	28	11

Total number examined . . . 70.
Immature . . . . . 17=24 per cent.
Under 10 inches . . . . 6= 8 „
Under 17 inches . . . . 61=87 „
Under 14 inches . . . . 39=55 „

Thus, of the plaice landed by trawlers, 24 per cent. were immature, of those landed by the seines, 100 per cent. The trawled fish contained more than the average number of small fish, because on several occasions small fish were selected for examination, and consequently the percentage of immature among trawled fish taken all together is less than 24. The other percentages given are interesting in relation to the various proposals for restriction which have been made.

It is a well-established fact, the evidence for which has been published in full by Dr. Fulton, Mr. Holt, and myself, that the young of the plaice when they first take to living on the sea bottom seek the shore, and pass the first part of their lives in bays and

estuaries and in shallow water. In consequence of this fact we see that at Plymouth the principal destruction of small fish is caused by inshore fishing, such as the seines in the Hamoaze. Inshore trawling and large ground seines used at Teignmouth and Dawlish doubtless are equally destructive. It must be remembered that this

Plaice: January 1st to March 11th, 1893.

From Seines in Hamoaze, &c.

Length.	No. examined.	Males.		Females.	
		Mature.	Immature.	Mature.	Immature.
6 inches	1	0	0	0	1
7 „	25	0	9	0	16
8 „	11	0	2	0	9
9 „	1	0	0	0	1
10 „	0	0	0	0	0
11 „	1	0	0	0	1
12 „	0	0	0	0	0
	39	0	11	0	28

Total number examined . . . . 39.
Smallest . . . . . 6¼ inches.
Largest . . . . . 11¼ „
Immature males . . . . . 11.
„ females . . . . . 28.

destruction is not remunerative to the men who practise it. Plaice of 7 or 8 inches long fetch a low price, and are poor food even as compared with merry soles of the same size. There can be no doubt that trawlers working in shallow water, in the bays and close to shore, take a large proportion of small and immature plaice. On the south-west coast there are no flats which extend far out from the shore into extra-territorial waters, and I know of no ground where small plaice are taken in excessive proportion to large except in territorial waters. It has been proposed by the Devon Fisheries Committee to exclude beam trawling in great part of their territorial waters altogether. This would of course put an end to the destruction of small plaice at present effected by those boats in those waters. But it would not affect the destruction, which is due to other kinds of fishing, in particular to ground seining.

The measures which might be carried out for the protection of small plaice may be of the following kinds.

(1) Prohibition of landing, possession, or sale of fish under a certain limit of size.

(2) Prohibition of fishing on certain grounds.
(3) Prohibition of capture in certain seasons.
(4) Mesh regulations.

The proposal to establish a size limit offers many difficulties. If the limit of 10 inches proposed by the National Sea Fisheries Protection Association were applied rigorously to all coasts of the kingdom, it would not bear very hardly on deep sea trawlers in the south-west. It would mean throwing overboard about 8 per cent. of the plaice caught, and as these are the smallest fish, it would not be a very great loss of earnings. Still it would be some loss, and would be strongly opposed by the fishermen. Then, again, the fish thrown overboard would not all be alive. Trawling in winter-time in strong winds is such rough work, and so much attention has to be given to mending and shooting the trawl and navigating the vessel, that the fish often cannot be picked out from the mass of stuff brought up by the trawl until it has been on deck some time. It is making a great demand on the crews of trawlers to expect them to carry a measure and measure their fish ; and if they were forced to do it, they would think more of the importance of not throwing overboard any fish which they could legally keep than of returning the fish to the sea alive and in good condition. Fishermen, as a rule, do not understand the conditions necessary to the life of a fish. They almost always fail to bring fish alive when requested and paid to do so, because they do not handle them with enough care, or supply them with water properly.

On the other hand, Mr. Holt has proved that the Conference limit of 10 inches would not prevent fishing in the eastern grounds of the North Sea, the destruction of small plaice on which gave rise to the present agitation. No higher limit would be tolerated by the south coast trawlers. It must be remembered that it is not practicable to enforce the biological limit. On the south-west coast the limit is 15 inches, but a large proportion of the fish under this size are mature, and they are certainly marketable. To enforce this limit would deprive the trawlers of about 50 per cent. of the total number of their plaice, and probably dislocate the industry. Mr. Holt believes that a limit of 14 or 15 inches would be enough to prevent fishing on the eastern grounds of the North Sea, but he tells me that in winter a good many fish of this size are taken on other grounds, and suggests enforcing the restriction only in summer. It is of course true that the imposition of a size limit would prevent to a great extent the capture of small plaice by shrimping and seining in inshore waters. But there is a great deal of destruction carried on in shrimping and seining of plaice which are so small as to be

unmarketable, and this would not be affected by the establishment of a legal size limit.

It seems to me that, apart from the question of the extra-territorial eastern grounds of the North Sea, if the capture of plaice could be prevented altogether in territorial waters in this country the fish would be protected to a most important extent, and the difficulty of interfering with the operations of deep sea trawlers would be avoided. At the same time beam trawling, except for shrimps, should not be allowed in territorial waters. There would be no greater difficulty in this than in preventing the capture of salmon by illegal nets, which has been done for years. Plaice taken by shrimp-net and seines can be returned to the water alive; those taken by deep sea trawls, speaking broadly, cannot. The wanton destruction of plaice by shrimpers and seiners can be easily punished by the local committees.

This proposal could not be carried out on the west coast of Ireland, where nearly all the available trawling-ground is inside the territorial limit. But there is no need for protection on that coast at present.

I need not consider the question of the enlargement of the mesh, because on the south-west coast the deep sea trawlers refuse to consent to it, for the reason that with a larger mesh they would not catch thickbacks (*Solea variegata*), queens (*Pecten operculatis*), or squid (*Loligo*), which make part of the men's earnings.

In order to prevent destruction on the eastern grounds of the North Sea it would be necessary, without a size limit, to close the grounds wholly or partially by means of an international convention.

It must be remembered that, as I have shown in the first portion of this paper, we have as yet no statistical evidence of a diminution in the supply of plaice, except a decrease in the total quantity landed on the *south coast*. Even Dr. Fulton's figures do not include separate figures for plaice.

Soles.

The soles of which the particulars are contained in the following table (p. 75) were all taken by trawlers and purchased on the landing quay. All of them were selected on account of their small size. The number is small, but the results are not likely to be greatly altered by examination of a larger number. There are no immature males among them. The smallest mature female is 12 inches long, the largest immature is 13 inches. Mr. Holt found in the North Sea no immature females above 12 inches, while his smallest mature female was only 10 inches long. Perhaps the soles on the south-west

coast are a little larger in average adult size than in the North Sea. On the other hand, Mr. Holt found some males immature at 11 inches, and I have seen no immature males ; but since the testes are so small it is difficult to be certain that a male is immature. The difference is in any case slight: according to Mr. Holt the "biological limit" of immaturity is 12 inches, according to my result 13 inches ; but to exclude all immature fish it would have to be 13 and 14 inches respectively.

Soles : January 1st to March 11th, 1893.

Length.	No. examined.	Males.		Females.	
		Mature.	Immature.	Mature.	Immature.
6 inches	0	0	0	0	0
7 „	0	0	0	0	0
8 „	0	0	0	0	0
9 „	5	5	0	0	0
10 „	5	3	0	0	2
11 „	15	12	0	0	3
12 „	21	12	0	5	4
13 „	3	0	0	1	2
14 „	8	0	0	8	0
15 „	3	1	0	2	0
16 „	1	0	0	1	0
17 „	0	0	0	0	0
	61	33	0	17	11

Total number examined . . . 61.
Immature . . . . . 11=18 per cent.
Mature males . . . . . 33=54 „
Under 10 inches . . . . 5= 8 „

It is important to notice that only eleven of these fish were immature, 18 per cent. ; while among the sixty-one selected as the smallest obtainable, 54 per cent., more than half, were mature males. This shows how comparatively slight is the destruction of immature soles by deep sea trawlers on the south-west coasts. The smallest sole obtained was 9 inches long, but smaller specimens down to 8 inches have been seen on other occasions. Soles less than 8 inches long are not destroyed by deep sea trawlers landing fish at Plymouth. If the Conference limit of 10 inches were enforced it would mean throwing overboard much less than 8 per cent. in number of the soles taken.

It seems, then, more important to ascertain whether soles less than 9 inches long are destroyed, and if so how and where. A few are taken at Plymouth by the shrimp trawlers, but I have no statistics,

and the number is not very great. I have heard that larger numbers are taken by the ground seines on the coast of Devon, but have not yet made personal investigation of this mode of fishing.

Curiously enough on the eastern grounds, which are so often referred to, small or immature soles are not taken in any important numbers, according to the observations of Mr. Holt. The destruction of soles too small for the market by inshore fishing in the Humber has been shown to be insignificant by Mr. Holt in the preceding number of this Journal, as they are returned to the sea alive. A considerable number, however, from 6 to 10 inches long are taken and sent to market by shrimp trawlers in the Humber. On the Lancashire coast Mr. Dawson finds similar facts with regard to soles. Large numbers of soles are taken in the district much under the size which should be taken, but few under 4 inches have been observed. In trials with the shrimp trawl Mr. Dawson constantly took small soles and plaice in such proportions as 4 to 900, 136 to 520, 8 to 720, and so on. The whiting were even more numerous than the plaice. On the west coast of Ireland Mr. Holt found only three soles under 10 inches out of a total of 529. The history of the early stages of the sole is by no means cleared up. The probable conclusion is that the young are not principally aggregated at particular depths or in particular regions, and few have been taken in deep water because small-meshed trawls have been little worked there. It is desirable, however, to protect the young which do occur in shallow water, and I think the best way would be not to allow them to be taken in territorial waters. As in the case of the plaice, it would be possible to compel the men to return all soles caught by inshore fishing alive to the water. It has been urged that it would not be practically easy to discriminate between fish caught in territorial waters and others. But it would be sufficient to inflict penalties for taking certain fish in territorial waters, without interfering with market, landing, or sale. In places where the fish were exceedingly abundant all kinds of fishing could be prohibited.

Turbot.

Hitherto I have only examined seven turbot, and these were the smallest I could obtain ; none were under 12 inches, and all were landed by deep sea trawlers. Three were mature males, the smallest 13 inches long ; there were no immature males. Three were immature females, the largest 17 inches long. The smallest mature female was 19 inches long. These results, so far as they go, indicate that there is no difference between the south-west coast and the North Sea with regard to this fish. Mr. Holt says the prohibition of turbot

under 12 inches would not prevent the fishing in the eastern grounds in the North Sea, where a large number of immature turbot are taken and brought to market. There is no great destruction of turbot under 12 inches, saleable or unsaleable, anywhere; but some are taken in inshore waters, &c., and it would be advisable to compel the men to return these to the sea alive. What has been said of the distribution of soles and measures for their protection applies also to turbot.

Brill.

I have examined eight brill, none under 12 inches, and all from deep sea trawlers, the smallest I could procure. There were no immature males and no immature females. The smallest mature female was 16 inches long. Immature brill are not taken, according to Mr. Holt, on the eastern grounds in the North Sea.

North Sea Investigations.

(*Continued.*)

By

Ernest W. L. Holt,

Naturalist on Staff in Charge of Investigations.

Introductory.

I have again so many acknowledgments to make for help received that it would be invidious to select names, whilst to enumerate all would unduly trespass on the space allotted to me.

The work, as before, has been carried on at the Marine Fisheries Society's Laboratory at Cleethorpes.

I. On the Relation of Size to Sexual Maturity in Round Fish.

Since the flat fishes appeared to be of more immediate importance, and time did not suffice for the thorough examination of both forms, I have deferred to deal with the round fishes until the present spawning season. Up to the time of writing only cod and haddock have been spawning, and neither species has ceased to do so. My records are therefore incomplete, even for these two forms, and especially for the last named, owing to the difficulty which has been experienced in procuring specimens from which the viscera have not been removed. Sufficient information, however, has been gained to justify the proposition of provisional size-limits, which will be useful in considering the statistics given below (p. 81) as to the destruc-

tion of undersized fish. For this purpose the observations of Dr. Fulton, who has now (Rep. S. F. B., 1892) enhanced the value of his former records by adding particulars as to sex, are of great assistance, since the conditions of the area from which his information was derived are, in great measure, identical with those of the parts of the North Sea with which I am here dealing.

The standards of maturity which I have proposed below are founded on the same basis as those put forward in the case of flat-fish. It seems preferable to deal with the methods of distinguishing the different conditions when the inquiry is more complete, but, of course, it may be taken that, *exceptis excipiendis*, what is true of one group of Teleosteans applies, in great measure, to others.

Cod (*Gadus morrhua*).

Provisional size-limit, 25 inches.

Examined during the spawning season.

Length.	MALES.				FEMALES.			
	No. examined.	Ripe or recently spent.	Approaching ripeness.	Immature.	No. examined.	Ripe or recently spent.	Approaching ripeness.	Immature.
At 12 inches	1	0	0	1	1	0	0	1
„ 14 „	2	0	0	2	2	0	0	2
„ 16 „	1	0	0	1	1	0	0	1
„ 18 „	5	0	0	5	5	0	0	5
„ 20 „	9	0	0	9	8	0	0	8
„ 22 „	16	1	0	15	17	0	1*	16
„ 24 „	18	1	1	16	14	0	0	14
„ 26 „	30	8	1	21	22	3†	2	17
„ 28 „	43	10	9	24	37	0	15	22
„ 30 „	32	6	16	10	31	2	9	20
„ 32 „	27	12	11	4	29	2	22	5
„ 34 „	15	5	9	1	17	3	13	1‡
„ 36 „	2	0	2	0	2	0	2	0

Some larger and smaller fish examined were all mature and immature respectively. On account of the large size of this fish, I have used divisions of two inches instead of one inch as in smaller forms.

From consideration of the fish obtained during the survey on the west coast of Ireland, I expressed the opinion that the limit for the female should be about 26 or 27 inches. The above table seems to show that such a limit would not be too high for the North Sea; all the fish, however, were caught on the hook, and gravid females,

* Three parts ripe: exact length 22¾ inches.

† Smallest ripe fish: 26½ inches.

‡ Largest immature fish: 35 inches.

though in this respect the species before us is less particular than some others, are known not to take a bait very readily. Moreover a good part of them are inshore fish, and on this coast the cod appears to spawn chiefly off shore. Hence it may be that the percentage of immature indicated by the table is somewhat too high to be applicable to the whole species. My inquiries are not yet complete, and I have therefore chosen a provisional limit which is very unlikely to have to be lowered.

It appears from Fulton's observations (Rep. S. F. B., 1892, Tab. v, p. 239*a*) that on the east coast of Scotland the female may be nearly mature at 21 inches, and this, no doubt, occurs in exceptional cases in other parts of the North Sea. My own results show very little difference between males and females in the size at which maturity is reached, which is the less remarkable since the two sexes do not greatly differ in size ; indeed, according to Fulton (op. cit., 1890, p. 247), the male is the larger fish of the two. The same authority, however, found the females to be the most numerous, and such is my own experience as regards specimens of all sizes. It is, therefore, rather singular that my table, which includes all the fish of the given sizes which I could procure here, shows an almost exact equality of number. The manner in which they were caught, which has a tendency, as I have mentioned, to be less efficacious in the case of gravid females, may partly explain the phenomenon so far as it is apparent in the case of the larger sizes in the table.

Haddock (*Gadus æglefinus*).

Provisional size-limit, 13 inches.

It appears from the limited number which I have as yet examined that the average size at which the female begins to spawn is about 13 or 14 inches. The largest immature and the smallest nearly mature examples of this sex measured 16 and 11 inches respectively, and the smallest fully mature specimen 15 inches. The male seems to mature at a somewhat smaller size, viz. about 11 inches ; all males of less than 10 inches were immature, and in fish of less than 9 inches it was very difficult to find the testes at all. All of more than 12 inches were mature or nearly so. Fulton's table (loc. cit.) appears to indicate a very similar experience as to facts, and it is evident that the pre-eminence in size which this authority ascribes to the male is no bar to the latter attaining maturity at a smaller size than the female. If we assume that rate of growth is proportional to size, it would seem to follow that the duration of reproductive life must in this case be greatest in the male. That the same difference in attaining maturity is less apparent in the cod is

probably explained by the greater advantage in size which Fulton's figures indicate for the male in that species: the male haddock being only very slightly larger than its mate, and having a longer reproductive life, the difference in the size at which the sexes spawn is more marked than in the cod, in which species the male, also fertile for the longer period, has a more noticeable advantage in size over the female.

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

I propose to resume this subject at the point at which I left it in the last number of the Journal, and to arrange my remarks under the same headings.

Beam-trawling by Large Vessels.

That the destruction of small fish in this area is far greater in the summer than in the winter months is a fact which is probably sufficiently familiar to most readers of this Journal; the explanation being that it is only at the former time that young flat-fish congregate on certain grounds, alluded to in the last number of the Journal, in sufficient numbers to attract many boats to the grounds. Nevertheless a certain amount of small flat-fish appeared to be destroyed at all seasons of the year, whilst the destruction of young round-fish by trawlers is, as I shall endeavour to show, greatest in the winter months. The different species will be dealt with separately.

Plaice.—We have seen that the number of boxes containing only small fish landed here from the beginning of April to the end of August reached a total of 10,119. If we examine the figures for the different months we find the destruction at its maximum in June, each succeeding month showing a sensible diminution. I was given to understand, by those who should be well qualified to impart information on this point, that very little fishing would be done on the eastern grounds after the end of June; but, as the event proved, this was far from being the case. My informants, I have no doubt, spoke from their experience in former years, so that it would appear that the grounds in question remained productive, or were fished, to a later period than usual. If, as I suppose, the latter solution is in part correct, it does not appear that we have much to hope from the effect of public opinion on the fishing community in general, though, as I have already said, there are honorable exceptions.

In September the diminution continued, the total number of boxes landed during that month being 1184, as against 1924 in August. To this number the small fleet on the Terschelling ground contributed

the largest number. I understand that the vessels ceased "fleeting" some time during this month, but some of them continued to work the same ground while "single boating." Only one steam trawler brought in small plaice—viz. 295 boxes in three trips.

In October the total falls suddenly to 295 boxes, of which 133 were contributed by a Hamburg steam trawler, fishing to and from Grimsby on account of the cholera at home. Before this the German steam-vessels do not seem to have molested the small plaice much. I do not know whence the bulk of the small fish caught this month was derived, except that part, and I believe a large part, came from the Terschelling ground, where the very minute fish are not found. Examination of the catches brought in from this ground during the whole of the season failed to reveal any noticeable increase in size, and since we know that individual fish grow rather rapidly, the inference is that there is a constant succession, the fish passing from shallow to deeper water as they grow larger.

October is the last month (for 1892) of the small plaice fishery, and, indeed, it may be said that the season was practically over in September. In November and December no boxes containing only small fish were observed in the market.

About October a migration of fine plaice to the grounds lying off the "Holman" (Hantsholm) lighthouse is always expected, and occurred in 1892 as usual. In the same neighbourhood in the summer only small fish can now be obtained, and these rather closer inshore than the fine autumn fish; but, as I have been told by many old fishermen, all the grounds north of the Horn Reef formerly yielded fine fish in the summer, without any very small ones; thus forming a contrast to the more southern grounds along the east coast, where small fish seem always to have abounded, though plenty of fine examples are said to have been also obtainable. In fact, my information goes to the effect that the wholesale destruction of small fish on these grounds had been going on every summer for many years (ever since about 1830, when British trawling vessels seem first to have taken to fishing the Dutch grounds) before it attracted public attention. It escaped notice for this reason,—that as long as the supply of fine fish held out, the small ones, which were at least as numerous as they are now, were shovelled overboard, and thus never made their appearance in the market. The same thing is going on at the present day, only the items of the catch which are too small for the present market are indeed minute.

In January, 1893, twenty-one boxes, and in February forty-seven boxes of small plaice were observed in the market, but of these a considerable proportion were not derived from Grimsby boats. The

fish had been culled out from large consignments of plaice sent by rail from Lowestoft, but I could not discover what were the proportions of large and small in the whole consignment, nor was it possible to trace their origin any further than the port at which they were landed. The trawlers from Yarmouth, Lowestoft, Barking, &c., usually fish to the westward of the Terschelling ground during the winter, but I have no knowledge as to the quality of the fish caught there. Early in March a Grimsby steam trawler visited the Dutch and German coasts, but brought in no small plaice. About the middle of the same month two vessels visited the same or adjacent grounds and landed moderate catches of plaice, mostly answering to the market description of "half-fish," *i. e.* short of the biological standard of maturity, but too large to be classified in this connection as small. Thus it would appear that the "body" of small fish is not yet on the eastern trawling-grounds, but, if last year's experience be repeated, they may be expected to make their appearance there early in April.

Whilst enumerating the quantities of small plaice landed during the different months of the year it may be as well to give the quantities of larger fish landed at the same time. This cannot be done with absolute accuracy, as the only possible way of recovering the total quantity is by accepting the returns furnished by the Board of Trade statisticians. I found it impossible last year to take account of all fish, even of any one important species, landed at the pontoon; and the method adopted by the statistician, who bases his estimate mainly on information furnished by the railway company as to the amount despatched on their line, depends for its accuracy on the correctness of the deductions made for weight of packing material, additions for difference in condition of fish, home consumption, &c.

Now the fish arrives at the pontoon either whole ("live") or with the viscera removed. It may leave Grimsby in almost any condition. It may be sent off *in statu quo*, or may be cleaned, beheaded, boned; only a small part of it may be worth transmission. It may be wet or dried, pickled or smoked; it may come in as a codling, and go out as a "Finnon" haddock!—be caught as the head of Anarrhichas and tail of Lophius, and go out as the masseter muscles of Raia! The last instance, however, would not affect the correctness of the return, as these three kinds are not thought by the Board of Trade authorities to be worthy of discrimination, but go, in company with lemon soles, witches, conger-eels, dabs, &c., to swell the column for "All other except shellfish."

It will be admitted that the circumstances noticed above furnish rich opportunities of error, and in my opinion the statisticians deserve

the greatest credit for the large degree of accuracy which I believe to exist in their returns.

These returns deal with values and weights only, but the latter can easily be converted into boxes, the term of which I have hitherto made use in these reports. Nine stone may be taken as the average weight of fish in a box packed in the ordinary manner for sale in the market, that is with the fish piled to some height above the top of the box. A box which is only filled up to the top is spoken of as a "level." No other measures are now in use in the Grimsby market, turbot, brill, and halibut, and large round-fish being sold either separately, or in the rows in which they are laid out when first landed. Inferior fish, such as gurnards, are generally sold in heaps.

The subjoined table gives the figures arrived at by accepting the Board of Trade totals expressed in the first column. They are intended here to comprise only North Sea fish.

1892. Month.	1. Total weight. cwt.	2. Total number of boxes.	3. Boxes containing only "small" fish.	4. Other boxes.	5. Percentage of total formed by No. 3.
April . .	11,000	9,777	1,836	7,941	18
May . . .	12,000	10,666	830	9,836	7
*June . .	10,400	9,244	3,470	5,774	38
*July . . .	17,000	15,111	2,059	13,052	13
*August . .	10,600	9,422	1,924	7,498	24
September .	15,000	13,333	1,184	12,149	8
October . .	20,000	17,777	295	17,482	1

It will be noticed on consulting columns 3 and 5 that the gradual diminution of the actual numbers of boxes of "small" is not accompanied by a similarly regular decline in the same item when converted into percentages of the total. This is, I think, to some extent due to my having deducted too little for the Iceland fishery in July and August; but there must also be other causes, of which I have no knowledge. Apart from abundance or scarcity of fish there must always be some irregularity in the supply, as individual boats are constantly shifting from the pursuit of one species to that of another, according to the luck or inclination of the skippers.

It must be borne in mind that the boxes of "small" are very far from exhausting the number of undersized fish brought to market.

* In June, July, and August I have deducted 1000 cwt. from the Board of Trade totals as representing a very moderate estimate of 800 boxes, in this case packed so as to contain 10 st., derived from the Iceland grounds, and therefore not products of the North Sea Fishery proper.

In fact, it is my experience that, taking one box with another, at least a third of the fish contained in the boxes enumerated in column 4 fail to reach the proposed biological standard of maturity, and, indeed, we should still be in no danger of exaggeration if we were to assume that that proportion is actually sexually immature. I am here speaking of a proportion of numbers, which is a very different matter from one of weight or bulk, such as is given in the case of boxes of "small" in column 5.

We might certainly arrive approximately at the proportional number of small fish derived from all sources by converting boxes into numbers contained therein, but I have to confess that my confidence in the accuracy of column 1 is not such as to tempt me to elaborate further on that basis. Certain items of work, which during last season engrossed a great deal of time, having now been dealt with, it is my intention during the forthcoming small-fish season to take steps for obtaining statistical information which shall not be dependent for its accuracy on the correctness of any estimate whatsoever.

Turbot.—So long as boats continued to work the eastern grounds for small plaice last year, they continued to bring in with them a large proportion of immature turbot, not essentially differing from that noticed for the earlier months in the last number of the Journal (p. 383). As soon as the eastern grounds were abandoned immature turbot ceased to be a conspicuous feature in the market. It is not, however, clear that the small turbot leave the eastern grounds at the same time as the plaice, or, if they do so, it would appear that they may return earlier. Thus a smack returned on the 3rd March, 1893, from the Dutch and German grounds, bringing fifty-five turbot, of which thirty-five were immature, but no plaice. On the other hand, another smack, also from "across," brought in a good lot of small plaice, but no considerable number of small turbot.

It may be not uninteresting to compare the price of turbot now with that which could be obtained some twenty-five years ago.

From an account belonging to my friend Mr. G. L. Alward I find that in April, 1867, two boxes of turbot were sold in Billingsgate Market for £2. On one day in March of the present year the price in Grimsby Market rose as high as 2*s.* per lb. We may reckon about 9 st. of fish to a box, which at 2*s.* per lb. would make the price £25 4*s.* for the two boxes. The comparison is not altogether a fair one, as Mr. Alward tells me that prices were extraordinarily low on the occasion mentioned even for that period ;* whereas 2*s.* per lb. is the highest price, at first hand, of which I have heard even in Lent in recent years. To what extent the difference is explicable by decrease

* Nevertheless large turbot were often sold for only 1*s.* each.

though it must not be imagined that the grounds they fish are within the three-mile limit or anywhere near it. Such vessels are also known as "Cleethorpers," the name conveying, as I gather, a delicate insinuation on the part of more adventurous spirits that they never get beyond the mouth of the Humber. Fish of all sorts having become very scarce during the winter, it appears that these vessels, finding a fair supply of codling at and near a ground known as the "Yorkshire Hole," continued to fish there regularly in default

of fish and increase of demand respectively it is hard to say, but surely the former factor is not the least significant in the case.

Soles.—Immature soles have not been a conspicuous feature amongst the catch of large trawling vessels belonging to this port at any time since I have been at Grimsby, but on the 21st February of the present year a consignment of soles from Lowestoft included about 200 pairs, measuring from $6\frac{3}{4}$ to $7\frac{3}{4}$ inches. On the following day a similar consignment was also received in the market. I have no actual knowledge as to where or how these fish were caught, but am informed that they were most probably taken by Lowestoft boats off the Hook of Holland, which appears to be the earliest ground for soles on that coast, or near the English coast.

Cod.—Local custom divides the individuals of this species into four sizes. Up to about 20 inches they are "codling," thereafter they rank as "sprags," until at about 30 inches the dignity of "half-cod" is attained. Larger fish are spoken of simply as cod. A sprag is therefore on the borderland of sexual maturity, a condition of which all codling fall short.

My own experience on the North Sea grounds, and the records of a great number of hauls kept for me by my friends amongst the trawling fraternity, point to the fact that rather more immature than mature fish are caught by trawling, but that the number during most months of the year and on most grounds is not such as to call for special attention. On occasions, when a shoal of herring or some less patent cause has attracted large cod to a particular ground, good takes are often made; but, as a general rule, the species appears to be, in point of numbers, rather an insignificant product of the fishery. Nevertheless, having regard to the high price commanded by fish of fair size, and their relative and, as is asserted, increasing scarcity, it is obvious that the destruction of young and comparatively worthless examples is a matter to be exceedingly regretted, though it may not be easy to suggest a remedy. The most notable instance of their destruction which has come under my own observation occurred on the Great Fisher Bank in July. A great part of this important ground is covered by a very dense growth of *Flustra foliacea* (locally termed "scented" or "lemon weed"), and the net often brought up a cart-load or more of it. Very few large or even fair-sized codling were taken, but whenever the net came near the surface any number of minute examples, 2 to 4 inches long, would float out from among the Flustra, dead or dying, marking the wake of the ship with the gleam of their silvery abdomens. Others would be found when the net was got in, and though it was of course a difficult matter to count them, I should say that some hundreds must have perished with each haul on the "weed"-covered part of the ground. It is

evident that a number of vessels working in this locality must effect a serious injury to the species, the smallest members of which appear to suffer sufficient persecution from a natural enemy, the long rough dab.

Observations of fish brought to market up to the end of the autumn of 1892 supported the conclusion derived from consideration of records kept at sea, viz. that no very considerable number of codling (apart from the very small examples which suffered in the way I have just indicated) were destroyed. A boat would bring in one or two boxes, or there would be a certain number of codling mixed up with the haddock, but I never noticed any large quantity. In the winter, however, there was a marked change, and codling began to be quite a conspicuous feature in the market. A number of experienced men have drawn my attention to this as something quite unprecedented, though I understand it is not unusual for fish of this sort to be rather more abundant in winter than at other times of the year.

The number of boxes landed, from the time at which they first became noticeable, is as follows :

1892	November (last week only)	180 boxes.
	December	825 „
1893	January	1605 „
	February	1763 „
	March 1st to 20th	896 „
	Total	4469 „

There are about 100 fish in a box, so that the above figures represent over 400,000 fish. They are from 12 to 20 inches in length, but an odd fish amongst several boxes may reach a length of 25 inches or a little more. Thus all but an utterly insignificant proportion are sexually immature. A box fetches about 5*s.* 6*d.*, more or less, according to the state of the market, and is therefore worth not very much more than one full-grown fish in good condition.

By far the greater number of these fish were caught by a firm of steam trawlers, which, from their habit of making short trips and never going very far off port, are locally termed " inshore " boats, though it must not be imagined that the grounds they fish are within the three-mile limit or anywhere near it. Such vessels are also known as " Cleethorpers," the name conveying, as I gather, a delicate insinuation on the part of more adventurous spirits that they never get beyond the mouth of the Humber. Fish of all sorts having become very scarce during the winter, it appears that these vessels, finding a fair supply of codling at and near a ground known as the " Yorkshire Hole," continued to fish there regularly in default

of prospects of more legitimate success elsewhere. The pecuniary results seem to have been sufficient to attract other vessels, steam and sailing, to the same grounds, which thus furnished by far the greater part of the codling landed up to the last week of February. The greatest number landed by any vessel in a single trip was 122 boxes. A "voyage" of 23 boxes from the Great Fisher Bank at the end of January, one of 48 from "Botney Gut," and two of 78 and 104 from the "N. N. E. Hole" in February, assisted to swell the total, but the two last grounds are not far from the Yorkshire Hole. Of course the contributions from all other grounds, however insignificant individually, form collectively a sensible quantity.

Towards the end of February the chief agents in this matter shifted to the (Flamborough) "Head ground," attracted by good catches of plaice which were being made there. A diminution in the number landed has therefore been noticed, though at first codling were rather abundant on that ground also, one vessel bringing in a "voyage" of 40 boxes. They have since become less abundant, 13 boxes being the average catch of six steam trawlers at the end of the period with which my records deal. There is also, I think, a steady diminution on other grounds, though a good number still continue to be brought in. The fish appear to be scattering, though the decrease may be due in part to an involuntary migration to Grimsby. At any rate, there can be no doubt that the injury inflicted this winter on the cod fishery in general is out of all proportion to the profit derived.

Haddock.—North Sea haddock are divided by Grimsby fishermen into large and small, the limit between the two lying at about twelve inches. They are always cleaned at sea, and the larger fish become either "kits," *i. e.* suitable for packing in tubs of the same name, or "gibbers," according to the method in which the offal is removed. In "gibbing" the viscera are withdrawn through an incision along the abdomen, which does not extend as far forward as the isthmus, and therefore spoils the external appearance less than the ordinary process to which "kit" and small fish are subjected. Whilst the larger fish are mostly cured, the ultimate destiny of the small is the fried-fish shop. Consequently, whilst boxes of the former may contain a considerable admixture of sizes, the latter are always packed separately. On this account I have found it convenient to adopt the local standard of size in recording the quantity of undersized fish landed. Of course a certain number of immature fish, mixed up with others in boxes of "kit," are excluded, but I do not see that it is possible to recover the exact or even approximate numbers. It must therefore be remembered that while all the fish included in the figures given below are short of the provisional

biological standard, in point of fact less than 13 inches in length, the figures are not intended to be inclusive of all sexually immature fish.

Being occupied with other matters, I made no attempt to record the quantity landed during the earlier part of 1892, but noticed that the quantity decreased towards the summer and began to increase again in the autumn. My statistical inquiries were commenced towards the end of September.

The figures are as follows :

1892	September (last week only)	366 boxes.
	October	542 „
	November	1335 „
	December	1440 „
1893	January	1416 „
	February	1471 „
	March 1st to 20th	1551 „

As a rule, no considerable number of haddock in the market are of less than ten inches, the limit advocated by Dr. Fulton, but once or twice during the summer tug-boats not belonging to the regular fishing fleet brought in a good many smaller fish, mixed up with small whitings, gurnards, lemon soles, and dabs. I am not sure where they were caught, but was given to understand that they were probably from some of the "roughs" off the Yorkshire coast. Mr. Cunningham, in the last number of this Journal (p. 359), in estimating the age of some of these specimens, places the limit between those of one and two years old at 9 inches.

My own experience at sea, confined so far as haddock grounds are concerned to the spring and summer, is that many more mature than immature fish are trawled during that period, and the bulk of the evidence afforded by records kept for me by trawling skippers supports the same conclusion, and extends it to all seasons of the year. Still in several hauls, in each case on some part of the Dogger Bank, more small than large fish seem to have been caught. I have never trawled many haddock so small as to be unmarketable, but have got a few very small ones entangled amongst Flustra. On this occasion no sizes intermediate between $3\frac{1}{2}$ and 10 inches were represented. From various grounds I have occasionally received a number of very small fish, specially saved for me, but usually when these were caught there were no large fish. Similarly, it is the common experience of liners on the east coast of Scotland that the large and very small fish are not taken on the same ground at the same time.

We know that the haddock is gregarious to a greater extent even

than the cod, though our information as to its earlier life-history remains singularly meagre. Speaking generally, we may say that the shoals containing large fish—in fact, the only shoals of which we have definite knowledge—contain also fish of all sizes that are marketable, and some which are usually considered too small to be included in this definition; but the very small fish live apart. The explanation seems to be that young fish do not join the shoals until they have attained such a size as enables them to prey on similar organisms, and to keep up with the frequent and very rapid migrations of their larger brethren. Such size or condition appears to be reached at about 8 to 10 inches. Now, if the young haddock attains a length of about 6 to 9 inches in the first year of its life, it is evident that, as this fish is an early spawner, there will be a considerable accession of young fish to the shoals in the winter months. The period during which such increase would be noticeable might be expected to be somewhat more extended than that during which the species spawns, since it must be some time before these recruits attain a size which places them outside the category of "small" haddock. It remains to be seen whether a continuation of statistical inquiries will confirm the general impression, and my own, that small fish are more plentiful in the winter and early spring than at other times of the year; but if such prove to be the case, the above speculations as to the cause may be not devoid of interest.

Shrimp-trawling.

It will be remembered that in my last report I alluded to a bye-law of the North-eastern Sea Fisheries District Committee which prohibited the use of shrimp-trawls in the Humber, and in certain other inshore waters with which I have no acquaintance, between the beginning of April and the end of September, and altogether prohibited the use of fish-trawls in the same waters. I also found it necessary, owing to the very general disregard of such part of the regulation as referred to fish-trawls, and the difficulty of discriminating in the market between Humber fish taken by the different kinds of trawl, to include all such fish in one category.

Since the report was published I have had an opportunity of obtaining a more intimate acquaintance with the conditions of the industry. Complaints were numerous on the part of those dependent, wholly or in part, on the Humber fisheries, that the season closed by the bye-law was too long, and a petition was presented to the Committee, praying that shrimp-trawling might be allowed from the beginning of March to the end of October; in other words, that the open season might be extended by a month at each end.

With a view to satisfy themselves as to the wisdom of granting such concession, the Committee asked me to carry out a series of investigations on the subject, for which purpose Mr. J. W. Woodall, a member of the Committee, and one whose interest in the welfare of our fisheries as well as in marine biology for its own sake is too widely known to need more than a passing reference here, offered the use of his steam yacht, the "Vallota," R.Y.Y.C., for a month. The Council of this Association accorded the necessary permission, and I propose here to give a brief account of the work done and the conclusions arrived at.

The "Vallota" draws only 4 feet of water, and is therefore eminently suited for work in a shallow estuary, such as the Humber. The gear we used consisted of a professional shrimp- or prawn-trawl, beam 13 feet, mesh $\frac{7}{8}$ inch "from knot to knot," or $\frac{7}{16}$ inch square, in cod end. No pockets. Hemp ground-rope $9\frac{3}{4}$ inches in circumference. False bellies of leather, cork, and coarse netting. We also carried a small fish-trawl of ordinary pattern, $17\frac{1}{2}$ feet beam, and a naturalist's trawl, 9 feet beam, of sprat-mesh lined with mosquito net, and fitted with a heavily chained ground-rope.

The services of a professional shrimp- and prawn-trawler were secured to pilot the yacht, point out the different grounds, and work the gear.

The chief object of the investigations was to arrive at a knowledge of the amount of destruction of young fish of valuable kinds which would be likely to ensue from the regular working of the grounds by shrimp- and prawn-trawlers during the season then closed by the Committee's bye-law, or during such part of it as was included in the time when the investigations were carried on, viz. from October 19th to November 17th. For this purpose a number of hauls were made on all the grounds with the professional gear, and the results accurately recorded, the *modus operandi* being as far as possible assimilated to that of the small sailing-boats engaged in the industry. The fish-trawl was used on the grounds affected by sole-trawlers, so as to ascertain the quantity and sizes of fish present during the current season, and also in various parts of the river not usually accessible to sailing-boats, partly with a view to obtaining all possible information as to the distribution of fish in the river, and partly, in conjunction with cod ends of different mesh, to test the relation between size and pattern of mesh and size of fish caught. As these operations do not intimately concern the subject under discussion, I shall not refer to them further in this place. The naturalist's trawl was used at the same time as the fish- and shrimp-trawls, in order to find out what fish or other organisms passed through the meshes or beneath the ground-rope of those engines.

Fishing-grounds.—The same boats and gear are employed for the capture of both shrimps (*Crangon vulgaris*) and prawns (*Pandalus annulicornis*), but as the latter are the more valuable, they receive by far the greatest share of attention.

Subjoined is a list of the grounds, with local names, and soundings at low water.

Prawn Grounds.

"Inside the Middle Sand" . . .	23 to 50 feet.
"Outside the Trinity Sand" . . .	30 to 70 „
(Clee) "Ness Channel" . . .	13 to 40 „
"Back of the (Clee) Ness" . . .	15 to 30 „
"Tetney"	24 to 30 „

Shrimp Grounds.

"Paull Middle" (Sand) . . .	8 to 16 feet.
"Sand Haile"	8 to 16 „

Shrimps are represented to some extent on all the grounds, but very few large prawns are present on the shrimp grounds.

Owing to the prevalence of wrecks and other obstructions, such as clay banks and accumulations of "ross" (Sabellaria), the grounds are very sharply defined, so that a sailing boat is absolutely dependent on favorable conditions of weather to allow her to work at all. Except at slack water, it is only possible for her to trawl with the tide, and it will be readily understood that it is not every day that the wind allows a sailing boat to keep her course drifting along a very narrow strip of ground. In the "Vallota," owing to her large size and comparatively high freeboard, it was difficult to go slow enough when wind and tide happened to be in the same direction. As a rule, however, we were fortunate in being able to work at the required speed, and, when the wind was abeam, an occasional use of the engines enabled us to keep our course in a manner impossible to a sailing vessel, while at slack water we could, of course, choose our own direction.

Method of working gear.—To avoid damage to the net professional shrimp-trawlers attach one buoy by a long line to the cod end, and another to the end of the warp, which is made fast to the boat by a stop of small cord. Thus, if any obstruction is met with, the stop will break before much damage is done to the net, which can afterwards be lifted by whichever end is most convenient.

Capture of fish.—In dealing with the results it will be necessary to consider the shrimping and prawning grounds separately, since, as might be expected from the difference in soundings, they differ

considerably from each other in relation to the capture of small fish. Further, the different prawning grounds are not all alike in this respect.

The fish of any known value which we met with consisted of sole (*Solea vulgaris*), plaice, common dab, lemon sole, flounder, cod, whiting, whiting-pout, sprats, thornback, and spotted ray (*Raia maculata*). Besides these we took a number of unmarketable kinds, viz. "hard-heads" (*Cottus scorpius*), "bull-routs" (*Agonus cataphractus*), "gobblers" (*Liparis Montagui*), gunnels (*Centronotus gunnellus*), viviparous blennies (*Zoarces viviparus*), "eel-pouts" (*Motella mustela*), "Williams" or "sweet fish" (*Gobius minutus*), a few *Raninus raniceps*, and one long rough dab: the vernacular names in inverted commas are those in local use; some species have no local designation.

I have never come across a solenette (*Solea lutea*) in the Humber, and am pretty certain that the species does not exist there. Hence the confusion which is so abundantly evident in the mind of the fisherman and amateur fishery expert wherever solenettes and young common soles are found together does not exist in this locality.

"Trinity" ground.—As this is the most important ground, especially at the season during which our operations were carried on, we devoted especial attention to it. In eleven hauls with the professional gear we always obtained a fair catch of prawns, considering the lateness of the season.

Only nine soles were taken, four hauls being blank so far as this species was concerned. The largest number taken in any one haul was two. The fish measured as follows: two less than 2 inches, two small, exact size not recorded, two at $5\frac{1}{2}$ inches, one at $9\frac{1}{2}$ inches, and one at $13\frac{1}{2}$ inches.

Early in October I had made the discovery that young lemon soles occur in the Humber in autumn, all previous information having induced a general belief amongst those interested in the matter that the early life of this form was passed in comparatively deep water, and consequently at some distance from land on most coasts. Only a few were taken on the occasion referred to, and it was therefore with the greatest interest that we found fresh specimens yielded by almost every haul on the ground now under consideration. The number was in no case large, sixteen being the most in one haul. Another yielded eleven, but no other more than seven. The smallest fish measured 2 inches in total length, and the usual size was from $2\frac{1}{2}$ to $3\frac{1}{2}$ inches; a few were taken at sizes ranging from that last mentioned up to $8\frac{1}{2}$ inches, and there was one specimen of 11 inches.

Plaice were very scarce; in the eleven hauls we only got eight fish, viz. five in one haul, one each in other three, and none in the remainder. Six of these fish measured from $5\frac{1}{2}$ to $9\frac{1}{2}$ inches, and

the others 14½ and 17½ inches respectively. I may add that this last is the only instance of the capture of a fair-sized plaice in the Humber that has come under my notice.

Common dabs were more numerous. They occurred in October in the first eight hauls, but were absent from the remaining three, which were made in November, but I do not know that we are justified in attaching much importance to this circumstance. The largest number taken in a haul was twenty, no other haul yielding more than seven. With the exception of one translucent metamorphosing example of ½ an inch, the smallest size taken was 1½ inches, the largest being 10½ inches. Taking 7 inches as a convenient limit for dividing large and small of this species, about two thirds of the fish caught must be included in the last category.

Small cod and whiting were always taken. The average of eight hauls (the exact number taken in the remainder was not recorded) was 79 of the former and 78 of the latter, but the two kinds did not occur with equal regularity. Thus the extreme numbers taken in single hauls were for cod, 15 and 179; and for whiting, 36 and 156. All sizes of cod from 2½ to 7 inches were present, but the majority were under 5 inches. A solitary example measured 21 inches. Whiting were from 3 to 7½ inches, but mostly less than 6 inches.

Except a small ray, and an inconsiderable number of sprats, no other fish of known value occurred on this ground.

All the kinds of unmarketable fish which I have mentioned above were represented, but Liparis predominated. Small Cotti and half-grown Agoni and Gobies were also abundant.

Besides the prawns, which exhibited a very deep red colour whenever we dropped into the 9-fathom hole near the lower end of the ground, a few shrimps were always taken. Other Invertebrates included a few sun-stars (*S. papposa*) and common star-fish, a few shore-crabs and common hermits, a good many swimmer-crabs (*P. holsatus*), masses of "ross" (*Sabellaria alveolata*), and a few whelks. A good many mussels would occur when we kept rather too close to the Trinity Sand. A little Delesseria was the only algoid noticed.

It appears from the above that, save for a sprinkling of lemon soles and an occasional irruption of common dabs, this ground is very little affected by flat-fish, small or large, at the time when our investigations were made. On the other hand, it is evident that young cod and whiting must be extensively trawled by prawners at that season, should the conditions of their distribution be alike in all years.

"*Middle Sand*" *ground.*—This is an important ground earlier in

the season, but, at the time we visited it, yielded very few prawns. Only three hauls were made there.

With the exception of lemon soles, which were not represented, the supply of flat-fish was much the same as on the last ground. Soles were only taken in one haul, viz. three from $2\frac{7}{8}$ to $6\frac{1}{8}$ inches. Plaice occurred also in only one haul, viz. four at from $2\frac{1}{4}$ to $4\frac{1}{4}$ inches. Common dabs were absent from one haul; in another twenty-seven were taken, the sizes ranging from $1\frac{1}{4}$ to $8\frac{1}{2}$ inches, but all but four were less than 7 inches. The number taken in the remaining haul is not recorded; it was not considerable.

Small cod and whiting were about as numerous as on the last ground. Of unmarketable fish, Liparis were less numerous, as might be expected from the comparative scarcity of their prey, the prawns. Other conditions were much the same as on the Trinity ground.

"*Ness Channel*" *ground.*—This ground seems to rank next to the two foregoing in importance, but yielded only very moderate catches of prawns when worked by the "Vallota." Five hauls were made, but of these one resulted in a foul net, and in two others we came fast. The ground is very intricate, and can only be worked in security in clear weather, as the marks are not easily seen if it is at all hazy.

Flat-fish were poorly represented. No very small soles were taken, the only two captured measuring $9\frac{1}{2}$ and 10 inches respectively. Plaice were not more numerous than on the Trinity ground, and ranged in size from 5 to $9\frac{1}{2}$ inches. Dabs were scarcer than on any other ground, only five from 2 to $7\frac{1}{2}$ inches being taken. Lemon soles occurred in three hauls, five being the largest number taken, the sizes ranging from $2\frac{1}{2}$ to $7\frac{3}{4}$ inches.

Round-fish, viz. young cod and whiting, were numerous in two hauls, but very scarce on the occasions when the net came fast. Probably some escaped, though little else seemed to have been lost.

Of unmarketable fish Cottus, Agonus, and Liparis were the most abundant. A few edible crabs and a good many shrimps were taken.

"*Back of the Ness*" *ground.*—This is worked by professional trawlers either in one haul or two. We tried it in both ways, making in all six hauls with the professional gear. A moderate catch of prawns was always obtained, and shrimps were more plentiful than on the grounds that have already been discussed. It appeared that most prawns were yielded by the upper half, the converse holding good with regard to shrimps.

There were very few soles on any part of the ground, four being the largest number taken in any haul. The sizes were from $2\frac{3}{4}$ to $8\frac{3}{4}$ inches. Lemon soles were present in only three hauls, one of which, however, yielded 12 fish, of the usual size. I could not

find that they specially affected any particular part of the ground. Plaice and dabs, on the contrary, appeared to be much more abundant on the lower half. Of the former, 35 was the largest number taken in a haul on the whole ground; on the upper half 5, and on the lower half 27 were taken in two consecutive hauls. The same hauls yielded 6 and 38 dabs respectively, whilst 80 were taken in one haul over the whole ground. The sizes of the plaice were from $1\frac{1}{4}$ to $10\frac{3}{4}$ inches, most being less than 6 inches, whilst the dabs measured from 1 to $8\frac{1}{2}$ inches, the great majority being less than 7 inches. Small cod and whiting were as plentiful as on other grounds, but the bulk of them appeared to be derived from the lower half. Two whiting-pout, 8 inches in length, were taken on this ground.

Unmarketable fish, including Cottus, Agonus, Liparis, Centronotus, and Gobius, occurred in variable numbers, but it was not noted that they were more plentiful on one part of the ground than another.

A good many sun-stars, hermits, shore and swimmer crabs were taken. Sabellaria was very abundant towards the upper end of the ground. Hydroids were represented by *Thuiaria thuia, Antennularia ramosa, Halecium* sp., &c.

"Tetney" ground.—During the period of our investigations this ground was very effectively closed to trawling by the prevalence of whelkers' gear, the buoys on which are so arranged as to watch only at certain states of tide. Consequently we were unable to use the professional shrimp-trawl there. Early in October, however, Mr. Woodall having kindly lent his yacht for some work in connection with this Society's mesh investigations, several hauls were made on the prawn ground with the naturalist's trawl used to check the results obtained with the fish-trawls.

The take of prawns varied, but was never very large; but of course it is not possible to judge from such a net the results likely to be yielded by one specially designed for the capture of this species.

Small soles were rather abundant, as many as eleven being taken in one haul, though usually the number was less. A few large fish were also present on the ground, but were caught only in the fish-trawl. Very few lemon soles were taken, this form apparently preferring the deeper part of the river, or it may be that the immigration was only just commencing. There were a great many small dabs, over 300 being taken in an hour's haul on one occasion. Twenty-eight small plaice were caught at the same time, but once, when we went rather too close inshore to catch many prawns, we took over 200 small plaice. Generally there were a few small flounders, and once we got a "chicken" turbot, 13 inches in length. Small whiting were as numerous as on the other grounds later in the season, but cod were comparatively scarce, as, indeed, at the end of

September and beginning of October, they proved to be in all parts of the river which we visited.

We sometimes took enormous numbers of half-grown Agonus and Centronotus, while Cottus, Liparis, and Gobius were always fairly plentiful. *Callionymus lyra* ("dragon"), a species not observed on other grounds, occurred pretty often, *Trachinus vipera* less frequently.

The ground includes the site of the old Tetney native oyster bed, but whilst we always got a lot of shells we only once obtained a living native, probably well-nigh the last survivor of its race. Edible crabs were caught now and then, and there was always a large assortment of shore, hermit, and swimmer crabs, and sometimes a few *Hyas araneus*. *Solaster papposa* was rather abundant.

"Paull Middle" ground.—Of the shrimping grounds this appears to be the most important, as the Paull boats often take a haul over it whilst dropping down with the ebb to the lower reaches of the river. The "Vallota" was only able to make two hauls there. The most productive yielded a quart of shrimps, the rest of the catch consisting of 35 plaice at $1\frac{7}{8}$ to 11 inches, 18 dabs at 3 to 8 inches, 250 small whiting, 8 small cod, and a few flounders, besides a few fish of less importance.

"Sand Haile" ground.—Here we made one haul of an hour's duration, and caught a quart of shrimps and a pint of prawns, some unmarketable fish, and the following :

One sole at 13 inches, and 12 at $3\frac{1}{2}$ to $8\frac{1}{2}$ inches ; 1 lemon sole at 6 inches ; 554 dabs at $1\frac{1}{4}$ to 4 inches, and 17 at $4\frac{1}{4}$ to $7\frac{1}{2}$ inches ; 6 plaice at 2 to $2\frac{1}{4}$ inches, 4 at 5 inches, and 59 at 7 to 13 inches ; 115 small cod ; 410 small whiting.

Summary of capture of fish.—It will be seen from the detailed statements given above that very few flat-fish are liable to be caught at the season under discussion on the "Trinity," "Middle Sand," and "Ness Channel" prawning grounds ; that the upper part of the "Back of the Ness" ground is also comparatively free from flat-fish, but that some quantity may occur on the lower half. It also appears that the most abundant species is the comparatively worthless common dab.

The "Tetney" prawning ground, however, yielded a good many flat-fish, though here again dabs were the chief sufferers ; but it must be remembered that this ground was worked with a trawl furnished with a narrow chained ground-rope, specially designed to pick up very small flat-fish, and, so far as I could judge, rather more efficacious for this purpose than the thick hemp rope of the professional shrimp-trawl.

It is, however, evident that great numbers of small cod and whiting are liable to be caught on all the prawning grounds.

Turning to the shrimping grounds, we find a moderate quantity of small flat-fish on Paull Middle, less than on Tetney, but considerably more than on the other prawn grounds; whilst of round-fish, cod are but poorly represented. On the Sand Haile we find a great quantity of flat-fish, very much reduced if we eliminate the dabs.

Destruction of fish.—Having thus dealt with the *capture* of fish on different grounds, it behoves us next to consider how many of them are thereby *destroyed.*

In the ordinary course of the industry, when the trawl comes on board the catch is shot into a box, or on to the deck, and as many as possible of the unsaleable products are picked out by hand and pitched overboard. In this way the Cottus, Liparis, Agonus, crabs, &c., are at once returned to the water, and being all hardy forms, are none the worse. I question very much whether it would not be wiser to destroy the Cottus and Liparis, as their appetite for prawns is inordinate, and they do not appear to subserve any function useful to the fisherman. Swimmer crabs, also, I am inclined to regard as deserving scant consideration. By the same process the whiting and cod, having no value at such a small size, are returned to the sea—to be out of the way, if for no more provident intent. Such flat-fish as are saleable are put aside, the remainder being thrown overboard, at least such as are large enough to attract attention.

The catch of prawns or shrimps, having thus been roughly cleared, is placed on the sieve and riddled over the side of the boat. In this way the smaller prawns and shrimps find their way back to the sea uninjured, and any flat-fish which have previously escaped detection also pass through the wires. The fisherman's object being to get the prawns ready for cooking as soon as possible, it is evident that no time will be lost in getting the unsaleable items of the catch out of the way. It remains to be seen whether the small fish of valuable kinds are in any way the worse for their temporary sojourn in the net and on deck.

No doubt the most delicate forms are the young whiting and cod, but I have found occasion to modify an opinion expressed in the last number of this Journal, that the former would not survive even if immediately returned. Both species are always full of life when they come on board (except such as may have been nipped by a shore or swimmer crab in the net, or gorged by a Cottus), but, if allowed to lie on the deck for any time, very soon become sickly and die. If, however, they are at once thrown overboard they swim away apparently little the worse. With a view to ascertaining the degree of vitality as far as possible, on several occasions the small whiting and cod were thrown into a tub of water instead of overboard, and examined at the end of an hour. The conditions might have been more

favorable, as the tub was small, and the water stagnant or only occasionally renewed. The percentage of dead at the end of the hour varied. On one occasion 24 cod and 34 whiting, being the total catch of these species, were placed in the tub. At the end of an hour 21 cod and all the whiting were alive and vigorous, two cod were sickly, and one was dead. The haul on this occasion yielded the usual quantity of prawns, crabs, and lumps of Sabellaria, &c., and I believe the favorable result of the experiment was simply due to the small number of fish, the capacity of the tub being insufficient for the respiration of larger numbers.

Another time the catch included 111 cod and 99 whiting, which were placed in the tub. At the end of an hour (an hour and a half before all were counted) the number of living was 99 cod and 63 whiting. There was some delay in getting the fish into the tub, in which, moreover, they were very much crowded. I do not think that, when fish are returned to the river in the ordinary way, the mortality is ever greater than in this last experiment, and probably it is much less. Other experiments support the conclusion that the cod are more hardy than the whiting, and it was noticed that fish of both species, which appeared moribund when first placed in the water, gradually recovered and ultimately seemed none the worse.

Of course the survival of a fish for an hour cannot be said to prove its absolute recovery, and I had no further means of testing it. The two miles' jolting in a cart involved in conveying fish from the dock to the Cleethorpes tanks proved very fatal to the young cod and whiting, and few of the latter survived it for any length of time. They seemed to suffer much more than the cod from any injury to the skin, such as must necessarily occur from the rostra of the prawns in the net, as well as from handling. Nevertheless, my own opinion, based on the facts which I have recapitulated, is that a large proportion of these returned at once to their natural surroundings escape any serious injury.

Soles and lemon soles, of whatever size, are seldom injured by capture in the shrimp-trawl. Lemon soles are especially hardy. A large number of those which were caught by the "Vallota" were placed in the Cleethorpes tanks. There was slight mortality amongst them for the first few days, probably more due to the journey than to any other cause, but the bulk of them, five months later, are still alive and apparently in excellent health. Soles which had been chafed, either in the net or in handling, ultimately died in the tanks, as at Plymouth (*teste* Mr. J. T. Cunningham, The Common Sole) ; but I do not think it follows that they die if returned to the sea, as soles which have evidently recovered from rather serious

injuries are sometimes trawled. Moreover the very small mesh of the shrimp-net appears to lessen the percentage of chafed fish, since it is in struggling to get through larger meshes that injuries to this species usually occur.

Plaice of all sizes suffer no injury from being caught in the shrimp-trawl, and may even be allowed to lie on the deck a considerable time without being any the worse. There has been very little mortality amongst a great many of all sizes which were placed in the Cleethorpes aquarium, whereas I have always experienced a difficulty in getting similar specimens, taken in the shove-net, to live. This may be due to the amount of mud and sand in suspension in the only water available for conveying shove-net specimens to the aquarium, or it may be that the buoy of the shrimp-trawl is beneficial in slightly lifting the cod end off the ground.

Flounders are about as hardy as plaice under similar circumstances.

Dabs, unlike plaice, will not survive a long exposure on deck, the very small specimens being particularly delicate. The mortality amongst those sent to Cleethorpes was at first considerable, though a good many survived. Still, if they are returned to the sea at once, they dart away apparently uninjured. This species appears even more susceptible to injuries arising from chafing than the sole.

Conclusions.—It appears to me that the facts I have set forth show that capture in a shrimp-trawl in the ordinary course of the industry is not essentially injurious to any considerable proportion of young fish of marketable species. If shrimp-trawlers bring to market some small plaice and soles which ought really to be returned to the sea, it is not easy to blame them as long as the same practice, as far as plaice are concerned, is carried on with perfect impunity on an infinitely larger scale by the larger boats which visit the eastern grounds. The remedy for this evil lies so evidently in the imposition of a size-limit applicable to all North Sea fisheries alike that the subject needs no discussion here. Moreover it is apparent that the bulk of the small flat-fish, which, for reasons explained at the time, I found it necessary to class as caught by shrimp-trawling, were in reality derived from the illegal use of fish-trawls.

I have made it, I hope, sufficiently evident that, except off Tetney, flat-fish are so exceedingly scarce on the prawning grounds that there is not even the risk of them being injured thereon.

I am not prepared to say that, in the case of so large a catch of small fish as has been enumerated from the Sand Haile shrimp-ground, some considerable number of small dabs and, to a less extent, plaice, might not have suffered, since to sort them out would

take a good time; but as a matter of fact the take on this occasion was so worthless that the fishermen, after picking out the few saleable fish, would, no doubt, have shot the remainder straight overboard. Indeed, both shrimping grounds might be said to be effectually closed, at the time we visited them, by their very unproductiveness.

It must be remembered, also, that whenever any number of small flat-fish occurred, the majority of them were always common dabs, and I would call attention to the opinion expressed by Fulton (Rep. S. F. B., 1890) that it is questionable whether any benefit is to be derived from protecting the young of this species, since it is never of great value, and is a most severe competitor with fish of greater value, *e. g.* soles and plaice, in the matter of food.

In any case it appeared to me that by confining the operation of the closure to the shrimp grounds and the Tetney prawn ground, enough would be done at that season of the year to practically eliminate the risk of destruction of immature flat-fish, whilst the legitimate conduct of the industry would be hardly at all affected thereby.

My recommendations to the Fisheries Committee, in reporting the results of the operations under their auspices, were accordingly made on the above lines, though it was expressly stated that they could only claim to hold good for the period during which the investigations were made. The Committee subsequently repealed their former bye-law, and substituted one which granted the extension of the open season prayed for in the petition to which I have alluded. The use of the shrimp-trawl is therefore now lawful in the waters with which the bye-law deals from the 1st March to the end of October. Though it has not appeared, from the results obtained during last March (1893), that either prawns or shrimps are to be had in sufficient numbers to make their pursuit profitable so early in the season, I have little doubt that the measure will be found on the whole satisfactory, once the enforcement of the existing prohibition against fish trawling shall have removed the imputation which the conduct of a few individuals now allows to rest on the whole fraternity.

For my own part, I have always advocated legislation which deals with the size of fish landed, so far as flat-fish are concerned, rather than with the kind of trawl in which they are caught. Since I am satisfied, from the whole of my experience of the Humber fisheries, that the absolute lack of mature fish in the river would preclude the existence of a legitimate plaice fishery, whilst flounders and dabs are neither sufficiently numerous nor valuable to attract pursuit by themselves, the imposition of a size limit would in effect limit the use of fish-trawls to a short period in the summer when there are some

mature soles in the river, if it did not abolish it altogether. This may seem, as it were, an academic discussion, since it is allowed that the same or nearly the same end is attained by either means; but the method I favour would be an effectual safeguard against the abuse of shrimp-trawls for catching small plaice on grounds where neither prawns nor shrimps are to be had. I have found such a practice to be quite feasible, and have no doubt it might be occasionally remunerative, but I must confess that I have no knowledge that the possessors of shrimp-trawls ever divert them from their legitimate prey.

Migrations and spawnings of shrimps and prawns.—Shrimps and prawns seem to arrive at about the same time, viz. the beginning of April, on those grounds in the Humber which they respectively frequent, but the time of arrival, as of departure, is said to vary according to the weather. My own experience is too short to enable me to offer any comments on this point.

The shrimp season for shove-nets usually closes about November, though in very open winters it is said to last longer. The quantity present on the sandy margin, so far as this can be gauged by the takes, is at all times subject to rather sudden variation, and becomes, I believe, especially variable after the end of September. Any diminution in the normal turbidity of the water, more readily perceived by those engaged in the industry than others, is regarded as prejudicial to good catches. The variation of the trawling grounds appears to be even greater than on the margin. Some few shrimps are found in all parts of the river throughout the year, but I do not know what becomes of the remainder in the winter. In digging for lugworms, in February, near high water mark I have found a shrimp, living but very torpid, some few inches below the surface of the sand, at a time when none were obtainable in the shove-net; but it would be unwarrantable to conjecture from this single instance that any considerable number take refuge in this manner during the winter months.

I have made no effort to ascertain the chief spawning period; here, as elsewhere, some shrimps are found carrying ova at all seasons.

Prawns are certainly most abundant in the Humber in summer. It is commonly asserted that a north-westerly gale in autumn has the effect of driving large numbers of them out of the river, and I had the opportunity of observing last year that the number obtainable certainly decreases after such weather. It is also said that once their bellies turn green they begin to leave the river. The green colour is that of the ova attached to the abdominal appendages. We found only a few with spawn at the beginning of October, but later in the same month and in the early part of November the

proportion in that condition increased rapidly, whilst there was a considerable decrease in the total number as compared with that obtainable on the same grounds earlier in the season. Our operations were not carried on late enough to show the final disappearance of the species, but I am given to understand that none, or hardly any, are to be found in the Humber in December. I am told, on authority which I have found reliable in other matters, that the prawns, on leaving the Humber, pass to the deeper grounds along the Yorkshire coast, and I know that the species is to be found there in the winter. It has a very wide vertical range, extending well beyond the 100-fathom line on our western coasts.

Recent literature.—The very interesting report of Professor Herdman "On the Lancashire Sea Fisheries Laboratory" (Liverpool, 1893) deals with shrimp-trawling in some detail. From certain statistics collected by Mr. Dawson it is evident that the number of small fish captured in that district by shrimp-trawlers is infinitely greater than anything we have to deal with here. Both shrimps and "shanks" (the local name for our prawn, *Pandalus annulicornis*) appear to be taken by trawlers, but it is not remarked whether there is any difference, as here, in the amount of fish taken in company with these two crustaceans. Mention is made of a prawn-net, presumably a trawl, devised by Mr. Dawson, in which a horizontal bar, 3 inches above the ground, is substituted for the ordinary ground-rope. This is an adaptation, probably an unconscious one, of a principle which has been employed for some years in the bottom tow-nets used at the St. Andrews Marine Laboratory.* The object is to catch prawns and pass over small flat-fish, and, according to Mr. Dawson, this object is achieved. It is also claimed that such a net picks up less débris than one of the ordinary pattern, and therefore fishes better on dirty ground. This is of some importance, as, although a very thick ground-rope is used by Humber fishermen to avoid the capture of "ross," they often catch a good deal, especially early in the season, before the winter's accumulations of the Sabellaria have been to some extent trawled flat. Still it is open to doubt whether a rigid bar would not be an additional difficulty in case of contact with a clay bank, and it would perhaps be better to replace this by a taut rope. In any case I do not see how such a contrivance would lessen the capture of young cod and whiting, which are the only important fish caught in any numbers on our prawn grounds.

* I understand that a similar contrivance has long been used for fishing rough grounds at Yarmouth.

Shore Fisheries.

Stake-netting.—This industry has again proved a failure at the Cleethorpes station. Nets were first set up there in January, but proved so unproductive that they were soon taken down again. Another trial in February was not more successful. At Humberstone, however, the nets did much better. They were first erected in the early part of January, and by the end of that month tolerable catches were obtained, 16 stone for one day being the largest amount of which I have a note. This was on the 28th of the month. Two days earlier only 5½ stone were found in the nets, after they had been fishing for nine days; there were also, according to my estimate, about two stone of young whiting, from 4 to 6 inches long, besides a few codling about 3½ inches long, and a certain number of plaice from 6 to 8 inches. As after this date the catch of sprats improved so much that it was worth while to lift the nets every day, or sometimes every tide, the number of young whiting became much less noticeable, though the total number destroyed in the same number of days may not have been any less. A few very small plaice, about 1 to 3 inches, were always to be found. The sprats at first comprised a good many that had hardly got beyond the whitebait stage, but towards the end of January and in February the size as well as the numbers increased. More nets were added to the Humberstone station, as many as 30 being down altogether. Thirty-five stone is the largest catch for one tide which I observed. The industry continued to be remunerative up to about the middle of March.

Shove-net and "seine" shrimping.—These industries closed for last year about the end of September, and up to the end of March of the present year shrimps have not been found in sufficient numbers to encourage the fishermen to make a regular start. A few small plaice, however, and a brill of 9 inches were taken in a shrimp-seine on the 10th March. It is worthy of remark that regulations affecting the use of shrimp-trawls apply equally to the shrimp-seine, which is undoubtedly a trawl in spite of its name.

Flat-fish netting.—This is a shore fishery to which I omitted to allude in my last report. The net resembles an ordinary ground seine. It consists of a piece of netting, mesh about the same as in a herring-net, about 20 yards long by a yard high, corked and leaded. The ends are kept open by pieces of wood. The net is worked by two men, each having a rope attached to one end of it, who wade about 10 yards apart along the shallow water near the margin and haul the net behind them. In the summer a considerable number of small plaice and some soles are said to be procurable in this

way, but the nets are not very often used. On the only occasion, in February, when I saw one worked, the only thing in the catch worth having was a smelt. As the nets are preferably hauled when the tide is rising no injury is done to the fish which are not saleable.

III. Remedial Measures.

Whatever success may attend the enforcement of a size-limit for flat-fish, there can be no doubt that this remedy will not be efficacious in the case of all round-fish, since (1) there is no area (such as the eastern grounds for small plaice and turbot) exclusively, or almost exclusively, inhabited by immature members; and (2) round-fish are liable to absolute destruction by the mere fact of being caught in the big beam-trawl as at present worked.

I have shown elsewhere that the shrimp-trawl worked in short hauls in shallow water is not in this district (and need not be, I suppose, in any district) particularly injurious to the small round-fish which frequent the areas where such engines are used, but the case in the deep sea is very different.

The approach of the trawl to the surface, even in such very moderate depths as 20 to 30 fathoms, is always marked by the appearance of a number of haddock, which float up with distended air-bladder through the mouth of the net or larger meshes of the "square," and drift helplessly about, a prey to the sea-gulls. When the net is boarded, a number of the smaller haddock are found meshed by the gills and perfectly dead, and very few are particularly lively. I have made efforts to keep those which appeared the healthiest alive in a tub of water, frequently changed, but never with success. I have, however, known a haddock, caught in the deep sea, to be brought into the Cleethorpes aquarium alive, but it died very soon. The skin is very delicate and easily inflamed, but I think the pressure of the weight in the trawl is more fatal, since line-caught haddock, which must get more or less handled, live well enough in the ship's well. Liners find it necessary, unless the fish are from very shallow water, to let the air out of the bladder if they wish the fish to live; and this they do, as also with cod, by a prick with a needle above the pectoral fin, care being taken to avoid the liver. Cod treated in this way live for months in the floating boxes in Grimsby Docks, and I suppose haddock would as well. I am told that even ling, in which the stomach has been everted by the pressure of the air-bladder, can be kept alive by the same means, though in this case the puncture is usually made above the anus. Now this process is well enough for the liner, who finds it tend, moreover, to his immediate profit, but I do not think it is feasible to

any very great extent on board a trawler. Though cod are somewhat hardier, haddock, especially small ones, succumb very rapidly if kept out of water; and it is certain that, even if they were attended to before the second trawl (where two are carried) was shot away, many out of a large catch would be beyond surgical aid before it arrived. Flat-fish, on the other hand, are better fitted, by the structure of their gill-covers, to stand exposure to the air, and, in general conformation, to resist pressure, whilst they are, of course, subject to no difficulty arising from an air-bladder. Hence, since only moderate hauls are now to be obtained on any grounds other than the eastern, a large proportion of the undersized members of the hardier kinds would probably survive if returned. Of the less robust species, two, the common and long rough dabs, are of small account, and undersized specimens of the third, the witch, appear to be seldom taken by our trawlers.

To return to round-fish. If, as I hold, no great number of those taken in our large trawls would survive if returned, it would serve no useful purpose to throw them back. Hence the only possible remedy lies in some scheme of mesh restriction, as to which I am not prepared to make suggestions. Though, thanks to much assistance from Mr. Woodall, my inquiries as to relation between size and pattern of mesh and size of fish caught have made considerable progress, I do not consider them as yet complete or conclusive.

It may be pointed out, however, that while it may be hoped that all immature whiting and at least a great proportion of immature haddock may be afforded a reasonable degree of protection by a successful adjustment of the mesh difficulty, there can be no hope by this method of protecting cod beyond a size which is far short of that at which sexual maturity is attained, and of course no net can be devised which will not be liable to get choked by weeds or other rubbish. Every one, I suppose, admits that a fish should have a chance of spawning before it is killed, but I really cannot say how this advantage is to be secured for the codfish. If it were possible to persuade those trawlers who, as I have shown, have been responsible for most of the destruction of codling during the past winter, that it would tend to their ultimate advantage to avoid the grounds most frequented by these fish, one might hope for a sensible mitigation of the evil. It is, however, sufficiently difficult to persuade a man of what is absolutely true, whereas, since adult cod are the prey of the liner rather than the trawler, the proposition perhaps hardly falls into such category.

Monthly Reports on the Fishing in the Neighbourhood of Plymouth.

By

W. L. Calderwood, F.R.S.E.

III.

The four charts produced in this number, showing as nearly as possible the positions of the various fishing boats in the neighbourhood of Plymouth, are a continuation of the series of charts already introduced in Nos. 3 and 4 of vol. ii. They represent the conditions found during last September, October, November, and December, and complete the year's observations.

September.—The Plymouth area is in this chart shown to be densely covered with fishing craft.

A great line of *mackerel boats* is noticeable stretching along to the east side of the Eddystone. This refers, however, only to the latter part of the month, being most noticeable on the 26th day. The mackerel fishing of the early part of the month was carried on twenty to thirty miles south of the Eddystone, and is therefore not indicated. The small patch of mackerel boats shown five or six miles south of the Eddystone occurred on the 18th night. It is the first indication of the breaking up of the large massed shoals, which is shown more clearly in October and November.

The *whiting boats* were very much scattered throughout the month and difficult to follow.

The *long lining* or bolter fishing shown, took place only in the early part of the month, that shown south of the Eddystone during the first week, that all round the Eddystone on the 12th day. The boats then went along the coast of Cornwall, and at the end of the month were fishing off the Lizard.

October.—The *mackerel fishing* during October was carried on, for the most part, fifteen, twenty, and by some boats thirty miles south of the Eddystone. Towards the end of the month, however, instead of travelling out of all reach as was feared, some shoals struck inshore again. The fishing round the Eddystone shown in the chart for this

month occurred on the 25th night. The *trawling* shown to the south of the Eddystone on the "home ground" occurred on the 10th day. A curious patch of *crabbers* is noticeable two to three miles south of the Mewstone.

November.—The *mackerel* marked in last chart are now shown to have been joined by other shoals. Fishing continued a few miles south of Eddystone during most of the month, but on the 19th the position shown just south of the Mewstone was discovered.

On the 5th the *trawlers* worked over the same ground as the mackerel men, and considerable damage to the drift-nets resulted.

A little long lining, which occurred in the early part of the month, is noticeable inside of the Eddystone, the boats having returned from the west. Towards the end of the month, however, the takes being poor, the lines were transferred to Bolt Head.

Only six *crabbing boats* were at work during this month.

December.—It will be noticed that the *mackerel* have now disappeared from the inshore waters. The boats followed them to the eastward, however, as they receded. On the 10th good takes were obtained twenty miles off Salcombe, and also off Start Point.

In coming to the end of the inshore mackerel fishing for another year, it may be well to glance for a moment at the paper I published in a previous number of this Journal on *The Mackerel Fishing of* 1889–90 (vol. ii, No. 1, p. 4). In looking first at the whole season the same general systematic movements can be observed, viz. the appearance of the shoals away off-shore to the eastward of Plymouth, the gradual travelling westward and approach to the shore, the appearance of very large shoals during the height of summer, followed by their division into smaller shoals, which gradually recede during the autumn in the direction from which they came.

That considerable variation takes place as to the exact time when mackerel are found in a definite locality is, of course, to be expected. The causes which influence the natural instinct of the fishes are, no doubt, many. Unfavorable climatic conditions or powerful artificial influences, such as target practice seawards or torpedo and mine firing, may have a direct action on the movements of the fish themselves, or may affect their food so as to cause a similar result.

A continued low or high temperature may retard or accelerate the breeding season, and hence the coming of the fish.

With regard to the fishing seasons of the two years under comparison there seems to be a slight difference in time. In July, 1890, the mackerel began to come close inshore, and during the month of August were taken in considerable quantities in Plymouth Sound. On the 1st of September we read, p. 13, "Mackerel going off into open water. Shoals breaking up."

In July and August of last year (1892), on the other hand, the shoals did not approach the shore, but rather appeared to be leaving the land, so that many fishermen considered the fishing over for the season and took in their drift-nets. In September, however, the usual condition asserted itself, and although the shoals never actually entered Plymouth Sound, yet they were found going through the same general movements in September, October, and November as characterised the fish in August and September of 1890.

To make suggestions as to the causes which produced this result would, in the present state of our knowledge, be mere idle speculation. I desire simply to point out that while the movements of these shoaling fish can be relied upon with tolerable accuracy, one season may be found to be as much as two or three months behind or in advance of another.

With regard to fish which do not move in shoals, it is well-nigh impossible to draw up certain courses, which may be relied upon as indicating their probable movements at any particular period of the year.

The present system of tabulating as nearly as possible the average positions of the boats during each month of the year was commenced by me in January of 1892. By continuing the process during the first few months of this year, it has been possible to compare the conditions found during these months and the early months of last year.

This comparison shows that in studying the movements of the fishes which do not form themselves into shoals, an extreme amount of variation may be present. So much does this appear to be the case that, without observations from a great number of years, it will be impossible to arrive at an accurate mean condition. I do not think it likely, therefore, that a comparison of charts for certain months in different years will be found of any benefit in trying to arrive at a knowledge of the probable movements of fish which do not shoal. At the same time it seems to me to be advisable that, in all localities where target practice seawards is carried on, or where other operations which interfere with fishing may be engaged in, information should continually be collected, so that at any date the positions of the fishing boats, and more specially the small line and crab and lobster boats, could be reported.

In support of this view I gave evidence before the Commission appointed to inquire into Target Practice Seawards, and am pleased to be able to state that in the official return of this Commission, published a short time ago, the suggestion has been advocated, and one of my charts issued as an example.

It seems also possible that a great additional benefit would be obtained, not only to the fishermen but to those firing, if when the

order for practice either from a fort or a gunboat was given, some signal or official notice was displayed in the fishing quarter of the adjoining port or fishing village or villages.

It seems certain that if some notification of this kind were given, fewer fishing boats would be found to interrupt operations by appearing in the line of fire.

With reference to the collection of particulars as to the positions of the boats, the method adopted has been first of all to form a committee of fishermen representing the various branches of the industry, viz. trawlers, drift-net men, &c., and to obtain regular information from them as to where they themselves and the majority of their neighbours were working. Latterly, the collection of this information has been augmented by the efforts of Roach, the fisherman of the Association.

The great advantages to be derived from telegraphic communication with isolated lighthouses and lightships, so ably advocated by a prominent member of the Marine Biological Association, comes most forcibly into view in this connection. Not only could the indications of the movements of shoals of fish be communicated to the fishermen, but the positions of the fishing boats at work on the grounds within a radius of many miles could most readily be ascertained, and communicated to officers of either service controlling gunnery practice in the locality.

The key to the symbols used in the charts is again repeated. In the last numbers the symbol used to represent long-lining was omitted by mistake. Comparatively few boats are now engaged in this industry at Plymouth. The symbol will be found below.

Key to Symbols used in Monthly Fishery Charts.

= position of herring boats.

= ,, of mackerel boats.

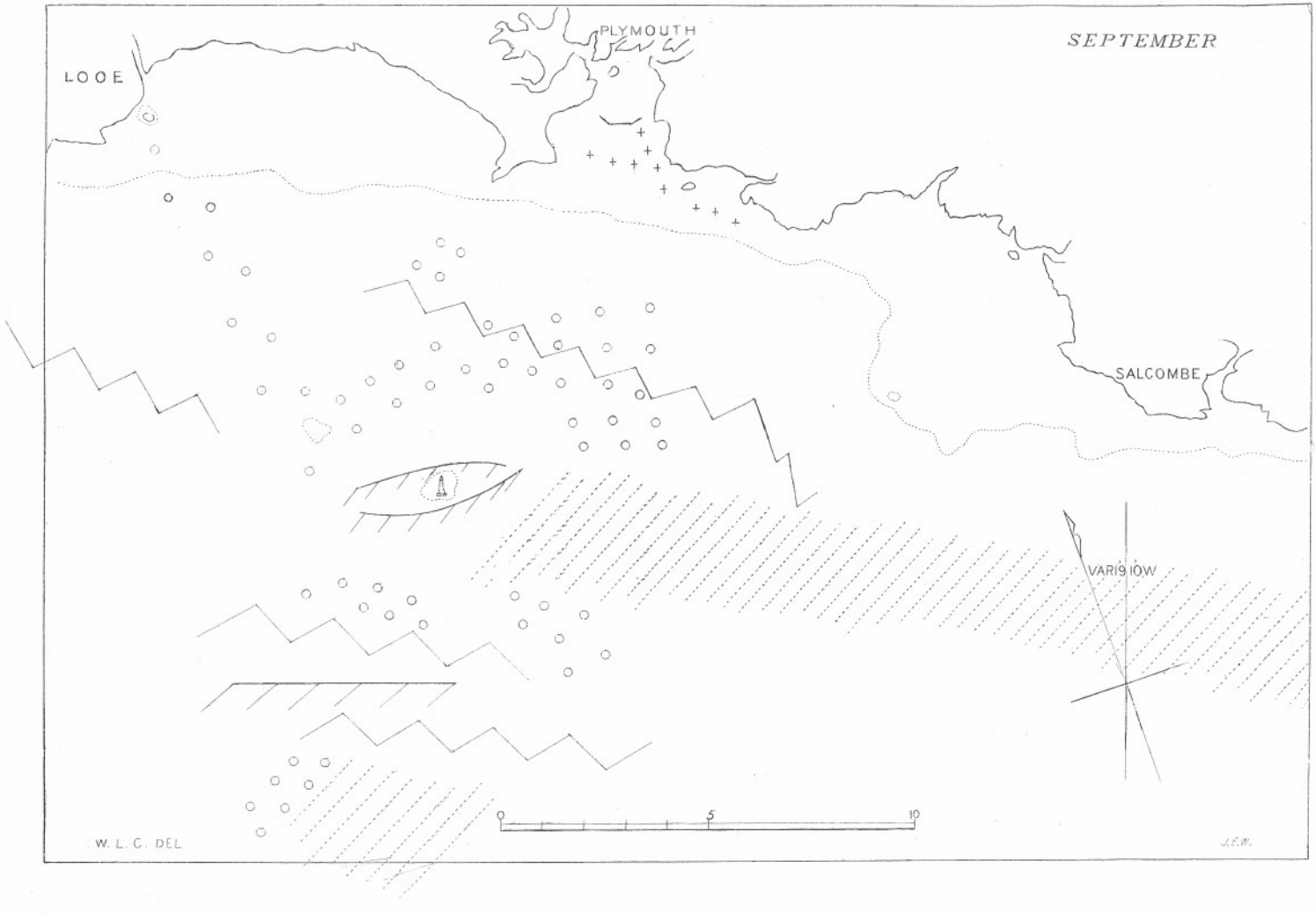
= ,, of pilchard boats.

= ,, of trawlers.

= ,, of whiting boats.

= ,, of crab and lobster boats.

= ,, of long line fishing.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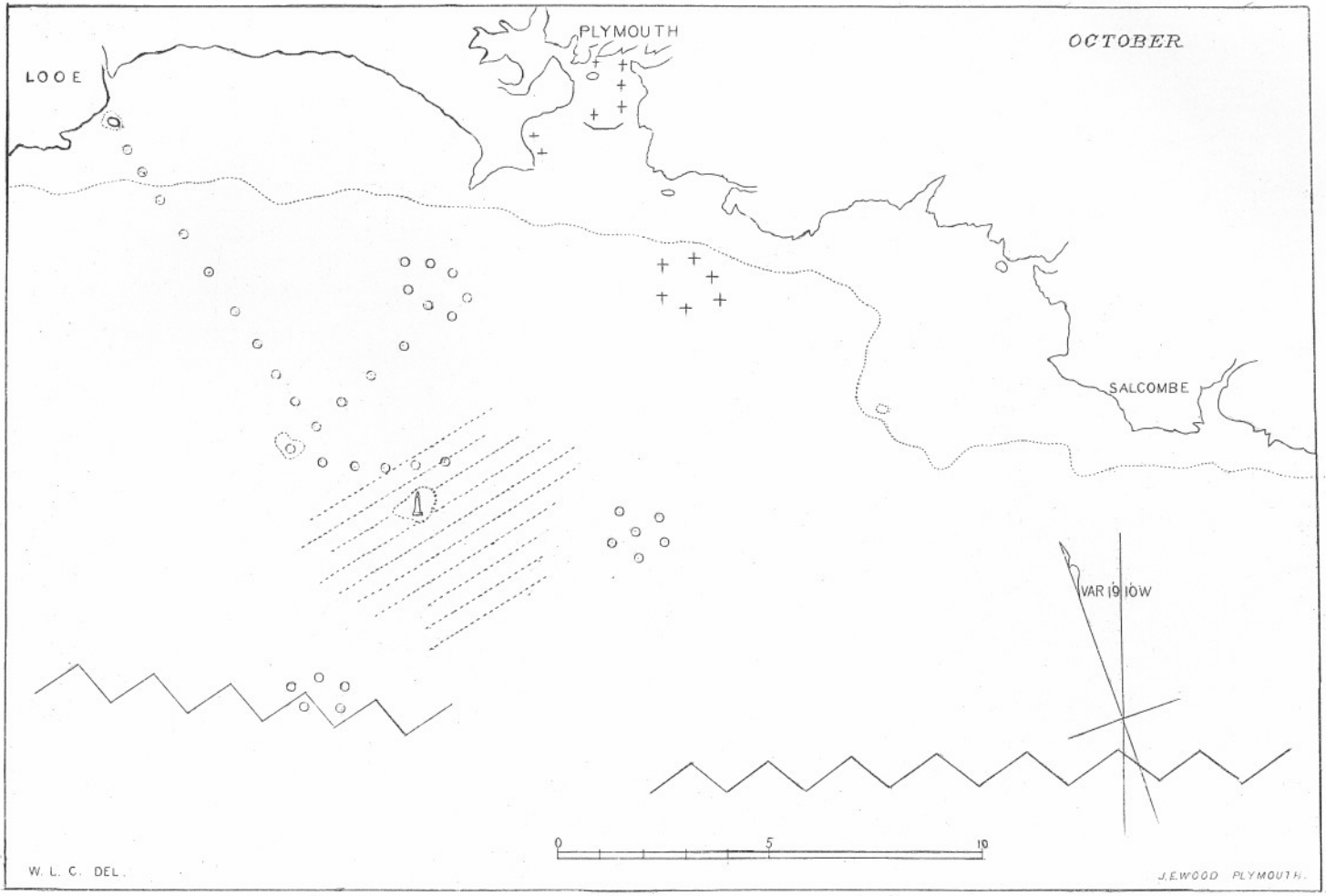
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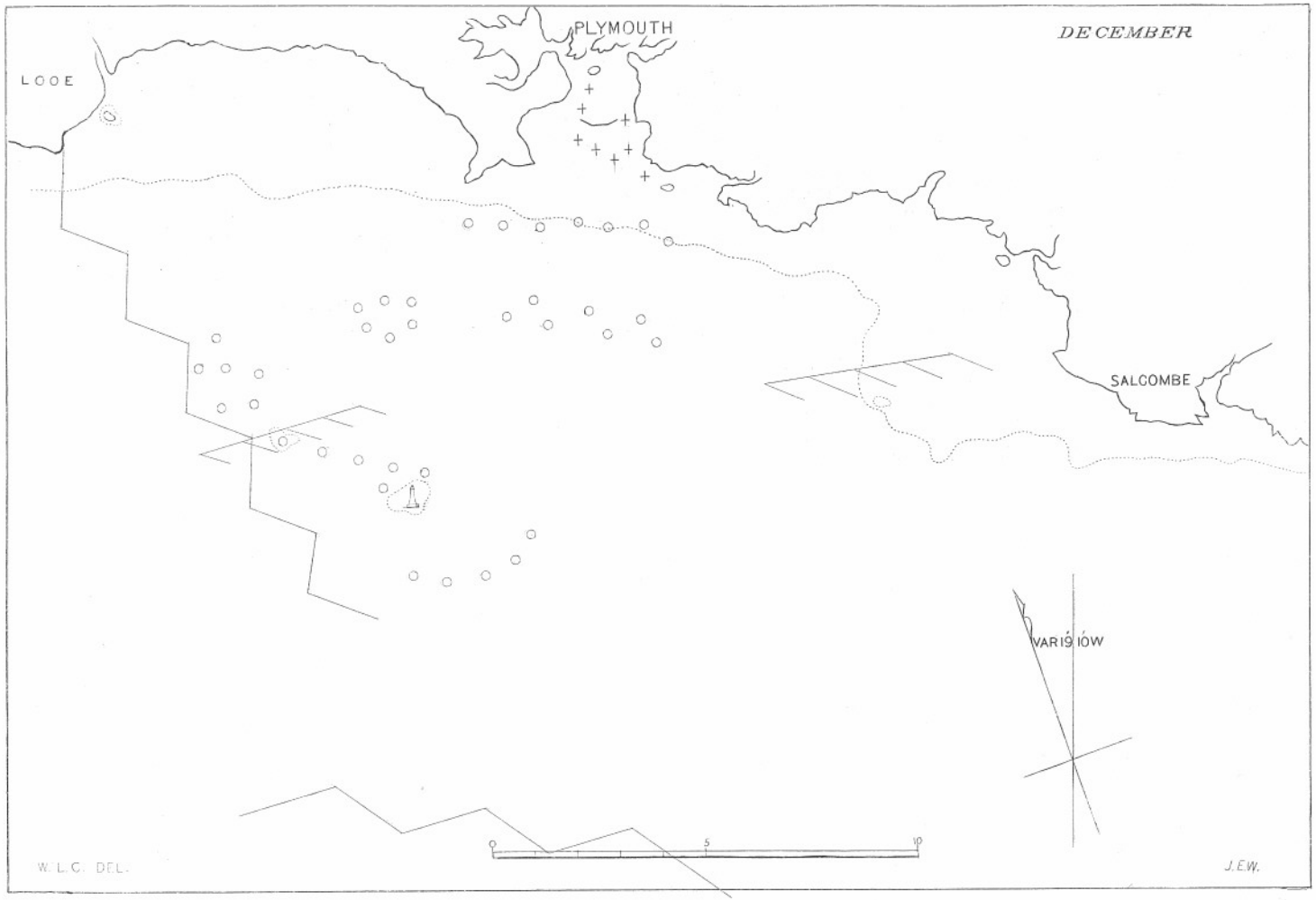
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Researches on the Coloration of the Skins of Flat-fishes.

By

J. T. Cunningham, M.A.,
Naturalist to the Association.

In the year 1890 I tried an experiment upon young flounders, with the object of discovering what would be the effect upon the lower sides of the fish if these sides were continually exposed to daylight. Under ordinary conditions the upper side of the fish is dark-coloured, the lower side white ; and the upper side is exposed to light, while the lower side being usually in contact with the ground, and always turned away from the sky, is protected from the light. A connection between the difference of the two sides in relation to light and in coloration naturally suggests itself. If the difference in coloration is due to the difference in the exposure of the sides to light, when the lower side of the fish is kept exposed to the light it ought to become coloured.

When the flounder or other flat-fish is first hatched it has chromatophores on both sides equally, and these chromatophores disappear from the lower side during the metamorphosis. It seemed more likely that illumination of the lower side would prevent to some extent this disappearance, than that it would cause the reappearance of chromatophores on the lower sides of older specimens. My first experiment (described in the Zool. Anzeiger, 1891) consisted, therefore, in taking a few young flounders which had not completed their metamorphosis and rearing them in a glass bottle supported on a plate of glass, underneath which was placed an inclined mirror reflecting the light from a window vertically upwards. I covered the sides and top of the bottle with an opaque cover made first of brown paper, afterwards of cloth, so that the light was to a great extent prevented from entering the bottle in any direction except from the mirror. The rearing of flounders from this stage to maturity, although requiring minute and constant attention, presents no great difficulty. The methods of feeding them and maintaining a circulation of the water containing them were described

in this Journal, vol. i, No. 4, 1890. A circulation was kept up in the bottle over the mirror in the experiment by connecting it with another bottle by means of a siphon outflow tube, the aperture of the tube being protected by silk bolting cloth, so that the little fish could not escape.

I was absent from Plymouth in July and the early part of August in 1890. When I returned I noticed that the little flounders continually clung with their lower sides to the darkened sides of the bottle, so that the object for which the apparatus was arranged was to a great extent defeated. I tried to prevent this by confining the fish beneath a horizontal partition of coarse cloth fitted into a cylindrical glass vessel substituted for the bottle, but the cloth did not allow of sufficient renewal of the water beneath it, and the fish were found all dead one morning, having been killed by suffocation. There were thirteen of these fish, and all except one had some pigment on the lower side. The greatest extent of the pigmentation was over the region along the edges of the lower side, from the base of the dorsal and ventral fins inwards, the region corresponding to the muscles of the fins. As far as could be observed in the course of the experiment (it was not possible to make a minute examination without risking the life of the fish), the pigmentation present at the end of the experiment was not due to a retention of the pigment present on the lower side before the transformation of the larval fish was complete, but the original chromatophores had disappeared from the lower side as usual, and had been redeveloped under the action of light.

In my next experiment I took four flounders belonging to the same brood as those of the first experiment. These were some of a number which had been reared under ordinary conditions, which had long passed their transformation and had no pigment on their lower sides. They were about five or six months old, and between 2 and 3 inches long. I removed the covering from the sides of the vessel, and left off using any partition inside it, keeping only an opaque cover on the top. In consequence of this the fish could not protect their lower sides from the light by clinging to the sides of the vessel, and their upper sides were illuminated by light passing through the sides, as well as their lower sides by the light from the mirror. At the beginning of 1891 I had made a wooden tank with a plate-glass bottom, which is still in use, and is shown in the figure illustrating this article. It is $3\frac{1}{2}$ feet long, 2 feet 3 inches broad, and 11 inches deep, and I procured large mirrors to place beneath it. In this tank the four flounders lived and grew. A recurrence of the old difficulty of the fish clinging to the opaque sides took place, and I met this as far as possible by keeping the water in the tank very

shallow. After this experiment had lasted six months I observed a commencement of pigmentation on one of the four fish. At the end of June, 1891, one of the four died. I had placed bricks in the tank to keep the fish in the centre of the glass bottom, and this specimen had got fixed between a brick and the side of the tank.

In September one of the three survivors had developed pigment all over the external regions of the lower side; in the other two pigment could not be detected with certainty. In this month another specimen, fortunately not the pigmented one, died. The remaining two lived on till July, 1892, when another died. This one was 23 cm. (about 9 inches) long, and had a large number of separate spots of pigment on the lower side. These spots were of considerable size and dark. Under the microscope they were found to consist of chromatophores exactly similar to those which constitute the pigmentation of the upper side. The fourth specimen is still alive at the present time. It is now three years old, and has lived in the apparatus since September, 1891. It is now deeply pigmented all over the lower side with the exception of a very small area.

There can be no doubt that the pigmentation in this experiment was due to the exposure of the lower sides of the fish to light. There were only four fish used, and two of them which lived long enough developed pigment which continually increased in extent. This is 50 per cent., and although pigment occurs on the lower sides of flounders living under natural conditions as an occasional abnormality, the percentage of such specimens is nothing like 50 per cent. It is important to point out that these four specimens were taken from a number reared in the aquarium in tanks with sand at the bottom, and subjected to no artificial conditions except captivity. In this Journal, vol. ii, No. 3, I have given the result of the examination of all such specimens reared from the brood of 1890. There were ninety specimens altogether, and one of these had a few small patches of pigment on the lower side. These were two years old when examined, and a more rigid control experiment could scarcely be required.

In another experiment I took one of this same brood (not one of the ninety just mentioned, but one taken before the examination referred to) which had one small spot of pigment close to the pectoral fin, and placed it in the apparatus, where its lower side was exposed to the light. In a few months the pigmentation of the lower side had extended over the greater part of that side.

Other similar experiments are described in greater detail in the full memoir by Dr. MacMunn and myself recently communicated to the Royal Society. Other experiments are now in progress, and a figure of the apparatus in use, prepared from a photograph, is here

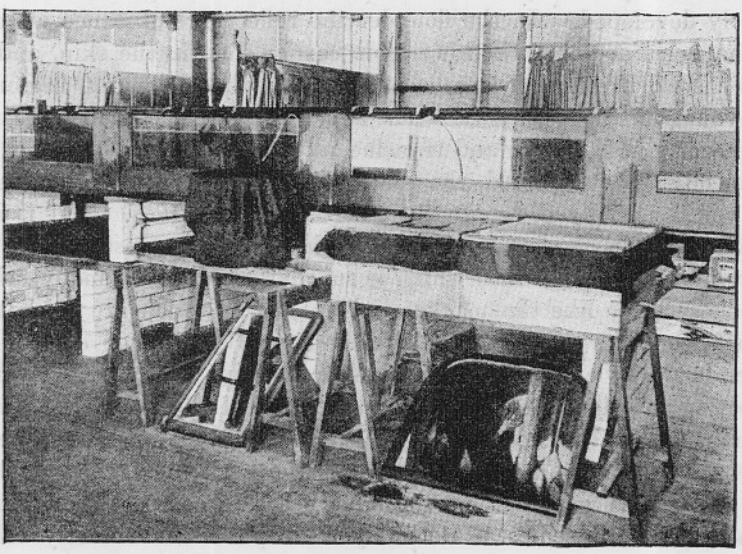
given. Besides the wooden tank already described and seen in the figure, there is also a large bell-jar. Both vessels are supported on trestles, and the large mirrors are placed beneath, upon the floor of the Laboratory. The vessels are placed in front of the tanks on the south side of the Laboratory and opposite the south windows, the supply of water being conveyed into the vessels by siphons from the Laboratory tanks. The fish are seen by reflection in the mirrors. At present the entrance of light is absolutely prevented by coverings of black cloth, or wooden covers lined with black cloth, except through the bottoms of the two vessels. The smaller fish are some reared from the brood of 1892, and the results exhibited by these are not yet published anywhere; the two larger fish are sole survivors from two separate experiments, and each of these is almost completely pigmented on the lower side.

During the period of time over which these experiments have extended, I have been studying, in collaboration with Dr. MacMunn, the anatomy and the physical and chemical properties of the elements to which the coloration is due. The results of these studies are fully described and illustrated in the memoir communicated to the Royal Society. A general account is all that can be given here. In the skins of flat-fishes the chromatophores have been described by Pouchet and other zoologists. They are of two kinds. Those of one kind are black or dark brown, have very definite outlines, and are contractile. They are stellate in form, having, when expanded, branching processes stretching out from the centre in all directions; but these processes can be partially or entirely retracted, and when completely contracted the chromatophore has a circular outline, being really nearly spherical in shape. The chromatophores of the other kind are yellow in colour. In the flounder the yellow deepens to orange at the centre. Usually the outlines of the coloured chromatophores are much less distinct and definite than those of the black, and it generally looks as though the pigment had diffused to some distance into the surrounding tissue. Nevertheless, contraction and dilatation of these yellow chromatophores takes place.

The chromatophores are of considerable size, easily seen with a low power of the microscope when a slice of the fresh skin is examined. But there are present much smaller elements which affect the coloration. These are angular plates of opaque substance of fixed form, having no colour, but reflecting light strongly. They are called iridocytes.

In the flounder, in the skin of the upper side a layer of chromatophores and iridocytes occurs close beneath the epidermis outside the scales, which are small and rudimentary. In the deeper part of the skin there are scarcely any chromatophores and no iridocytes, but

on the inner surface of the skin there occurs another layer of chromatophores, black and yellow as in the superficial layer. Associated with the chromatophores here there are no iridocytes, but the place of the latter is taken by a continuous layer of opaque reflecting substance similar to that of which the iridocytes are composed. On the lower side of the fish chromatophores are entirely absent, but the iridocytes of the superficial layer are well developed. It is not these, however, which cause the opaque whiteness of the lower side of the flounder, for the layer containing these can be removed with a razor, and the whiteness of the skin remains. This characteristic of the lower skin is due to a thick, dense, continuous layer of reflecting substance on the inner surface of the skin, corresponding to the layer mentioned above in similar position on the upper side. This layer is much thicker on the lower side than on the upper.



The character and location of the elements of coloration are quite similar in other flat-fishes, but they are not always developed to the same degree. The chief variation is in the subcutaneous reflecting layer, which is in some species, *e. g.* the Megrim (*Arnoglossus megastoma*), almost entirely absent, represented only, whether on the upper or lower side, by separate small plates quite similar to iridocytes, but not so regularly arranged. In fact, comparative observations of different species, and the history of the development in the flounder, prove that the internal reflecting layer is actually derived from a layer of separate iridocytes which enlarge until they become continuous. This explains why the lower skin in the young flounder

absorption bands in the spectroscope, and easily bleached under the action of light when removed from the living body.

To return finally to the effect of the action of light on the lower side of the flounder. Analysis shows that the result is a development of black and yellow chromatophores exactly similar to those of the upper side. At the same time there is a gradual diminution in the amount of the reflecting substance in the argenteum, while a change in the superficial iridocytes has not been observed. Whence do

is not opaque white, but bluish and translucent. The chromatophores, both black and coloured, are the first elements of coloration to develop, appearing in the skin of the embryo even before it is hatched. The external iridocytes appear next, and are found in the flounder during its transformation when it is $\frac{1}{5}$ to $\frac{1}{4}$ of an inch in length. The internal reflecting layer of the lower side develops late and very gradually. It first appears in streaks along the lines of the intermuscular septa, when the flounder is about $1\frac{1}{2}$ inches long and extends gradually. When the flounder is 3 to 4 inches long, the white opacity is usually fully developed. The peritoneum contains the same elements of coloration as the skin, namely, chromatophores and reflecting substance, and it is an important and significant fact that in the normal flat-fish the chromatophores are present only in the peritoneum of the upper side, while in that of the lower side they are absent or very scarce, and on this side the reflecting tissue is more largely developed. In the flounder the reflecting substance appears in the peritoneum of the lower side earlier than in the skin, and as it is visible through the walls of the body the abdominal region in the young flounder is marked out as a white area, while the rest of the lower side is bluish and translucent.

As might be expected, the elements of coloration in other fishes are not essentially different from those of flat-fishes. But it is a striking peculiarity in the flat-fishes that they are destitute of the silveriness and iridescence which is so characteristic of many fishes, especially those like the mackerel and herring which are migratory or pelagic. Investigation shows that the silveriness of such fishes depends almost entirely on a thick subcutaneous or internal layer of reflecting substance corresponding to that of the flat-fish. These layers, in fact, are homologous, the difference in appearance being due to a difference in the structure of the reflecting layer, which in the flat-fish is granular, in the silvery fish is composed of minute parallel rods or needles. Both layers may be conveniently called the argenteum. In other fishes as in flat-fishes, chromatophores, black and coloured, occur in an external layer and an internal, and where the chromatophores are most developed the argenteum is evanescent, and *vice versâ*. In other fishes there are also bodies corresponding to iridocytes, but they vary in form and arrangement. In fishes whose skins are iridescent, as the herring, this quality is due to a layer of parallel rods or prisms of reflecting substance, which in the herring line the inner surface of each scale, or more accurately are present between those parts of the scales which overlap one another. The scales themselves are never iridescent. This iridescent substance is obtained from the scales of certain fishes, especially the fresh-water bleak (*Albunus lucidus*), and

placed in the interior of thin glass beads to make artificial pearls. The coloured chromatophores of fishes are always of some shade of yellow or orange, deepening to red ; in some the colour is a distinct red, as in the gurnards and red mullet. Green fishes occur, *e. g.* the green pipe-fish (*Siphonostoma typhle*) and the mackerel, but in such cases the colour is not due to green chromatophores. The coloured chromatophores in such fish are of a lemon-yellow colour by transmitted light, though it approximates to green when viewed at certain angles by reflected light. The green colour exhibited by the fish is due to the mixture of this yellow colour with the black of the black chromatophores, just as a mixture of gamboge and black among artists' pigments produces a green. No blue pigment either occurs in any fishes that I have examined, blue colours being due to the reflections of iridocytes, modified by black chromatophores.

As to the histological nature of these elements, it has generally been held that they are modified connective-tissue cells. This may be true of the chromatophores, but probably is not true of the iridocytes and reflecting tissue.

From a chemical point of view the reflecting substance is composed of a definite organic compound in an almost pure state, and the opacity and reflecting properties of the reflecting tissues or elements are those of this compound, varying according to the state of aggregation in which it exists. This substance, whose formula is $C_5H_5N_5O$, is connected with the uric acid series, but its chemical relations are not well understood. It is found in small quantities in the excretions of the excretory organs of certain Invertebrates, but has never been found associated with the kidneys of Vertebrates. It was first recognised as an abundant constituent of guano, derived in that substance from the skins of the fish devoured by the sea-birds, whose excrement formed the guano. The pigment of the black chromatophores is known as melanin, an organic compound which is extremely insoluble and indestructible, and, with slight variations, occurring almost universally in the animal kingdom. The pigments of the coloured chromatophores all belong to a well-characterised class of pigments known as lipochromes or fat-pigments, being of an oily nature, soluble in alcohol, ether, and other fat solvents, giving absorption bands in the spectroscope, and easily bleached under the action of light when removed from the living body.

To return finally to the effect of the action of light on the lower side of the flounder. Analysis shows that the result is a development of black and yellow chromatophores exactly similar to those of the upper side. At the same time there is a gradual diminution in the amount of the reflecting substance in the argenteum, while a change in the superficial iridocytes has not been observed. Whence do

these chromatophores come? Do they migrate along the skin or through the tissues of the body from the skin of the upper side? or are they formed *in situ*, and, if so, how? We are not prepared at present to answer these questions definitely. We believe, however, that their presence is not due to migration, but that the pigment is formed from the elements supplied by the blood at or immediately near the place where they appear. That they do not come round the edge of the body along the tissues of the skin is proved by the fact that spots and patches of pigment may appear in any position, and quite isolated, on the lower side.

It is important to mention that, although chromatophores are present on both sides of the fish in the intermediate stages of metamorphosis at which most of these experiments have commenced, the action of light on the lower side never results in the retention of these chromatophores. The latter disappear from the lower side completely, and after prolonged action of the light they reappear. It is certain, therefore, that the disappearance of the pigment from the lower side in the normal flat-fish is an hereditary character, and not due to the withdrawal of the action of light in the individual. If the latter were the case, of course the pigment would be retained permanently from the larval stage as soon as the light was allowed permanently to act upon the lower side of the fish. The disappearance of the pigment is, therefore, an hereditary family character in the Pleuronectidæ. On the other hand, the fact that in these experiments the pigment, after prolonged action of the light, actually reappears is strong evidence (to my own mind a proof) that originally, in the beginning of the evolution, the pigment disappeared in consequence of the withdrawal of the lower sides from the action of light. If this be granted, it follows, of course, that a character originally acquired has become hereditary.

Pigment occurs as an occasional variation on the lower sides of flounders living free under natural conditions. That this does not invalidate the significance of these experiments is shown by the fact that in a number reared under normal conditions in the aquarium, only 1 in 90 showed a spot of pigment on the lower side, while of 94 specimens obtained from the estuary of Hamoaze only one showed a coloured spot on the lower side. Moreover, in the experiments the extent of the pigmentation, and the number of specimens exhibiting it, steadily increase from month to month, while in nature pigment on the lower sides is not any more common in large specimens than in small.

The above is a mere brief summary of general results and conclusions. The full description of the investigations, with illustrations, is contained only in the memoir communicated to the Royal Society.

NOTES AND MEMORANDA.

The Distribution of Unciola crenatipalma, Bate.—In my *Notes on the Marine Invertebrate Fauna of Plymouth for* 1892, in the last number of this Journal, I stated (p. 337) that although this interesting Amphipod is plentiful at Plymouth, its distribution seems to be very restricted, and that it is absent, among other catalogues, from my friend Mr. A. O. Walker's lists of the L. M. B. C. Amphipoda. Mr. Walker has, however, kindly called my attention to the fact that he has recorded the capture of several specimens of *Unciola irrorata*, Say, on the coast of Anglesey (Proc. Liv. Biol. Soc., iv, 1890, p. 243), and that he had little doubt that this name should really be *U. crenatipalma*, Bate. Upon comparison with some specimens of *U. crenatipalma* from Plymouth, Mr. Walker has been able to confirm the identity of the forms from the two localities, so that his record of *U. irrorata* in reality extends considerably the northern range of *U. crenatipalma*. The true *U. irrorata* of Say, he tells me, may be at once distinguished from *U. crenatipalma*, Bate, by the lower angles of the last two pleon segments, which in the former are produced into curved points, a distinction mentioned neither by Stebbing (Chall. Amphipoda) nor Bonnier (Bull. Sci. France, &c., 1889, t. xx, pp. 373—398). The known distribution of *U. crenatipalma*, from north to south, is now, therefore, as follows :—England : Anglesey (A. O. Walker) ; Weymouth (Gosse) ; Plymouth (Garstang). France : Dunkirk (de Guerne and Chevreux) ; Boulonnais (Bétencourt and Bonnier) ; Luc-sur-Mer, Belle-Ile and Croisic (Chevreux) ; Gulf of Gascony and north coast of Spain (Chevreux).—W. Garstang.

Raniceps raninus, Linn.—On the 23rd June, 1892, I received a specimen, $3\frac{1}{16}$ inches in length, which had been taken in a shove-net on the shore opposite New Clee Railway Station. No other examples were forthcoming until October, when, on the 25th and 26th, we took three on the Trinity, and four on the Middle Sand prawning ground in the shrimp-trawl. Of these, one measured $4\frac{1}{8}$ inches, and the others were about the same size. Two of them were placed in the Cleethorpes Aquarium, where they lived for some days, choosing, in the daytime, the darkest corner of the tank. One died, apparently from the effects of chafing ; and the other, which seemed healthy,

contrived to get down the escape-pipe, and was killed. The resemblance borne by these lesser forkbeards to the dark variety of *Liparis Montagui*, which is the most common on the grounds where they were caught, is very striking when the fish are viewed from above. Even the dermal papillæ of Montagu's sucker are represented, though much less closely set, on the head of the gadvid.

Examples have been recorded from most of the British coasts, and the species has been taken in estuarine waters before, but I do not know that there is a distinct record of its occurrence at the extreme margin, as in the case of our first specimen. I imagine it must occur pretty regularly in the Humber, though I have found no one here who recollects to have met with it before. The resemblance to Montagu's sucker would probably account for its being overlooked by shrimp-trawlers.—E. W. L. H.

Chimæra monstrosa, Linn.—A male and a female of this species were taken in the second week of May by a Grimsby smack trawling from 70 into 135 fathoms, at the edge of the deep water to the north of the Great Fisher Bank, 320 miles from the Spurn. The abdominal viscera had been removed before they came under my observation. The male measures 27¼ inches in total length, the caudal filament being nearly perfect, whilst the pre-anal region measures 9½ inches. All the accessory sexual organs are well developed; it is the smallest mature male that I have seen. The female was about the same size.—E. W. L. H.

Lumpenus lampetræformis, Walbaum.—I have received a specimen taken, in company with another, by Mr. F. Klotz, s.s. "Dominican," at 23 to 25 fathoms, 240 miles E. ½ N. of the Spurn Light-vessel during the last week of July, 1892. The species was first added to the British list by the occurrence of an example on the east coast of Scotland (*vide* Day, Rep. S. F. B., 1884, p. 78), and has since been recorded by Dr. Günther from the west coast (P. R. S. E., vol. xv, 1888, p. 211). The locality from which mine was derived lies outside the British area, but I was under the impression that it was rather further south than any that had been recorded. Dr. Günther, however, informs me that he has seen a specimen said to have been taken on the coast of Norfolk.—E. W. L. H.

Gastrosteus pungitius, Linn.—The ten-spined stickleback is common in some brick-field ponds at Beaconthorpe, though not so numerous as the three-spined species. Both kinds have been used at the Cleethorpes Aquarium for some time for feeding anemones, especially *Urticina felina*, and I had never noticed that one species

seemed less tolerant of sea-water than the other. I was therefore rather astonished to find an assertion, attributed, I suppose correctly, by Day to Couch, that *G. pungitius* "will not exist when confined in salt water, however diluted such may be." To test the truth of this, five examples were transferred from fresh to salt water. Three of them showed very little apparent irritation, but the two others gasped a good deal for some time, but finally, as far as the salinity of the water was concerned, the discomfort appeared to cease. These examples have failed, however, to adjust their air-bladders to the greater density of the salt water, and remained, in consequence, at the surface when at rest, though able to descend when inclined to do so. One has died, at the end of a week. Two appear perfectly contented with their new surroundings, and in no way inconvenienced by the density of the water, which is about 1·020°.—E. W. L. H.

Pleuronectes microcephalus, Donov.—I have alluded elsewhere to the occurrence of young lemon soles in the Humber in autumn. I have since received three, measuring $2\frac{3}{4}$, 4, and 5 inches respectively, which were taken on the Tetney ground on the 7th of April. It seems, therefore, probable that some of these fish remain in the river throughout the winter. Whilst reserving a more detailed description, it may be remarked that these small examples exhibit all the markings shown by the adult when taken on a bright-coloured ground. In both cases the markings disappear very rapidly after death, but the dark pigment can be fixed by alcohol.—E. W. L. H.

Scorpæna dactyloptera, De la Roche.—A specimen, $4\frac{3}{4}$ inches in total length, was taken in a shrimp-trawl on the Tetney ground on the night of the 17th April. It has the colours of the adult, but the lower rays of the pectoral fins are still connected by membrane, as in other young examples that have come under my notice.

The species is known to occur all along the European and North Atlantic slope, at depths between 54 and 527 fathoms, but there is no record of its occurrence on the English coast. As the Tetney ground is nowhere deeper than five fathoms, I would call attention to the extension of the vertical rather than to that of the horizontal range. From the accounts of prawn fishermen I believe that several other small examples have been taken in the Humber this spring. E. W. L. H.

Director's Report.—No. I.

Of the work undertaken during the winter 1892–3, and before my arrival at Plymouth in April, I must report that, as in the preceding winter, the anchovy nets were shot by the fishermen to whom they were entrusted, but unfortunately without satisfactory results.

In consequence of representations made to the Devon Sea Fisheries Committee and also to the Board of Trade by my predecessor, Mr. Calderwood, the following addition has been made by the Board of Trade to the Bye-laws which were submitted to them by the Committee for revision :

"Nothing in these Bye-laws contained shall apply to a person fishing solely for scientific purposes, under the written authority on that behalf of the Local Fisheries Committee of that district, signed by their clerk, and subject to the conditions contained in that authority." The permit in question will be granted, in due course, to the fishermen working for the Laboratory.

Under the regulations which fixed the shortest term for the renting of a table in the Laboratory at a month, but few workers have visited us during the short Christmas and Easter vacations. Now that the minimum charge is for one week (at the rate of thirty shillings), facilities are given for a short stay at Plymouth. This should induce investigators to take any opportunity which may occur at any time of the year to collect seasonable material, or to study living animals and plants available for the time being. The weekly announcements in "Nature" of new finds, of the composition of the Plankton, and of the animals breeding, will, it is hoped, prove useful by indicating what special material is being procured during the ordinary course of dredging and tow-netting.

Dr. S. J. Hickson continued his studies on Alcyonium last Christmas. During the month of April, Mr. Riches recommenced his word on the Nemertines of Plymouth ; Mr. Maurice S. Evans, F.Z.S., F.R.G.S., was instructed in the methods of collecting and preserving marine animals before his return to Natal. Dr. G. J. Romanes, a Governor of the Association, sent his representative to occupy a table.

The sea water circulating through the Laboratory tanks and those

in the Aquarium is in excellent condition, and has recently stood a severe test in a perfectly satisfactory manner. Mr. Cunningham has succeeded in rearing young flounders through their earliest and most critical stages in the tanks of the Laboratory. This fact speaks very well for the purity of the sea water, and certain modifications of the arrangements for pumping and storing the water will ensure the continuance of this favorable condition of things regarding what is, without doubt, the most important factor in almost all the research carried on at the Laboratory.

The nature and scope of the results obtained by the naturalists of the Association is amply testified by the contents of the present number of the Journal. The papers by Mr. Riches and Mr. Gamble are important contributions to the fauna of the English Channel, and in conjunction with the faunistic work which is being carried on by Mr. Garstang, show great advance towards a more complete and detailed knowledge of the rich and varied fauna in the immediate neighbourhood of Plymouth.

EDWARD J. BLES.

May, 1893.

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OBJECTS

OF THE

Marine Biological Association of the United Kingdom.

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

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

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

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

The Association has at present received some £20,000, of which £5000 was granted by the Treasury. The annual revenue which can be at present counted on is about £1820, of which £1000 a year is granted by the Treasury, the remainder being principally made up in Subscriptions.

The admirable Marine Biological Laboratory at Naples, founded and directed by Dr. Dohrn, has cost about £20,000, including steam launches, &c., whilst it has an annual budget of £4000.

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

CONTENTS of NEW SERIES, Vol. III, No. 1.

NOTICE.

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

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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.