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The Food of Post-Larval Fish.

By

Marie V. Lebour, D.Sc.
Naturalist at the Plymouth Laboratory.

With Figures 1–7 in the Text.

CONTENTS

ALTHOUGH much investigation has been made on the food of adult fish the information as to the food of the very young is scattered and fragmentary. It is the purpose of this paper to report on the food of a number of post-larval fish which have been examined fresh from the tow-nettings through the year 1917 from Plymouth Sound within the Breakwater and outside as far as the region of the Panther and Knap Buoys (about $2\frac{1}{2}$ miles from the shore) and occasionally from Cawsand Bay. The food of a number of preserved post-larval fish has also been investigated which were taken in the Young Fish Trawl in 1914 and reported on by Dr. Allen (1917). These latter were mostly examined as mounted and cleared preparations, the food usually being plainly seen. Others from this lot were examined by dissecting out the alimentary canal—a method not so satisfactory for preserved material although answering very well for the fresh fish which were all examined by this latter method.

A systematic examination of post-larval fish from tow-nettings was made by A. Scott (1906), who used the above methods, but the number examined was not large. Herdman (1893–1898) had also previously noted the contents of the alimentary canal in several young fish, chiefly those beyond the post-larval stages. Petersen (1894, 1917) also notes the food of young fish, especially *Pleuronectidæ*. Other records have chiefly to do with the food of artificially reared fish, when the food picked out by the post-larval fish from plankton given to them is noted.

In all these records it is found that the Copepoda form the chief food of nearly all larval and post-larval fish with other Entomostraca and Mollusk larvæ. It now seems to be a well established fact that the majority of young fish eat the small animals from the plankton more than the diatoms and other unicellular organisms, except in cases of some of the very young fish which have been found to eat diatoms before taking to animal food (Kyle (1898) found Dab from 10 to 16 mm. with stomachs full of diatoms), and in the few exceptional cases of fish which are true vegetarians. As examples of these latter cases Herdman (1912) shows that post-larval plaice first feed on diatoms before taking animal food; Dannevig (1897 and 1898) also found that the young plaice first took diatoms and in some cases Infusoria. The Grey Mullet which is herbivorous, with its mouth-parts adapted for browsing, eats in its post-larval stage according to Cunningham (1890) chiefly diatoms, although A. Scott (1898) has found that the older young eat Copepods as well as diatoms. Professor S. A. Forbes (1882–1884) shows that the young Whitefish (*Coregonus clupeiformis*) in a tank with only vegetable food nearly all died, whilst they fed eagerly on Entomostraca. Even before the yolk is absorbed a pair of small teeth are developed, well adapted for seizing animal food such as these small Crustacea (chiefly Copepods). Young herring take Mollusk larvæ before the yolk is absorbed, as do also the pipe-fish, *Nerophis lumbriciformis*, which hatched in a jar in the laboratory. Mollusk larvæ seem often to be taken very early, even before Copepods.

That a certain amount of selection of food takes place is evident from previous records and from our own observations. Dannevig (1897) states that only one species at one time was eaten by the baby plaice although different individuals might eat different species. It seemed as though one individual got used to a certain food and stuck to it for a time. Petersen (1894) shows that the Dab, living with the Plaice, selects Copepods of other species from those chosen by the latter fish, and Herdman shows that the natural food of fish is often that which is not most frequently present, so that the fish must hunt for it.

The following records show that certain fish undoubtedly prefer certain food; frequently two or three fish will like the same kind. For instance, *Solea variegata* and the few *Solea vulgaris* examined like the same food as the Dab, *e.g.* chiefly *Podon*, *Temora* and *Euterpina*, so that it may well be that the very abundant Dab takes away, in its very young stages, the food from its more valuable relatives. It is to be noted, however, that whereas Solea eats Crustacea as big as *Temora* almost at once, the Dab, *Pleuronectes limanda*, has a period up to about 5 mm. when no Crustacea are found in its alimentary canal, so that it most probably first eats softer food. It is not in the least the case that all Pleuronectids eat the same food, for one of the Top-knots, *Scophthalmus norvegicus*, specially eats *Pseudocalanus*, which is only very rarely found in the Soles and Dab, and *Arnoglossus* although not eating Copepods for some time also likes *Pseudocalanus*. *Podon*, probably *P. intermedius*, is a favourite with many young fish, and is often taken by the very young ones before Copepods; probably it is more easily digested. It heads the list of the food of post-larval fish in these records.

As regards the Copepods, we naturally find that the fish with the smallest mouths eat the smallest forms, both large and small being eaten by those with large mouths. Thus *Arnoglossus* up to about 20 mm. having a small mouth does not take larger forms than *Pseudocalanus*, whereas *Solea variegata* at 4 mm. can eat full-grown *Temora*, and *Scophthalmus norvegicus* at 4·5 mm. can eat full-grown *Metridia lucens*. It is a striking fact that *Calanus finmarchicus*, which is abundant, is eaten very little by these post-larval fish. It is apparently too large for any but the fair-sized young ones. The nauplii are seen oftener as food for the small ones, and probably are frequently among the unidentifiable Copepod remains. Fish caught in the act of swallowing Copepods always show the tail sticking out of the mouth, so that they are swallowed head first.

The commonest food in order of frequency is the following: *Podon* (probably *intermedius*), *Pseudocalanus elongatus*, *Temora longicornis* and *Euterpina acutifrons* in the proportion of 6 : 4 : 3 : 2, *Metridia lucens* and *Balanus nauplii* coming next, and afterwards other Copepods such as *Oncæa* sp., *Acartia* sp. *Corycæus anglicus*, *Centropages typicus*, *Calanus finmarchicus* in order, with nauplii especially of *Temora* and in very few cases *Microsetella norvegica*, *Harpacticus uniremis*, *Longipedia Scotti*, *Isias clavipes*, *Idya furcata*, *Oithona similis* and *Anomalocera pattersoni*. Cypris stages of *Balanus* occurred at certain times and *Evadne* sp. *Podon* and *Evadne* are not found in the winter but most of the fish that had eaten *Podon* were in summer hauls, and the *Balanus* nauplii which swarm in spring, beginning in February, were chiefly taken by young herring. The Copepods most frequently taken as food are amongst the commonest in the ordinary tow-nettings, although the Harpacticid *Euterpina acutifrons* occurs much more frequently in fish than in the tow-nettings, and the *Oncæa* (probably *media*) has not been taken with the tow-nets here. These two and *Metridia lucens* are evidently commoner outside, and the hauls in which the fish were taken which had chiefly eaten these were from the region of the Eddystone and Rame Head, the other common forms, *Podon*, *Temora* and *Pseudocalanus* also evidently abounding there. Besides Copepods and Cladocera small ova were frequently found in the fishes, especially the Pleuronectids and Herring; these were spherical and usually measured about 0·2 mm. in diameter. The very young fish frequently contained only these.

Very few unicellular organisms besides these ova were found in the young fish. Diatoms when present were sometimes in the Copepods eaten or in their fæces, but not very often free in the alimentary canal. In one instance a perfect specimen of a *Coccosphæra* was found in a Pouting, *Gadus luscus*. On another occasion a young *Ammodytes* contained several *Rhizosolenia Shrubsolei*.

To show that a certain amount of selection does take place a list was made of the food inside the fish from 2 hauls, and the food of each fish noted. For this purpose Hauls XIII and XIIIa were selected, both with the Young Fish Trawl, 1914. Haul XIII May 19th, 11.35 p.m. Mid-water, Eddystone, N. 6½, 39 fms. Haul XIIIa May 22nd, Eddystone, S.W. 3 miles, 28 fms.

Haul XIII.

Contained the following fish :—

406 *Clupea* sp.
1 *Ammodytes* sp.
8 *Gadus merlangus.*
7 *G. luscus.*
158 *G. minutus.*
5 *Onos mustela.*
1 *Labrus bergylta.*
70 *Pleuronectes limanda.*
55 *P. microcephalus.*
1 *Arnoglossus* sp.
84 *Scophthalmus norvegicus.*
1 *Zeugopterus unimaculatus.*
4 *Z. punctatus.*
48 *Solea variegata.*
5 *Gobius* sp.
150 *Crystallogobius Nillsoni.*
13 *Trigla* sp.
20 *Callionymus lyra.*

These contained the following food :—

DIATOMACEÆ.

Paralia sulcata.
Pleurosigma sp.
Navicula sp.
Guinardia flaccida.
Lauderia borealis.

PERIDINIALES.

Dinophysis sp.
Diplopsalis lenticula.
Prorocentrum micans.
Peridinium ovatum.
P. pallidum.
P. cerasus.
P. sp.

INFUSORIA.

Tintinnopsis ventricosa.

CIRRIPEDIA.

Balanus nauplii and cypris stages.

CLADOCERA.

Podon (cf. *intermedius*).

COPEPODA.

Calanus finmarchicus.
Pseudocalanus elongatus.
Metridia lucens.
Paracalanus parvus.
Temora longicornis.
Acartia (cf. *Clausi*).
Oncæa (cf. *media*).
Coryceus anglicus.
Euterpina acutifrons.
Also ova.

The Diatoms and Peridiniales were nearly all inside the Copepods. The Copepods chiefly taken were *Pseudocalanus, Temora, Euterpina* and *Metridia. Solea variegata* and *Pleuronectes limanda* ate chiefly *Podon* and *Temora, Solea* also eating *Euterpina, Oncæa, Corycæus* and *Balanus* larvæ, neither containing *Pseudocalanus.* On the other hand *Pseudocalanus* was the chief food of *Scophthalmus norvegicus,* which hardly ever took *Temora,* but in addition to *Pseudocalanus* contained

Metridia and occasionally *Podon*, *Acartia*, *Paracalanus*, *Oncæa* and *Euterpina*. *Pseudocalanus* was also almost the only food of *Gadus minutus* and *G. merlangus*. The *Clupea* were all empty and no food was found in *Pleuronectes microcephalus*. Those of the *Crystallogobius* examined (not all as they were almost adult) contained *Calanus finmarchicus*, showing that it was present although not taken by the other fish. *Callionymus lyra* eats almost anything. Besides the above food, many of the fish contained ova.

Haul XIIIa.

Contained the following fish :—

45 *Pleuronectes limanda.*
11 *Solea variegata.*
1 *S. vulgaris.*
10 *Zeugopterus punctatus.*
2 *Scophthalmus norvegicus.*
59 *Gadus* sp.
8 *Trigla* sp.
1 *Labrus bergylta.*
1 *Ammodytes* sp.
34 *Callionymus lyra.*

The fish contained the following food :—

PERIDINIALES.

Peridinium ovatum.
P. sp.

INFUSORIA.

Tintinnopsis ventricosa.

CLADOCERA.

Podon (cf. *intermedius*).

COPEPODA.

Calanus finmarchicus.
Pseudocalanus elongatus.
Paracalanus parvus.
Temora longicornis.
Centropages typicus.
Acartia (cf. *Clausi*).
Oncæa (cf. *media*).
Idya furcata.
Euterpina acutifrons.

AMPHIPODA.

Apherusa (cf. *Clevei*).

Thus the two hauls contain very similar food. Again we find that *Solea variegata* ate chiefly *Temora*, also *Euterpina* and occasionally *Oncæa* and *Acartia* but no *Pseudocalanus*. *Solea vulgaris* ate *Temora* and *Euterpina* and *Pleuronectes limanda* chiefly *Temora* and *Podon* but not *Pseudocalanus*. *Zeugopterus punctatus* ate chiefly *Temora* but also *Calanus*, *Oncæa* and *Euterpina*. Again *Scophthalmus norvegicus* ate chiefly *Pseudocalanus*, although *Paracalanus*, *Euterpina* and *Temora* are present. *Pseudocalanus* is also eaten by the Gadus sp. with several other Copepods including occasional *Calanus*, and by *Trigla* and *Ammodytes*. Again *Callionymus lyra* eats a variety, including *Apherusa*. From these notes it will be seen that certain fish do undoubtedly take certain foods in preference to others, and this is specially well shown in *Solea* and *Pleuronectes limanda*, which like *Podon* and *Temora*, and almost entirely pass over *Pseudocalanus* although present in abundance.

LABRUS BERGYLTA Asc. Ballan Wrasse.

Thirty-nine specimens were examined which came in the tow-nettings from both outside and inside the Breakwater, from June to September, and were examined fresh. They measured from 2·5 mm. to 11 mm., the small specimens being somewhat contracted so that they naturally were longer. The smallest were either empty or contained indistinguishable green food remains, those from 4 to 5 mm. containing almost entirely Copepod nauplii, especially *Temora*, with occasional remnants of diatoms (*Navicula*) and peridinians, with green food remains. At 6 mm. Copepods and Copepod nauplii were taken, one specimen containing the following :—

10 *Cittarocyclis denticulata.*	2 *Prorocentrum micans.*
1 *Temora longicornis.*	6 *Peridinium* sp.
3 *Euterpina acutifrons.*	1 *Lithomelissa setosa.*
1 *Copepod indet.*	1 *Tintinnopsis beroidea.*

The larger specimens contained Copepod remains including *Temora* and *Pseudocalanus*, and also *Podon*. Altogether 20 out of the 39 contained Copepod nauplii or young copepodid stages, so that evidently this, with small planktonic organisms, is their chief food in the post-larval state.

CARANX TRACHURUS L. Horse Mackerel.

Four specimens of young Horse Mackerel were examined, from inside and outside the Breakwater and Cawsand Bay,* in September and October, measuring 30 to 40 mm. They all contained Crustacea, chiefly Copepods including *Calanus*, *Centropages typicus* (15 in one specimen), *Temora* and many Harpacticids, including *Idya furcata*. Crab zoeæ and *Porcellana* larvæ were also present.

SCOMBER SCOMBER L. Mackerel.

Twenty-five Mackerel were examined fresh from the tow-nettings, measuring 3 to 16 mm., from inside and outside the Breakwater from the end of July to the middle of September. The very smallest either contained nothing or green food remains, but one of 3·5 mm. contained 2 *Temora* nauplii and another a larval gastropod. Nine specimens contained nothing, the remainder contained green food remains and Copepod remains which seemed to be almost entirely *Temora* nauplii. The specimen of 16 mm. with remains of Copepods in its alimentary canal had in its mouth (swallowed head first) 4 adult *Temora longicornis* which it had probably taken after capture.

* For a Plan of Plymouth Sound showing where the tow-nettings were taken, see Fig. 7, p. 459.

TRACHINUS VIPERA Cuv. Lesser Weaver.

Three specimens examined fresh from the tow-nettings from outside the Breakwater, 2 of 22 mm. in September, 1 of 5 mm. in October. One big one contained indistinguishable Copepod and other Crustacea remains, the other contained one *Pseudocalanus elongatus* and one *Anomalocera Pattersoni*. The small one contained 3 *Pseudocalanus elongatus* and one *Temora* nauplius.

LOPHIUS PISCATORIUS L. Angler.

Six specimens from outside the Breakwater were examined fresh from the tow-nettings in July, measuring 4 to 8·5 mm., 4 contained nothing, the other 2 indistinguishable Copepod remains.

COTTUS BUBALIS Euph. Father Lasher.

Twenty-two specimens, fresh, from the tow-nettings, were examined in March and April from inside and outside the Breakwater, measuring 4·5 to 10 mm. The smallest were however contracted and probably really were longer. The specimen of 10 mm. contained no food, one of 7 mm. contained a *Temora longicornis;* all the rest, excluding 4 containing nothing, contained green remains, Crustacea remains, diatoms or *Balanus* nauplii. The *Balanus* nauplii were in 7 specimens, and were in the smallest specimens. Evidently *Cottus bubalis* takes a mixed diet. One of 4·5 mm. contained the following :—

- 2 larval gastropods.
- 1 *Biddulphia regia.*
- 1 *Coscinodiscus radiatus.*
- 15 *Thalassiosira gravida.*

Another specimen also contained *Thalassiosira,* so that here we have one of the post-larval fish which does take diatoms as food.

TRIGLA GURNARDUS L. Grey Gurnard.

Only one specimen of 8 mm., from tow-nettings in the West Channel, contained one *Podon.*

AGONUS CATAPHRACTUS L. Armed Bullhead.

Two specimens, one from inside and one from outside the Breakwater in February and March, examined fresh from the tow-nettings. One contained nothing, the other one *Coscinodiscus excentricus.*

BLENNIUS GALERITA L. Montagu's Blenny.

One specimen from the White Patch, 17 mm. long, fresh from tow-nettings, July, contained 5 *Temora longicornis*.

BLENNIUS GATTORUGINE Bloch.

One specimen from the west end of Breakwater, fresh from tow-nettings, August, contained remains of crab zoeæ and Crangon larvæ.

GOBIUS MINUTUS Pall.

Twenty-four specimens, from both inside and outside the Breakwater, from fresh tow-nettings from July to September, were examined, measuring 2 to 14 mm. The smallest and most of those from 4 to 5 mm. contained no food, but one of 4 mm. contained remains of Copepod nauplii and one of 4·5 mm. contained a *Temora* nauplius. Those of 6 mm. contained Copepod remains including *Calanus* nauplii. From 6 5 mm *Pseudocalanus* was eaten and was in 3 specimens, one of which (14 mm. long) contained 3 *Pseudocalanus* and 4 *Temora*. Another of 14 mm. contained 3 *Acartia* sp. (probably *A. Clausi*).

The other Gobius species have not been identified. I have designated them Gobius sp. (a) and Gobius sp. (b). A third, very small and with orange and yellow pigment, contained no food.

GOBIUS SP. (a).

Nineteen specimens, from both inside and outside the Breakwater, fresh from tow-nettings, measuring 2 to 4 mm., in March and April. Ten contained nothing, one of 3 mm. contained a larval bivalve, one of 3·5 mm. a *Balanus* nauplius. One contained a *Coscinodiscus* and the remainder had green food remains in them.

GOBIUS SP. (b).

This is very like the larva of *Gobius niger* but with less pigment, and possibly may be *G. paganellus*. Nine specimens were examined from both inside and outside the Breakwater, in August fresh from the tow-nettings, measuring 11 to 13 mm. Two contained no food, one the remains of diatoms, including *Skeletonema costatum*, 2 contained green food remains and one a *Balanus* nauplius. The rest contained Copepods, all identified being *Temora*, adult, young and nauplii.

CRYSTALLOGOBIUS NILSSONI v. Düb. & Kor.

One fresh specimen from tow-nettings outside the Breakwater, October, measuring 21 mm. contained nothing. Twenty-eight preserved specimens from Haul XIII Y.F.T. 1914, all contained Crustacea, 13 contained *Podon*, and 2 *Calanus finmarchicus*, many remains probably representing the latter species. The specimens measured from 26 to 37 mm.

CALLIONYMUS LYRA L. Dragonet.

Forty-six fresh specimens from the tow-nettings were examined, from both inside and outside the Breakwater from March to October, from 1·5 to 8 mm. Up to 2 mm. yolk was present but diatoms or green food was sometimes present. *Coscinodiscus excentricus* and *C.* sp. *Paralia sulcata*, *Navicula* sp. and *Pleurosigma* sp. were present, at 3 mm. *Euterpina* was eaten, *Balanus* nauplii occasionally. Many of these small ones were empty.

222 preserved specimens from the Young Fish Trawl 1914 were examined, from 3 to 13 mm. At 3·5 mm. *Pseudocalanus* is eaten. After that a variety of Copepods including *Oncæa*, *Euterpina*, *Corycæus*, *Temora*, *Idya*, *Paracalanus*, *Calanus* and *Centropages*, with occasional *Podon* and *Apherusa*, also ova. The commonest Copepods taken are *Pseudocalanus* and *Euterpina*, *Temora* coming next. *Callionymus lyra* is thus a very miscellaneous feeder, beginning with diatoms when very young and soon feeding almost exclusively on Copepods.

CYCLOGASTER MONTAGUI Donov.

Four specimens from both inside and outside the Breakwater, March and April, 3·5 to 4·5 mm. Two contained nothing; one, diffuse brownish food remains, and one, remains of Crustacea.

CYCLOPTERUS LUMPUS L. Lump Sucker.

Two specimens from amongst the Zostera outside the Breakwater in July and August, 15 and 18 mm. That of 15 mm. contained 5 Amphipoda indet., and 1 *Harpacticus uniremis*, the other contained remains of *Eupagurus* larvæ and other larval decapods.

LEPADOGASTER CANDOLLEI. Risso.

Nine specimens from both within and outside the Breakwater, July and August, 4 to 8 mm. One of 4 mm. contained two young *Temora*, all the others (except one with nothing in it) contained remains of Copepods, including *Temora* nauplii and Harpacticids.

LEPADOGASTER GOUANI Lacep.

Five specimens from outside the Breakwater, August and October, 4 to 6 mm. The largest contained 1 *Centropages typicus* and 2 *Pseudocalanus elongatus*, 2 contained nothing, and the others Copepod nauplii and Harpacticids.

RHAMPHISTOMA BELONE (L.). Gar-fish.

Sixteen specimens from both within and without the Breakwater, July and August, from amongst Zostera, 10 to 29 mm., 6 contained nothing, 6 contained *Harpacticus uniremis*, the rest greenish food remains and 1 *Pleurosigma* sp.

PLEURONECTIDÆ.

Very few Pleuronectids were obtained fresh from the tow-nettings, but a large number from the Young Fish Trawl, 1914, were examined in a preserved state for food and show some interesting features. Thus we find they fall into two groups according to the form of the alimentary canal, which influences the food taken in the young forms. In the first group we may place those with a large mouth and a thick and short gullet and stomach; to this group belong *Solea variegata*, *S. vulgaris*, *S. lascaris*, *Pleuronectes limanda*, *Rhombus maximus*, *R. lævis*, *Zeugopterus punctatus*, *Z. unimaculatus* and *Scophthalmus norvegicus*. With this character goes the habit of taking such food as small Copepods and Cladocera at an early stage, so that the newly hatched fish very soon, and in some cases almost immediately, takes this food. The Plaice *Pleuronectes platessa* would probably be included in this group although in the very first stages after hatching it is known to eat diatoms and larval mollusks, soon however taking to Copepods and other small Crustacea, especially Entomostraca. The nearest to the Plaice in this respect is the Dab, *P. limanda*, which seems not to begin to eat Copepods until about 5 mm. in length, although it hatches under 3 mm. On the other hand *Solea variegata* hatches at about 2·5 mm. and at 4 mm. it may contain a fairly large *Temora* measuring 1·5 mm. *Scophthalmus norvegicus* hatches at about 2·5 mm. and still has yolk at 3·27 mm., but at 4·5 mm. it can eat a *Metridia* 2 mm. long. In these cases Copepods must be eaten very soon after hatching.

In the second group we may include *Pleuronectes flesus*, *P. microcephalus* and *Arnoglossus laterna* which have a long and narrow gullet and stomach, and these apparently do not eat Copepods or any Crustacea until a greater size is reached—the alimentary canal in the small specimens being either empty or showing indications of a diet of unicellular organisms, ova, diatoms or other microscopic plants. Thus in *Pleuronectes microcephalus* Copepods were only found in very few and these of the smallest kind in the larger fish, ova occurred in many, and diatoms (*Navicula* and *Pleurosigma*) and Peridinians in a few. In Arnoglossus

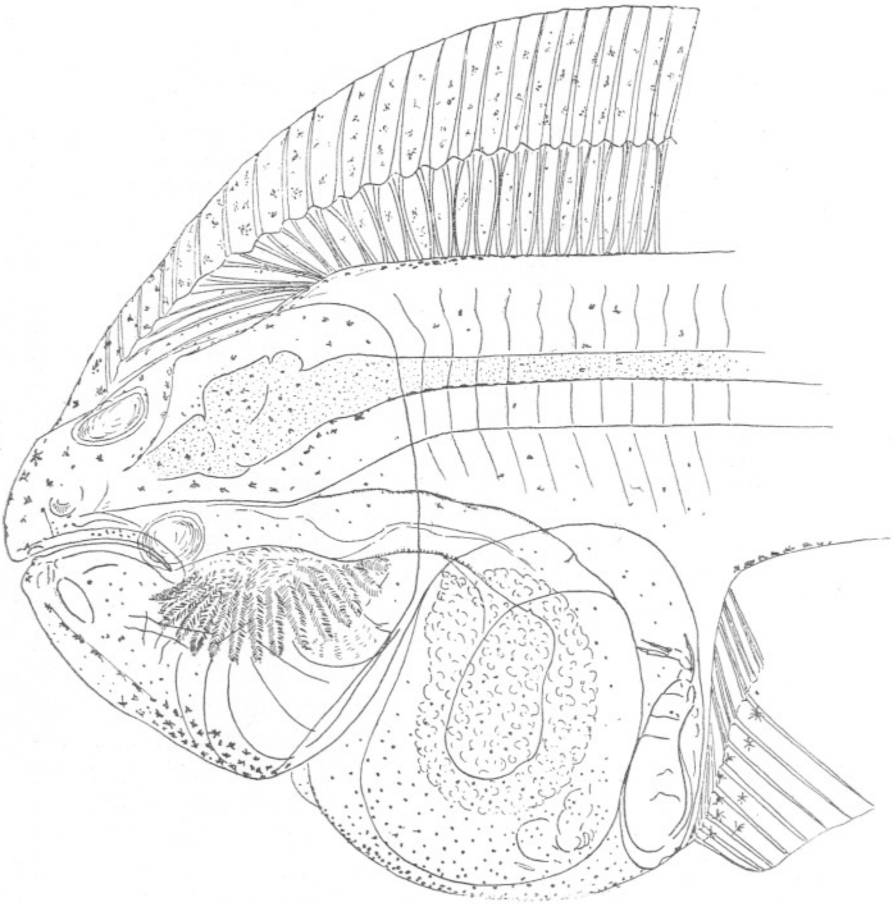

FIG. 1.—Post-larval *Solea variegata* 12 mm. long, from balsam preparation. Eyes seen through from left side.

only in those over 8 mm. were there any Copepods (*Pseudocalanus*). *Pleuronectes flesus* from 5·5 to 10 mm. had nothing inside larger than diatoms, but often diffuse masses which were apparently remains of unicellular organisms. Thus we have a great contrast between the two groups and a correlation between a large mouth with a broad, short gullet and stomach and an early diet of Entomostraca, and between a small mouth with a long and narrow gullet and stomach and an early more or less vegetarian diet, only going on to Entomostraca at a much later stage. (See Figs. 1–6.)

The large-mouthed forms do not all take the same kind of Crustacean food, but certain groups seem to do so. Thus *Solea variegata*, *S. vulgaris* and *S. lascaris*, *Pleuronectes limanda*, *Zeugopterus punctatus* and *Z. unimaculatus* take much the same sort of food, but *Scophthalmus norvegicus* differs in taking *Pseudocalanus* and *Metridia* chiefly, forms hardly

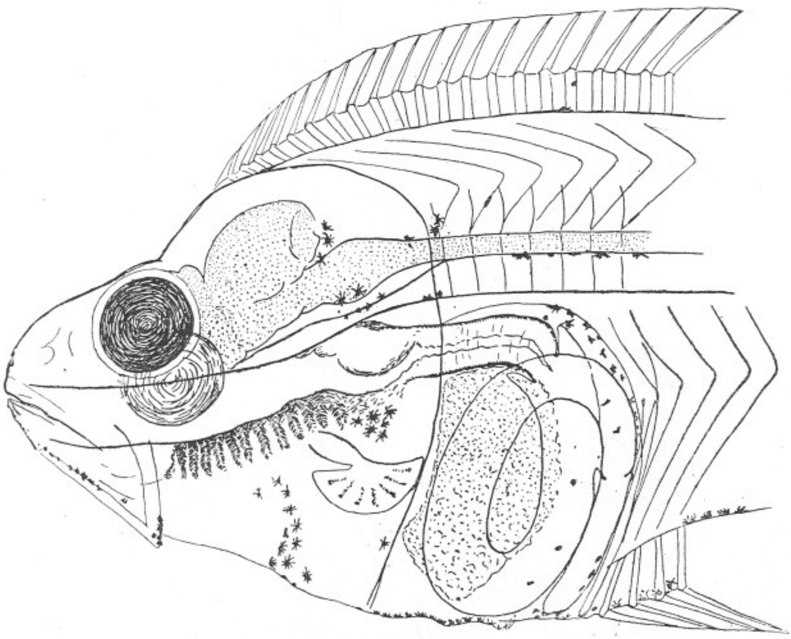

FIG. 2.—Post-larval *Pleuronectes limanda*, 12 mm. long, from a balsam preparation. Right eye seen through from left side.

taken at all by those mentioned above, *Pseudocalanus* on the other hand being the chief food of the larger post-larval *Arnoglossus*.

SOLEA VULGARIS Quensel. Common Sole.

Fourteen specimens examined, preserved, from Young Fish Trawl, 1914, 5·5 to 9·5 mm. The smallest contained Copepod remains, 3 contained nothing, 2 were indistinguishable and 2 contained ova. The rest contained Copepods (*Temora* and *Euterpina* and *Oncœa*), *Balanus* cypris stage and one contained a *Prorocentrum micans*. A. Scott (1906) found in a Sole of 7·5 mm., *Longipedia minor*, *Ectinosoma Sarsi* and *E. Normanni*, all littoral Copepods. Holt and Byrne (1905) state that between 7 and 11 mm. they feed largely on the larvæ of other fishes.

SOLEA LASCARIS Bonap. Lemon Sole.

Two specimens only, preserved, from Young Fish Trawl, 1914, 9·5 and 10·5 mm., one indistinguishable, the other containing *Temora* and *Euterpina*.

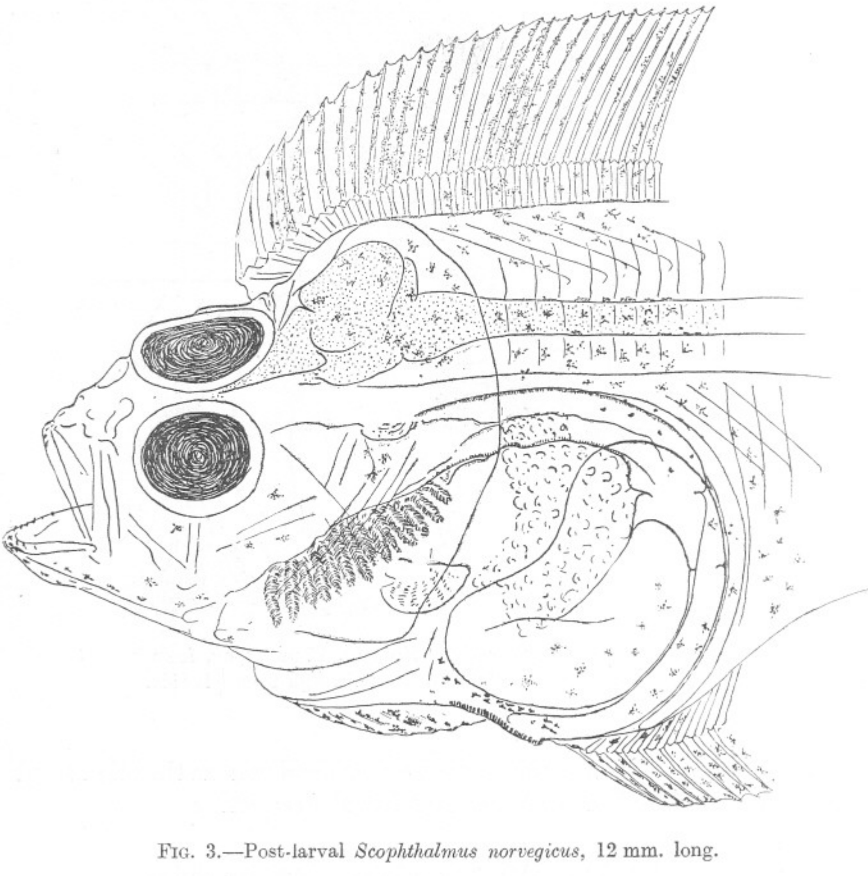

Fig. 3.—Post-larval *Scophthalmus norvegicus*, 12 mm. long.

SOLEA VARIEGATA Donov. Thickback.

221 specimens of the "Thickback" were examined, from the Young Fish Trawl, 1914, preserved. They varied in length from 4 mm. to 11·5 mm., and as it hatches at about 2·5 mm. some of them must be very

young. Twenty-two contained nothing, but the remainder had a good deal of food inside them, the smallest eating the same as the largest. Nearly all the food was Crustacea and small ova of two kinds, one with a tough sheath, the others without, and perhaps being ova of Copepods. The majority of the Crustacea were Copepods, Cladocera (*Podon*) coming next in abundance, and the cypris stage of *Balanus*. Of the Copepods the

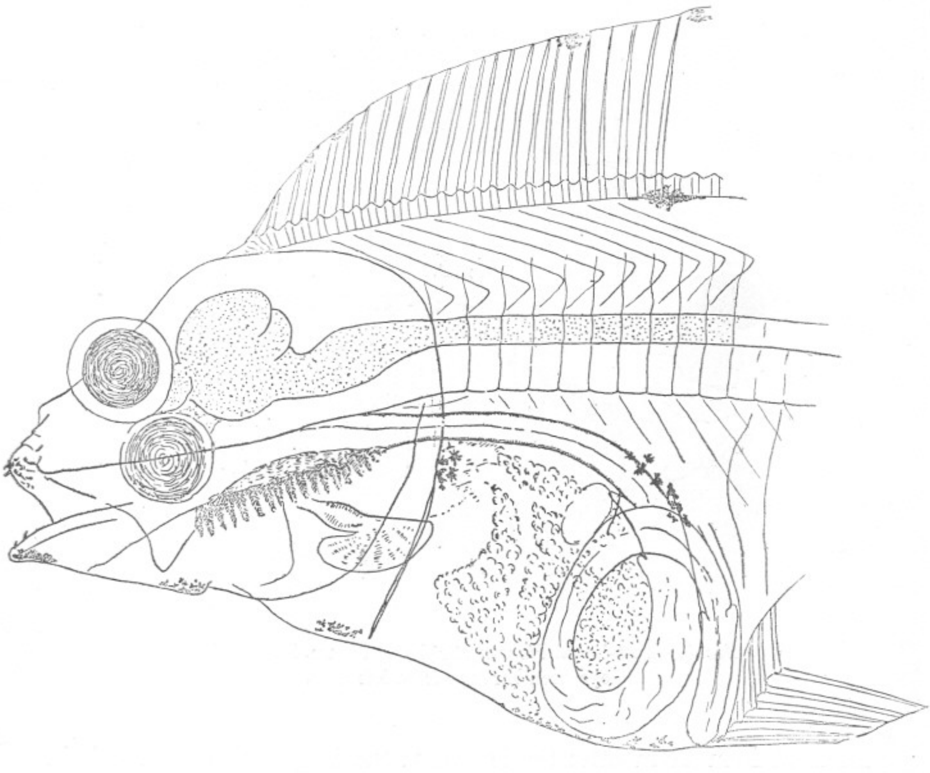

FIG. 4.—Post-larval *Pleuronectes microcephalus*, 12 mm. long. Right eye seen through from left side.

Harpacticid *Euterpina acutifrons* is the most frequent, occurring in 60 out of the 221 specimens, as many as 5 or 6 often being found in one individual. From May 22nd they are particularly abundant in Hauls XIII to XVII (for particulars of the hauls see Allen (1917) both from the region of the Eddystone and Rame, evening and morning, midwater and surface, and occur in fish from 4 mm. to 10·5 mm. long, very often with *Temora longicornis* and *Podon* (probably *intermedius*). *Temora*, as many as 6 in one individual, occurs in 51 out of 221 specimens, in all hauls except XVII and XXII (only one *Solea variegata* in the latter). They also are contained in the smallest (4 mm.) and the largest (11·5 mm.). A specimen of 4 mm. can swallow a *Temora* 1·5 mm. long. Other Harpacticids occurring rarely are *Longipedia Scotti* and *Microsetella norvegica*. *Oncæa* (cf. *media*) occurs fairly frequently, as many as 4 together, male and female, female the commonest. *Oncæa media* is a species not hitherto

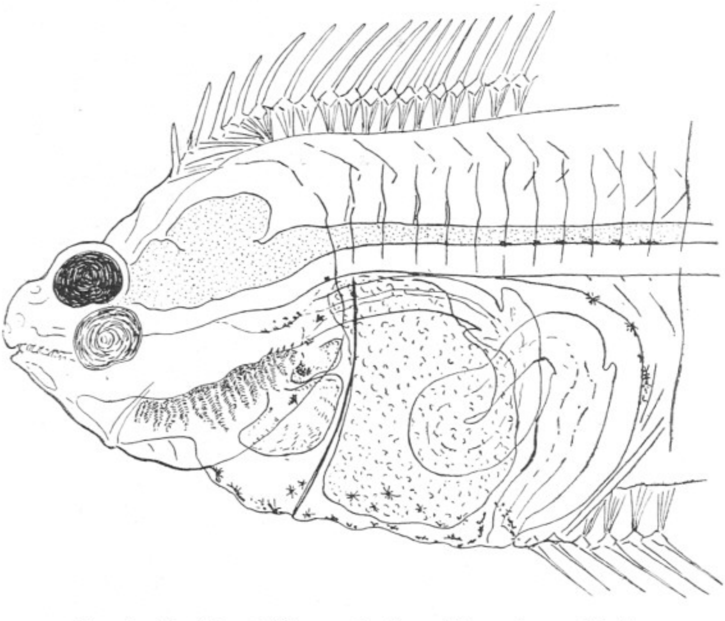

FIG. 5.—Post-larval *Pleuronectes flesus*, 10 mm. long. Right eye seen through from left side.

recorded from Plymouth ; the length of the body is less than it is in *O. mediterranea* and *O. venusta* and the caudal furca are different. It occurs in 25 out of 221. *Corycæus anglicus* occurs rarely, *Acartia* (cf. *Clausi*) and *Pseudocalanus elongatus* occur once only, singly, and evidently not liked by the fish, as they certainly occur in the hauls and are taken by other young fish (e.g. *Scophthalmus*).

Podon intermedius occurs in 76, thus it is the form most frequently taken. It occurs in specimens from most of the hauls, in the smallest and also in the largest.

Balanus cypris stages occur in 9 specimens. Larval gastropods occur only occasionally. Besides the ova, minute organisms such as Infusoria, Peridiniales and diatoms occasionally occur, generally contained in diffuse masses, which may be from the alimentary canal of the Crustacea eaten. They apparently form an unimportant part of the diet. *Tintinnopsis ventricosa* is the only Infusorian, *Peridinium* sp. and *Prorocentrum micans* the only Peridinians and *Paralia sulcata*, *Navicula* sp. and *Pleurosigma*

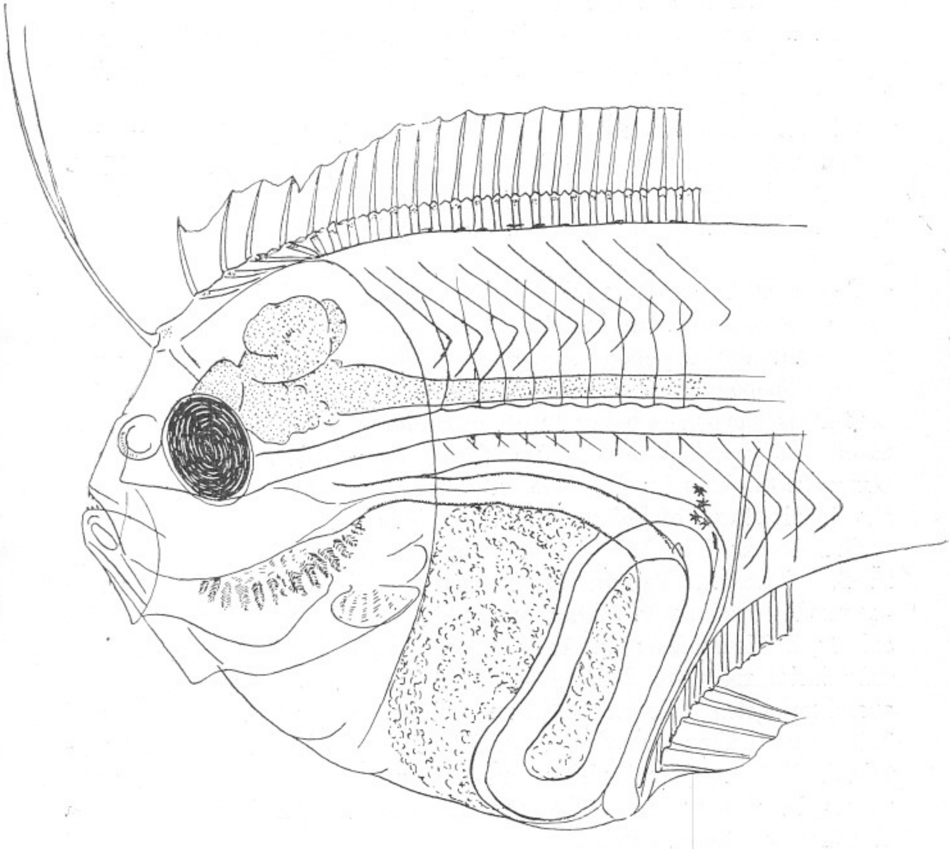

FIG. 6.—Post-larval *Arnoglossus laterna*, 12 mm. long.

sp. occur among the diatoms, especially chains of *Paralia sulcata*. Small bodies, possibly spores, also occur.

Apparently the smallest and the largest specimens feed on the same kind of food, as no difference was found. Also in May and June the months when the hauls were taken, no difference is found. Although so few specimens of *Solea vulgaris* and *S. lascaris* were examined, the evidence seems to point to their taking the same kind of food as *S. variegata*.

PLEURONECTES LIMANDA L. Dab.

1353 specimens of the "Dab" were examined, preserved, from the Young Fish Trawl, 1914. These measured from 4 to 17 mm. in length. 416 contained no food, chiefly the smaller specimens; in those from 4 to 4·5 mm. no food could be detected, the food taken at this stage probably being very minute. Remains of small Copepods first occurred in those of 5 mm. Fairly large Copepods, such as *Temora*, occurred from 7 mm. upwards, but not in those of a smaller size. Nearly all the food recognized was Crustacea or ova.

Of the Crustacea recognizable *Podon* (cf. *intermedius*) was the commonest, occurring in 427. Those from Hauls V to X and XVII to XLVIII did not contain *Podon*, which looks as if *Podon* if present in numbers is preferred, but certain Copepods may be taken instead.

Copepods, Copepod nauplii, Copepod remains and fæces occurred in 382, Crustacea remains, indistinguishable, in 91. *Temora longicornis* is the commonest Copepod, occurring in 170 from 7 mm. long upwards. Other Copepods were Harpacticids in 52, 46 of which were *Euterpina acutifrons*, the others being unrecognizable. Other Copepods occurring rarely are *Pseudocalanus* (in 10), *Oncæa* (in 7), *Metridia lucens* (in 3) *Corycæus anglicus* (in 3). The only other Crustacea recognizable were the Cypris stages of *Balanus* in one specimen.

Ova occurred in 198 specimens, spores (?) in 10, larval Mollusks in 2. Diatoms, Peridinians, Infusoria and *Distephanus speculum* occurred occasionally. Diatoms in 13, 6 of which were *Paralia sulcata*, 1 *Pleurosigma* sp., 1 *Fragillaria* sp., 1 *Coscinodiscus* sp. The only Infusoria were *Tintinnopsis ventricosa* in 6. Two *Distephanus speculum* occurred in one of 6 mm. Kyle (1898) examined 30 out of 300 young Dabs measuring 10 to 16 mm., and found they only contained diatoms (*Coscinodiscus* and others) although Copepods were resent in the water. The present records certainly show that Crustace are taken earlier.

PLEURONECTES FLESUS L. Flounder.

Two fresh post-larval Flounders were examined from the tow-nettings, one from inside and one from outside the Breakwater in May. The first, 8·5 mm. contained nothing, the second, 10·5 mm. which occurred on May 31st, when the tow-nettings were full of the flagellate *Phæocystis*, had its alimentary canal full of *Phæocystis* spores. Forty-two preserved specimens from the Young Fish Trawl, 1914, were examined, 5·5 to 10·5 mm., 15 of which contained nothing, the rest diffuse remains almost certainly vegetable, one containing *Paralia sulcata* and *Fragillaria* sp. Not one contained any Crustacea remains, and here we have a very distinct difference between the Flounder and Dab and the various species of Solea. The gullet and stomach of the Flounder is long and narrow and the mouth small, which go with its method of feeding.

PLEURONECTES MICROCEPHALUS. Donov. Merry Sole.

Only one fresh specimen was obtained from the tow-nettings, West Channel in April, but it was very small, 4 mm. with yolk sac and no food.

247 preserved specimens from the Young Fish Trawl, 1914, were examined, 5·5 mm. to 18·5 mm. Of these 195 contained no food, 35 contained ova; only one Copepod was distinguished, *Euterpina acutifrons*, in a specimen 10 mm. long. *Podon* (cf. *intermedius*) occurred in 3, 8·5 to 10 mm. long. Sixteen contained remains of Crustacea, 5 of which were recognizable as remains of small Copepods. One *Peridinium* sp. occurred and diatoms (*Navicula* and *Pleurosigma*) occurred in 3.

Thus the food of the "Merry Sole" is much more like that of the Flounder, than of the Dab and Sole, and its mouth and alimentary canal are of the small and narrow type which seems to go with a vegetarian diet, or at any rate a diet of small and soft organisms other than Crustacea.

ARNOGLOSSUS SP. (Walb.).

These are chiefly *A. laterna*. 288 specimens, preserved, were examined from the Young Fish Trawl, 1914, 3·5 to 22·5 mm. long. Nearly all the smaller specimens were from the early hauls (XIII to XXXVI). Most of the larger specimens being from the later hauls (XLII to LXXXIII). The alimentary canals of all the small specimens up to 8 mm. (except one ovum in a specimen of 5 mm.) were empty; one of 8·5 mm. contained *Pseudocalanus*, but with that single exception those measuring 8·5 to 10 mm. were empty. From 10·5 mm. to 22·5 mm. some specimens contained Copepods, but very many were empty. 241 out of 288 were empty, and of these 208 were from the early hauls in which only 3 contained anything, one of 5 mm. containing an ovum, and 2 specimens of 14 mm. in Haul XXXVI containing *Pseudocalanus*, which is the earliest appearance of a Copepod in any of the specimens. Twenty-five contained Copepods, 18 of which were *Pseudocalanus* (as many as 15 in one specimen 19·5 mm. long), one contained *Paracalanus parvus* and one *Euterpina acutifrons*. From this it seems that the smaller specimens do not eat Copepods and the larger specimens only eat the small species. Only a very few diatoms occurred, *Paralia sulcata* once and *Navicula* spp. in the Copepod fæces. Here again we have with the small mouth and narrow gullet and stomach an absence of Crustacea food in the young and only small Copepods in the older forms.

RHOMBUS MAXIMUS L. TURBOT.

Two specimens were examined fresh from tow-nettings from within and outside the Breakwater in August, 11·5 and 14 mm. The first contained 15 *Temora longicornis*, the second 2 *Balanus nauplii* and 3 *Centropages typicus*. One preserved specimen (mounted) from the Young Fish Trawl was too much pigmented for the food to be distinguishable.

RHOMBUS LÆVIS RONDEL. BRILL.

Two specimens were examined fresh from the tow-nettings within and outside the Breakwater in July and August, 14 and 18 mm. long. The first contained Copepod remains indistinguishable, the second contained 7 *Temora longicornis*, 3 *Centropages typicus*, 3 *Brachyura* zoeæ, 9 *Hippolyte* larvæ and a Nematode probably parasitic. Five preserved specimens from the Young Fish Trawl, 1914, were also examined, all of which contained *Podon* (cf. *intermedius*) and one also contained *Centropages*. Cunningham (1890) found that young Brill of 2·2 to 2·5 cm. ate the young Flounders of 12 mm. and he thinks that they probably naturally prey upon young fish at that stage, when they are nearly completely metamorphosed.

Both the young Turbot and Brill have a very large mouth with a thick gullet and wide stomach.

ZEUGOPTERUS PUNCTATUS (BL.).

Thirty-five specimens examined, preserved, from the Young Fish Trawl, 1914, 5 to 10·5 mm. long. The smallest contained ova, but at 6 mm. a specimen contained 4 adult *Temora longicornis*. They appear to feed very much like *Solea*, 23 contained *Temora*, 10 contained *Euterpina acutifrons*, 2 contained *Oncœa* (cf. *media*). *Calanus finmarchicus* occurred in one and *Metridia lucens* in one. Ova were frequent. A good many of the Copepod remains were indistinguishable.

ZEUGOPTERUS UNIMACULATUS (RISSO).

Fifteen specimens, preserved, were examined from the Young Fish Trawl, 1914, 4·5 to 9·5 mm. long. The food content was not easily seen, but all except 2 contained Crustacea. One of 4·5 mm. contained remains of Crustacea but indistinguishable. *Temora longicornis* occurred in 3, *Euterpina acutifrons* in one, *Podon* (cf. *intermedius*) in 3. *Paracalanus parvus* and *Pseudocalanus elongatus* occurred in one specimen.

These two Zeugopterus have large mouths and short and thick gullets and the food is much like *Solea* and *Pleuronectes limanda*.

SCOPHTHALMUS NORVEGICUS (Gthr.).

404 specimens, preserved, were examined from the Young Fish Trawl, 1914, 3·5 to 12 mm. long. There were only 2 of 12 mm. and neither of them contained any food. Thirty-six contained nothing, 34 contained ova only, two were indistinguishable and the rest contained Crustacea, chiefly Copepods, *Podon* occurring in several. Copepod remains which were indistinguishable were in 55 specimens of all sizes. The smallest (3·5 mm.) contained Copepod remains (probably *Pseudocalanus*) so as *Scophthalmus norvegicus* hatches at about 2·5 mm. it must take Copepod food almost directly. A specimen 4·5 mm. long contained a *Metridia lucens* 2 mm. long. One of 4 mm. contained a *Paracalanus parvus*, so there is no evidence that the smaller specimens eat anything different from the larger specimens, the same sort of food being found in all of them in these samples. A very few contained diatoms (*Paralia sulcata* and *Navicula* sp.), which very likely come from the alimentary canal of the Copepods. One specimen of 4 mm., which contained Copepod remains, contained also *Peridinium ovatum, Prorocentrum micans* and remains of other Peridinians. One contained *Tintinnopsis ventricosa*. Spores occurred once. Much more food was found in the specimens from Hauls X to XVI and little food in those from the later hauls.

Ova occurred in 34 specimens without anything else and in 65 specimens altogether. They are more abundant from the later hauls. Apparently when many Copepods are eaten these are not taken so much. All sizes eat them, but they are commonest in the smaller specimens of from 4 to 5·5 mm.

Copepods are evidently the favourite food and are found in 334 specimens. The favourite is certainly *Pseudocalanus elongatus*, which occurs in 158 specimens, as many as 6 at once and in all sizes from 4 to 11·5 mm., one of 3·5 mm. probably containing it also. It is very abundant, especially from Hauls X to XVI, absent from XVIII to XXVI.

The next favourite is *Metridia lucens*, which occurs in 75 specimens, up to 3 in one specimen, in all sizes from 4·5 mm. upwards, in the same hauls as *Pseudocalanus elongatus*. Next come *Acartia* (cf. *Clausii*) in 49, *Oncæa* (cf. *media*) in 26, *Paracalanus parvus* in 25, *Euterpina acutifrons* in 20, *Temora longicornis* in 6 only, and *Temora* nauplii in 4. *Calanus finmarchicus* (juv.) in 2 and *Corycæus anglicus* in one.

It is thus seen that a variety of Copepods is taken, but *Pseudocalanus* markedly predominates.

Seventy-one specimens were in Haul X and these contain almost entirely Copepods, chiefly *Pseudocalanus* and *Metridia*, *Acartia* also being fairly frequent. *Euterpina* and *Oncæa* not common and *Podon* occurs a few times, *Temora* only once. Comparing this with *Solea variegata* from the same haul we find *Solea* has chiefly eaten *Temora* and *Podon*, so that selection of food must take place. It is the same in Hauls XI, XII and XIII. In XIII *Pleuronectes limanda* has also selected chiefly *Podon* and a few *Temora*. In Haul XVII large Copepods seem rare and in XXIII the fish have eaten little.

GADIDÆ.

The Whiting, *Gadus merlangus*, is the commonest gadoid in the townettings, the Pouting, *G. luscus*, coming next. From the Young Fish Trawl a number of *G. merlangus* and *G. minutus* were examined, the Whiting not showing the food well in the preserved material. *Pseudocalanus* appears to be the favourite food of all the post-larval gadoids except the very young specimens.

GADUS MORRHUA L. Cod.

Only one specimen from inside the Breakwater, fresh from the townettings in May, 19 mm. This contained one *Calanus finmarchicus* and one *Temora longicornis*.

GADUS MERLANGUS L. Whiting.

Twenty-seven specimens examined fresh from the tow-nettings, April to July, from both inside and outside the Breakwater, from 4 to 34 mm. The first obtained on April 2nd and 4th were 4 mm. long; one had nothing inside, the other had 2 nauplii of *Calanus finmarchicus* and one *Coscinodiscus Granii*; one of 2·5 mm. ca. contained no food, but one of 3 mm. contained Copepod remains. The rest, excepting 3 which were empty, contained Copepod remains, of which 11 contained *Pseudocalanus elongatus* (from 1 to 3), 2 contained *Paracalanus parvus* and the rest were indistinguishable. The specimen of 34 mm. contained indistinguishable Copepods.

At 4 mm. nauplii are eaten and at 5 mm. full-sized *Pseudocalanus*.

171 preserved specimens from the Young Fish Trawl, 1914, were also

examined, but the contents were very difficult to identify. Size 6 to 11·5 mm., 49 contained nothing, 7 contained only ova, 2 contained *Evadne*, and the remainder contained Copepods. Except one *Oncæa*, all those identified were *Pseudocalanus*, and those not identified were probably *Pseudocalanus*.

GADUS LUSCUS L. Pouting.

Sixteen small specimens were examined fresh from the tow-nettings from both within and outside the Breakwater, from January to April, 1·5 to 7 mm. long. In October 2 more were obtained and one in November. The yolk sac was present in those up to 2·5 mm., and these contained no food, 2 of 3 mm. contained nothing, 2 contained green food remains and one (from the region of the Knap Buoy) contained a *Coscinodiscus* and a *Coccosphæra* sp. (cf. *atlantica*) in perfect condition. In October one of 4 mm. contained a *Pseudocalanus elongatus* and one of 7 mm. contained 2 *Pseudocalanus*, one *Acartia clausi* and one live *Calanus finmarchicus* just swallowed, with its tail sticking out of the mouth, apparently having been caught after the fish had been captured.

From the small amount of material available it would appear that the character of the food is changed at about 4 mm., those of a smaller size eating microscopic food and after that changing to a Copepod diet.

GADUS POLLACHIUS L. Pollack.

Eleven preserved specimens from the Young Fish Trawl, 1914, were examined, 5·5 to 24 mm. The smallest contained Copepod remains, 2 contained nothing and the rest Copepods mostly indistinguishable, but 3 contained *Acartia* (cf. *Clausi*) and one *Temora longicornis* and *Euterpina acutifrons*.

GADUS MINUTUS O. F. Müll. Bib.

140 preserved specimens from the Young Fish Trawl, 1914, were examined, from 6 to 14 mm. Of these 4 contained nothing, one contained ova, one a *Dinophysis* sp. and all the rest contained Copepods, 6 of which were indistinguishable, but all the rest contained *Pseudocalanus elongatus*. *Podon*, *Acartia*, *Euterpina* and *Metridia* each occurred once with *Pseudocalanus*. It is quite evident that *Pseudocalanus* is the favourite food of *Gadus minutus* and it occurs in those of all sizes examined.

ONOS MUSTELA L. Rockling.

Thirteen fresh specimens from the tow-nettings were examined, from both inside and outside the Breakwater, from 2 to 26 mm. long, from March to August. The small ones below 3 mm. had a yolk sac and contained no food, but in one of 3 mm. 2 *Temora* nauplii were present. One of 5 mm. contained ova and one of 5·5 mm. *Temora* nauplii, 2 of the others contained nothing and the rest contained indistinguishable Copepod remains.

AMMODYTES TOBIANUS L. Lesser Sand Eel.

Twelve specimens were examined fresh from the tow-nettings from both inside and outside the Breakwater, from 4·5 to 6·5 mm. from February to March and again in October. The smallest contained no food, but those from 5 mm., except one which was empty, all contained green food remains.

AMMODYTES LANCEOLATUS Lesaur. Larger Launce.

Thirty specimens were examined fresh from the tow-nettings from both inside and outside the Breakwater, from 7 to 14 mm., from July to October. Twenty-one contained no food, one of 8 mm. contained green food remains, the rest contained Copepods, 4 indistinguishable, *Acartia clausi*, *Pseudocalanus elongatus*, *Oithona* sp. and Copepod nauplii being recognized. One of 10 mm. contained Copepod nauplii and 5 *Rhizosolenia Shrubsolei*, the only time that diatom was seen in a fish.

GASTEROSTEUS SPINACHIA L. 15-Spined Stickleback.

Three 15-spined Sticklebacks were examined fresh from the tow-nettings, from among Zostera, both inside and outside the Breakwater in August and September, 7·5 to 8·5 mm. Two contained no food, the other contained remains of Amphipods and many Harpacticids.

SYNGNATHUS ACUS L. Greater Pipe Fish.

Five specimens were examined fresh from the tow-nettings from among the Zostera from both inside and outside the Breakwater, August to October, 2·5 to 6·5 cm. long. One contained nothing, one contained remains of *Temora* nauplii and *Pseudocalanus elongatus*, one contained 9 *Centropages typicus*, one contained many *Pseudocalanus*, one *Temora*, 2 *Acartia Clausi*, one *Corycæus anglicus* and the remains of *Centropages typicus*, the last contained 2 *Temora*, 4 *Centropages typicus*, many *Pseudocalanus* and 2 *Paracalanus parvus*.

SYGNATHUS ROSTELLATUS Nilss.

Three specimens examined fresh from the tow-nettings, from among Zostera, both inside and outside the Breakwater, August and September, 4·5 to 10·5 cm. Two contained remains of Decapods, the third contained 3 crab zoeæ, one Acartia sp., 8 *Pseudocalanus elongatus* and other Crustacea remains.

NEROPHIS LUMBRICIFORMIS Yarr.

Three specimens examined fresh from the tow-nettings from both inside and outside the Breakwater, August and October, 10 to 40 mm. 2 contained nothing, the third a young Copepod and 3 Copepod nauplii.

The young begin to feed almost at once. A male with eggs from Wembury was put in a glass jar and kept at a uniform temperature by immersing in a tank and the eggs hatched. Plankton was given at once, and after the first day, when a large yolk sac was present, the little fish ate *Halosphæra viridis*, larval Mollusks and small Copepods.

CLUPEA HARENGUS L.

1795 larval and post-larval Herrings were examined fresh from the tow-nettings, from both inside and outside the Breakwater, from January to March and again in October, measuring 5·5 to 18 mm. The yolk sac was present in all those from 5·5 to 8 mm., but it may remain up to 12 mm. in exceptional cases. However, even with the yolk present, from 7 mm. food may be taken. The yolk seems to stay longer in some lots, as though there were a shortage of food in certain areas with a consequent lengthening of time in keeping the yolk. The smallest specimen with any food inside measured 7 mm., and that was only green food remains. At 8 mm. Harpacticids may be taken and larval Mollusks.

On January 30th, 589 specimens from 7 to 12 mm. (mostly 7 to 10 mm.) were taken and all of these, except one of 12 mm., contained no food, the exception containing one *Euterpina acutifrons*. Those measuring from 7 to 10 mm. all had the yolk sac still present. On February 1st another lot of 431, measuring from 8 to 10 mm. all had the yolk sac still present except one of 10 mm., but 35 contained food, 16 of these containing larval gastropods, 2 larval bivalves, 12 green food remains, one a Harpacticid, one a Copepod nauplius, one 2 Peridinians (*Prorocentrum micans* and

Gonyaulax spinifera), one a diatom (*Paralia sulcata*). Green food remains are in the smallest, then larval Mollusks, Copepods coming next. On February 6th, 120 specimens taken are much like the last, even those 11 mm. long. Most of them contain no food, but green food, larval gastropods, larval bivalves, *Temora* nauplii, ova and Harpacticids were present. On February 9th it is the same sort of thing, but on February 13th, when evidently the *Balanus* nauplii had just appeared, they were taken by several of the young herring. Out of 234 specimens from 7 to 12·5 mm. long, most of those above 8 mm. had lost the yolk, 46 contained *Balanus nauplii*, 2 contained *Pseudocalanus elongatus*, 4 contained *Euterpina acutifrons*, one contained *Oithona similis*, several contained larval gastropods, larval bivalves and green food remains. It seems that with the coming of abundance of food the yolk sac disappears much earlier. On February 22nd *Balanus* nauplii were again frequently eaten, *Oncæa* sp. once, *Evadne Nordmanni* once (peculiarly early for this Cladoceran). Up to March 15th the same kind of food is present and then the Herrings stop, not appearing again until October 17th, when from that date to the middle of December they were caught in small numbers measuring from 8 to 18 mm. but not containing any food.

The earliest caught Herring, January 10th to 23rd, were further advanced than those taken late in January and early in February. Several from 9·5 to 13 mm. containing *Euterpina acutifrons*, *Pseudocalanus elongatus* (one of 12 mm. containing 5 *Pseudocalanus*), *Oithona similis*, *Corycæus anglicus* and Copepod nauplii, *Pseudocalanus* being the most frequent.

A few contained sand grains, others diatoms amongst which were *Campylodiscus* sp., *Hyalodiscus stelliger*, *Coscinodiscus* sp. and *Paralia sulcata*. The flagellate *Halosphæra viridis* was contained in 3, and possibly spherical bodies sometimes present are *Halosphæra*. The frequent presence of sand grains and the character of the diatoms, which are all bottom forms although often present in the plankton, suggests that the young herring sometimes feeds on the bottom.

From the above records it is seen that the larval herring eats before the yolk sac has gone, the earliest food being green food, afterwards larval Mollusks, both gastropods and bivalves, small Copepods and Copepod nauplii, Balanus nauplii and occasional diatoms and *Halosphæra viridis*. This agrees well with records by H. A. Meyer (1880) when feeding young Herring reared artificially. He found the greenish matter, larval gastropods and bivalves, Copepods and nauplii, the Copepod diet increasing as the fish grew. McIntosh (1889) has also noticed the green food remains in the very young Herring.

CLUPEA SPRATTUS L.

164 specimens were examined fresh from the tow-nettings, from both inside and outside the Breakwater, from January to May and from July to November, the bulk from January to April, measuring 3 to 27 mm. Those from 3 to 4 mm. have no eye pigment, a large yolk sac and no food. From 4·5 mm. the eye is pigmented and, although yolk may still be

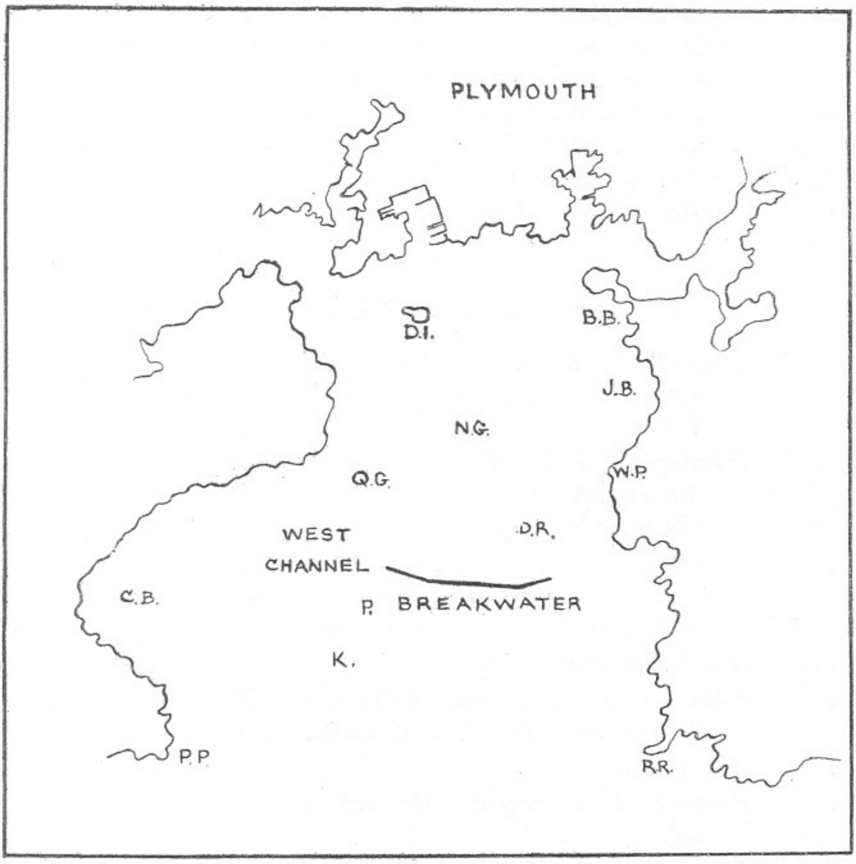

Fig. 7.—Plan of Plymouth Sound. B B = Batten Bay. C B = Cawsand Bay. D I = Drake's Island. D R = Duke's Rocks. J B = Jennycliff Bay. K = Knap Buoy. N G = New Grounds. Q G = Queen's Grounds. P = Panther Buoy. P P = Penlee Point. R R = Reny Rocks. W P = White Patch.

present, green food remains occur and also in the larger specimens. A spherical body which may be *Halosphæra* was present in one. From 4·5 mm. and upwards the yolk sac disappears, but green food remains are still present, probably from diatoms, as 6 *Thalassiothrix nitzschioides* were present in one of 5 mm. Not until July, in a specimen of 8 mm., is any crustacean food present, and this specimen contained 2 *Temora* nauplii in addition to green food remains. On October 3rd a specimen of 27 mm. contained 2 *Pseudocalanus elongatus*.

It thus appears that green vegetable food is taken chiefly, although at 8 mm. small Crustacea may be eaten. An examination of preserved material showed poor results, although *Pseudocalanus* was present in a few specimens and also larval Mollusks. A. Scott (1906) records *Pseudocalanus elongatus* from 2 Sprats of 15 mm., so it is evidently a favourite food of the larval Sprat.

The tow-nettings were taken with ordinary coarse and medium nets, and sometimes with a bigger net, which although not giving much better results, caught the fish from the Zostera, which evidently were feeding there. These included *Rhamphistoma belone*, various pipe fish and *Cyclopterus lumpus*. A small plan is given showing the various localities from which the tow-nettings were taken. (Fig. 7.)

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RECORD OF LARVAL AND POST-LARVAL FISH FROM THE TOW-NETTINGS.

Date.	Locality.	Fish.	No.	Size in mm.	Food present.
Jan., 1917					
10	West end of Breakwater	Clupea harengus	15	9·5–11·5	*Oithona similis*, *Pseudocalanus elongatus*, *Euterpina acutifrons*, *Copepod* nauplii, larval bivalves.
	Knap	,,	8	11–12	*Pseudocalanus elongatus*, *Euterpina acutifrons*, *Corycæus anglicus*, young Harpacticids.
16	Off White Patch	,,	2	10·5–11	*Pseudocalanus elongatus*.
		Gadus luscus	1	7	*Pseudocalanus elongatus*.
	West end of Breakwater	Clupea harengus	5	11·5–12	No food.
	West Channel	,,	4	10–12	*Pseudocalanus elongatus*.
	Knap	,,	2	5·5–12	No food.
18	West Channel	,,	10	5·5–13	*Pseudocalanus elongatus*.
	Off White Patch	,,	3	5·5–12	*Oithona similis*.
		Clupea sprattus	1	3·5	No food.
	Breakwater	Clupea harengus	5	9–14	Copepod remains.
	New Grounds	,,	14	6–13	*Pseudocalanus elongatus*, Harpacticids, Copepod nauplii.
	Knap	,,	4	10–13	*Pseudocalanus elongatus*, *Oithona similis*, *Euterpina acutifrons*.
		Clupea sprattus	5	3·5–3·6	No food.
23	Batten Bay	Gadus luscus	1	4	,,
		Clupea harengus	1	11·5	,,
	Off White Patch	,,	2	9–12	,,
	Inside Breakwater	,,	2	11	,,

Date. Jan.	Locality.	Fish.	No.	Size in mm.	Food present.
30	Inside Breakwater	Clupea harengus	205	7–12	*Euterpina acutifrons.*
		Clupea sprattus	1	4–4·5	No food.
	Off White Patch	,,	7	3–6	Green food remains.
		Clupea harengus	112	7–10·5	No food.
	Jennycliff Bay	,,	41	7–10·5	,,
	West Channel	,,	231	6–9	,,
Feb.		Clupea sprattus	5	4–5	Green food remains.
1	West Channel	Clupea harengus	147	8–10	Larval gastropods, green food remains.
		Clupea sprattus	3	3·2–5·5	No food.
	Off White Patch	,,	2	4	,,
		Clupea harengus	284	8–11	Green food remains, larval gastropods, larval bivalves, *Paralia sulcata*, Harpacticids, *Prorocentrum micans*, *Gonyaulax spinifera*, Copepod nauplius.
6	Jennycliff Bay	,,	41	9–12	Larval gastropods, *Temora* nauplius.
	Batten Bay	,,	29	9–11	Larval gastropods
		Clupea sprattus	1	3·5	No food.
	Middle of Breakwater	Clupea harengus	16	9–12	Larval gastropods.
	Breakwater	,,	34	10–12	Green food remains, larval gastropods, *Temora* nauplii.
9	New Grounds	,,	79	7–10	Green food remains, larval gastropods.
		Cottus bubalis	1	5	No food.
	White Patch	Clupea harengus	54	7–10	Larval gastropods, ova, green food remains.
		Clupea sprattus	3	4	No food.
	Jennycliff Bay	Clupea harengus	45	8–10	Larval gastropods, ova.
13	West Channel	,,	56	7–12·5	*Pseudocalanus elongatus*, *Euterpina acutifrons*, Copepod remains, *Balanus* nauplii, green food remains, larval gastropods, larval bivalves, *Halosphæra viridis*, *Coscinodiscus radiatus*.
		Clupea sprattus	4	4·5–5	Green food remains.
	Breakwater	,,	1	5·5	,, ,, ,,
		Clupea harengus	60	7–11·5	Green food remains, *Balanus* nauplii, larval gastropods, larval bivalves, *Campylodiscus* sp.
	Off White Patch	,,	30	8–11	*Balanus* nauplii, larval bivalves, ova, green food remains.
		Clupea sprattus	1	3·5	No food.
		Cottus bubalis	1	5	Crustacea remains.
		Gobius sp.	1	3·5	No food.
	Jennycliff	Clupea harengus	88	8–12	Green food remains, *Balanus* nauplii, ova, larval gastropods, larval bivalves, *Euterpina acutifrons*, *Hyalodiscus stelliger*.
		Clupea sprattus	1	4·5	No food.

Date. Feb.	Locality.	Fish.	No.	Size in mm.	Food present.
20	Off White Patch	Clupea harengus	6	10–12·5	*Balanus* nauplii.
	Duke's Rock	,,	20	9–12·5	*Balanus* nauplii, ova.
	Jennycliff Bay	,,	2	11	No food.
	New Grounds	,,	19	8·5–14	*Balanus* nauplii, Copepod nauplii, larval gastropods.
22	Knap	,,	35	9–12	Green food remains, larval gastropods, larval bivalves, *Balanus* nauplii, *Oncæa* sp., *Coscinodiscus* sp., *Hyalodiscus stelliger*.
		Clupea sprattus	4	4·5–5	Green food remains.
		Agonus cataphractus	1	8·5	No food.
	Panther	Clupea harengus	32	8–10	Green food remains, *Balanus* nauplii, larval gastropods, larval bivalves.
		Clupea sprattus	1	5	Green food remains.
	Penlee	,,	1	5	No food.
		Clupea harengus	12	8–10·5	*Balanus* nauplii, larval gastropods, *Evadne nordmanni*.
	Cawsand	,,	8	10–13·5	*Balanus* nauplii, larval bivalves, *Halosphæra viridis*.
27	Panther	Clupea harengus	2	8·5–10	*Balanus* nauplii, green food remains.
		Clupea sprattus	8	3·5–5	Green food remains.
		Cottus bubalis	1	5	*Balanus* nauplii.
	Breakwater	Clupea sprattus	5	3–5	Green food remains.
		Ammodytes tobianus	2	4·5	No food.
	Off White Patch	Clupea harengus	1	8·5	,,
		Clupea sprattus	5	3–5	Green food remains.
March.		Gobius sp.	1	3·5	,, ,, ,,
1	Off White Patch	Clupea sprattus	1	5	Green food remains.
	Breakwater	,,	1	3·5	No food.
		Clupea harengus	1	10	,,
	Knap	Clupea sprattus	2	4	,,
		Ammodytes tobianus	1	4·5	Green food remains.
	Panther	Clupea harengus	1	6	No food.
		Clupea sprattus	4	4·5	,,
	Batten Bay	,,	1	5	Green food remains.
		Clupea harengus	1	9	No food.
12	Breakwater	Clupea sprattus	3	5	Green food remains.
		Cyclogaster Montagui	1	4 ca.	Crustacea remains.
		Ammodytes tobianus	2	4·5–5·5	Green food remains.
		Cottus bubalis	2	4·5	No food.
	Knap-Penlee	Clupea harengus	1	11	*Balanus* nauplii, larval bivalve.
	West Channel	Clupea sprattus	5	3–5·5	Green food remains.
		Ammodytes tobianus	1	4·5	,, ,, ,,
	Off White Patch	,, ,,	1	4·5	,, ,, ,,
		Cottus bubalis	1	5	,, ,, ,,
15	Panther	Ammodytes tobianus	1	5·5	,, ,, ,,
		Cottus bubalis	1	4·5	,, ,, ,,
		Clupea harengus	3	10·5–11	No food.
		Gobius sp.	2	2·5–3	,,
		Callionymus lyra	1	2 ca.	,,
	Knap	Cottus bubalis	3	5	*Balanus* nauplii.
		Gobius sp.	5	3–3·5	No food.
		Ammodytes tobianus	1	5·5	,,
		Clupea sprattus	1	3·6	,,

Date. March.	Locality.	Fish.	No.	Size in mm.	Food present.
15	Off White Patch	Clupea sprattus	1	4	No food.
		Cottus bubalis	3	5–5·5	*Balanus* nauplii, Crustacea remains.
		Gobius sp.	1	4	No food.
		Ammodytes tobianus	1	6·5	Green food remains.
	Breakwater	Clupea sprattus	1	9	No food.
19	Off White Patch	,,	1	3	,,
		Cottus bubalis	1	5 ca.	*Balanus* nauplii.
	New Grounds	Clupea sprattus	10	3·5–7	Green food remains.
		Callionymus lyra	3	1·5	No food.
		Gadus luscus	7	2–3	Green food remains.
	Breakwater	,,	1	2·5	No food.
		Clupea sprattus	1	4·5	,,
27	Breakwater	,,	5	4·5–7	Green food remains.
		Onos mustela	1	2·5	No food.
30	New Grounds	Clupea sprattus	10	4–6	Green food remains.
		Agonus cataphractus	1	7	*Coscinodiscus excentricus.*
		Gadus luscus	1	1·5	No food.
		Callionymus lyra	1	2 ca.	*Paralia sulcata, Coscinodiscus excentricus.*
	Breakwater	Clupea sprattus	19	4–6·5	Green food remains.
		Gadus luscus	2	1·5–2	No food.
		Gobius sp.	5	2–3	Green food remains, larval bivalve, *Coscinodiscus* sp.
		Cottus bubalis	5	4·5–5	*Balanus* nauplii, *Biddulphia regia, Biddulphia* sp., *Coscinodiscus Granii*, larval gastropods, *Coscinodiscus radiatus, Thalassiosira gravida*, Copepod remains.
		Callionymus lyra	1	1·5	*Coscinodiscus* sp.
		Onos mustela	1	2·5	No food.
April. 2	Knap	Clupea sprattus	2	4·5–5	Green food remains.
		Callionymus lyra	2	2·5	Green food remains, *Navicula* sp., *Pleurosigma* sp., *Coscinodiscus* sp.
		Cyclogaster Montagui	1	4·5	No food.
		Gadus merlangus	1	4	,,
		Gadus luscus	1	3	*Coccosphæra* sp. (cf. *atlantica*), *Coscinodiscus* sp.
4	Breakwater	Clupea sprattus	9	4·5–6	Green food remains.
		Gadus merlangus	1	4 ca.	Nauplii of *Calanus finmarchicus, Coscinodiscus Granii.*
		Cyclogaster Montagui	1	3·5	No food.
12	Queen's Grounds	Gobius sp.	2	3·5–4	*Balanus* nauplii.
		Clupea sprattus	1	5·5	Green food remains.
		Callionymus lyra	1	2·5	No food.
		Zeugopterus (?) sp.	1	7	,,
	Duke's Rock	Gobius sp.	3	2·5–3·5	Green food remains.
		Gadus merlangus	2	2·5–5	*Pseudocalanus elongatus.*
		Callionymus lyra	1	1·5 ca.	No food.
		Cyclogaster Montagui	1	4	Brownish food remains.
18	N.E. of Drake's Island	Callionymus lyra	1	3·6	No food.
		Clupea sprattus	1	7	,,

Date. April	Locality.	Fish.	No.	Size in mm.	Food present.
23	Breakwater	Gadus merlangus	3	7·5–9	*Pseudocalanus elongatus* and eggs.
		Cottus bubalis	1	10	Nothing.
	Duke's Rock	Callionymus lyra	4	3·5–5	Copepod nauplii.
		Gadus merlangus	3	8–8·5	*Paracalanus parvus.*
		Onos mustela	1	4·5	Copepod nauplii remains.
	West Channel	Cottus bubalis	1	7	*Temora longicornis.*
		Pleuronectes microcephalus	1	4	No food.
25	Knap	Onos mustela	1	3·5	,,
		Gadus merlangus	1	7·5	*Pseudocalanus elongatus* and eggs.
30	Knap	Callionymus lyra	2	3–4	No food.
	S. of Knap	,,	1	4·5	,,
May.					
4	West of Breakwater	Gadus merlangus	2	10–11	*Pseudocalanus elongatus.*
10	Cawsand Bay	,,	2	6–12	,, ,,
		Gobius sp.	1	2·5	No food.
		Callionymus lyra	4	2–3·5	Copepod remains.
	Inner Knap	,,	5	2·5–5·5	,, ,,
		Gadus merlangus	7	3–14	*Pseudocalanus elongatus*, Copepod remains.
		Pleuronectes flesus	1	8·5	No food.
24	Breakwater	Clupea sprattus	1	24·5	,,
		Gadus morrhua	1	19	*Calanus finmarchicus*, *Temora longicornis.*
		Gadus merlangus	3	6–7·5	Copepod remains.
		Onos mustela	3	5–11	Copepod remains, ova.
		Callionymus lyra	2	3	No food.
	West Channel	,,	2	4	,,
31	Breakwater	Pleuronectes flesus	1	10·5	*Phæocystis* spores.
	Knap	Gobius sp.	1	4	No food.
June					
7	Off Reny Rocks	Callionymus lyra	1	5	No food.
12	Knap	,,	1	7	,,
	Breakwater	,,	1	5·5	,,
	West Channel	Trigla gurnardus	1	8	*Podon intermedius.*
		Gobius sp.	1	5	No food.
		Labrus bergylta	2	2·5	,,
July.					
2	Knap	Callionymus lyra	1	3	*Euterpina acutifrons.*
		Clupea sprattus	1	5	No food.
	Panther	Lophius piscatorius	1	8·5	,, vide p. 440 6 fish.
4	W. End of Breakwater	Clupea sprattus	1	7	,,
9	Off White Patch	Gobius minutus	10	3·5–8	Nauplius of *Temora longicornis.*
		Callionymus lyra	2	2·5–4	No food.
		Ammodytes lanceolatus	1	10	Copepod nauplii, *Rhizosolenia shrubsolei.*
	West end of Breakwater	,,	1	7·5	No food.
		Gobius minutus	1	6	Copepod remains.
	Knap	,,	2	6–6·5	*Pseudocalanus elongatus*, Copepod remains.
11	White Patch	Callionymus lyra	1	3	No food.

Date. July	Locality.	Fish.	No.	Size in mm.	Food present.
11	White Patch	Labrus bergylta	1	6	*Cittarocyclis denticulata*, *Temora longicornis*, *Euterpina acutifrons*, Copepod indet., *Prorocentrum micans*, *Peridinium* sp., *Lithomelissa setosa*, *Tintinnopsis beroidea*.
	Knap	Callionymus lyra	2	7	*Balanus* nauplii.
23	Breakwater	Rhombus lævis	1	18	*Temora longicornis*, *Centropages typicus*. *Brachyura* zoæa, *Hippolyte* larvæ.
		Rhamphistoma belone	13	10–28	Green and brown food remains, *Harpacticus uniremis*, *Pleurosigma* sp. ova.
		Onos mustela	3	15–26	Copepod remains.
	Off White Patch	Gadus merlangus	1	34	" "
	Panther	Rhamphistoma belone	2	12–17	Green food remains, *Harpacticus uniremis*.
		Cyclopterus lumpus	1	15	Amphipod remains, *Harpacticus uniremis*.
25	Panther	Clupea sprattus	1	5	No food.
		Gobius minutus	1	6	*Calanus* nauplii.
		Labrus bergylta	1	4·5	*Temora* nauplii, *Navicula* sp. Peridinian remains.
27	Knap	Lophius piscatorius	5	4–5	Copepod remains.
		Labrus bergylta	1	3	Green food remains.
		Onos mustela	1	3 ca.	*Temora* nauplii.
		Scomber scomber	3	3·5–4·5	Green food remains.
	Off White Patch	Labrus bergylta	3	2·5–4	*Temora* nauplii.
		Callionymus lyra	2	3–8	No food.
		Gobius minutus	1	4	Copepod nauplius remains.
	Breakwater	Labrus bergylta	2	2·5	Green food remains.
		Lepadogaster Candollei	1	4	No food.
30	Knap	"	2	4·5–6	Copepod remains.
		Labrus bergylta	14	4–6	Green food remains, Copepod and Copepod nauplii remains.
		Callionymus lyra	1	8	Copepod remains.
		Onos mustela	1	6·5	" "
		Scomber scomber	3	5–7	Brown and green food remains, Copepod nauplii.
	Panther	Scomber scomber	2	3–5	Brown and green food remains, Copepod nauplii.
		Labrus bergylta	7	4–6	Green food and Copepod nauplii remains.
		Onos mustela	1	6·5	Copepod remains.
		Callionymus lyra	1	7	" "
August.					
1	Knap	Labrus bergylta	2	5	Copepod nauplii.
	Panther	"	2	4–6	Young *Temora longicornis* and *Temora* nauplii.
		Scomber scomber	1	7	*Temora* nauplii.
7	Panther	Onos mustela	1	5·5	Young *Temora longicornis*.

Date. August	Locality.	Fish.	No.	Size in mm.	Food present.
10	Knap	Syngnathus acus	1	25	*Temora* nauplius remains, *Pseudocalanus elongatus*.
		Scomber scomber	4	3–4	Green food remains, Copepod nauplii, larval gastropods.
		Labrus bergylta	1	7	*Pseudocalanus elongatus*.
		Lepadogaster gouani	4	4–5·5	Copepod nauplii, Harpacticids indet.
		Lepadogaster Candollei	3	5–6·5	Young *Temora longicornis*, Copepod nauplius remains, Harpacticids indet.
	Panther	Labrus bergylta	1	7	*Temora longicornis*.
		Cyclopterus lumpus	1	18	Larval *Eupagurus*, Decapod larvæ remains.
13	West Channel	Lepadogaster Candollei	1	7·5	Copepod remains.
		Gobius sp.	1	11	Remains of diatoms, *Skeletonema costatum*.
	Breakwater	,,	3	12–13	Green food remains.
14	West End of Breakwater	,,	2	12	*Temora longicornis*, Balanus nauplus.
		Lepadogaster Candollei	1	8	Copepod remains.
		Blennius gattorugine	1	22	Remains of crab zoæa and Crangon larvæ.
15	Breakwater	Gobius sp.	1	11	No food.
		Gobius minutus	1	7	*Pseudocalanus elongatus*.
20	Breakwater	Labrax bergylta	1	7·5	*Podon intermedius*, young *Temora longicornis*, *Temora* nauplii.
		Lepadogaster Candollei	1	4	Young *Temora longicornis*.
		Scomber scomber	6	3·5–8·5	*Temora* nauplii, Copepod remains.
		Nerophis lumbriciformis	1	10·5	Young Copepods, Copepod nauplii.
		Rhamphistoma belone	1	29	No food.
	Panther	Syngnathus rostellatus	1	105	Decapod larvæ remains.
		Rhombus lævis	1	14	Copepod remains.
		Gobius sp.	1	13	,, ,,
		Labrus bergylta	1	10	,, ,,
	Off White Patch	Scomber scomber	1	5·5	*Temora* nauplii, remains of young Copepods.
22	Breakwater	Rhombus maximus	1	14	*Balanus* nauplii, *Centropages typicus*.
		Syngnathus acus	1	31	No food.
		Gasterosteus spinachia	2	75–79	Amphipod and Harpacticid remains.
	Knap	Rhombus maximus	1	11·5	*Temora longicornis*.
		Nerophis lumbriciformis	1	10	No food.
		Gobius sp.	1	12	Young *Temora* and *Temora* nauplii.
30	Breakwater	Syngnathus rostellatus	1	45	Crab zoæa, *Acartia* sp. *Pseudocalanus elongatus*, other Crustacea remains.
	Knap	Onos mustela	1	2	No food.
Sept. 3	Off White Patch	Gobius minutus	1	2	No food.

Date. Sept.	Locality.	Fish.	No.	Size in mm.	Food present.
4	Inside Breakwater	Gobius minutus	2	14	*Temora longicornis*, *Pseudocalanus elongatus*, *Acartia* sp.
		Syngnathus rostellatus	1	105	Larval decapod remains.
	Breakwater	Gobius minutus	1	8	No food.
		Clupea sprattus	1	11	,,
		Ammodytes lanceolatus	1	11	Copepod remains.
	Knap	Caranx trachurus	1	30	*Calanus finmarchicus*, *Porcellana* larva, Crustacea remains.
6	Breakwater	Clupea sprattus	1	23	No food.
	Outside Breakwater	Labrus bergylta	1	11	*Pseudocalanus elongatus.*
10	Off White Patch	Gobius minutus	1	10	Copepod remains.
12	Panther	Gobius minutus	1	4·5	No food.
		Gasterosteus spinachia	1	85	,,
	Off White Patch	Gobius minutus	1	7	,,
17	West Channel	Trachinus vipera	1	22	Copepod and other Crustacea remains.
	Breakwater	Ammodytes lanceolatus	20	7–14	*Acartia* sp. other Copepod remains.
		Scomber scomber	3	7–16	*Temora longicornis* Copepod remains.
20	Inside Breakwater	Gobius minutus	1	3	No food.
21	Breakwater	Syngnathus acus	1	7·5	*Centropages typicus.*
		Ammodytes lanceolatus	3	9–12	*Acartia clausi Pseudocalanus elongatus*, Copepod remains.
	Knap	Trachinus vipera	1	22	*Pseudocalanus elongatus*, *Anomalocera Pattersoni.*
		Caranx trachurus	1	30	*Centropages typicus*, *Temora longicornis.*
26	Off White Patch	Blennius galerita	1	17	*Temora longicornis.*
28	Breakwater	Caranx trachurus	1	30	Copepod remains.
		Syngnathus acus	1	85	*Pseudocalanus elongatus*, *Temora longicornis*, *Acartia clausi*, *Corycæus anglicus*, *Centropages typicus.*
Oct. 3	Panther	Trachinus vipera	1	5	*Pseudocalanus elongatus*, *Temora* nauplius.
		Gadus luscus	1	4	*Pseudocalanus elongatus.*
	Breakwater	Ammodytes lanceolatus	3	8–9	Green food remains, *Oithona* sp. Copepod remains.
	Knap	Clupea sprattus	1	27	*Pseudocalanus elongatus.*
5	Knap	Ammodytes lanceolatus	1	10	Copepod remains.
15	Knap	Lepadogaster Gouani	1	6 ca.	*Centropages typicus*, *Pseudocalanus elongatus.*
	Panther	Syngnathus acus	1	60	*Temora longicornis*, *Centropages typicus*, *Pseudocalanus elongatus*, *Paracalanus parvus.*
		Nerophis lumbriciformis	1	40	No food.
17	West Channel	Clupea harengus	1	9	,,

Date.	Locality.	Fish.	No.	Size in mm.	Food present.
Oct.					
19	Knap	Gadus luscus	1	7	*Pseudocalanus elongatus*, *Acartia clausi*, *Calanus finmarchicus*.
	Panther	Callionymus lyra	1	2	No food.
22	Knap	Clupea sprattus	1	6	Green food remains.
	Breakwater	,,	1	5	*Tintinnopsis ventricosa*.
23	Cawsand	Caranx trachurus	1	40	*Idya furcata*, Harpacticids indet. *Temora longicornis*, crab zoæa.
26	Breakwater	Clupea harengus	1	8·5	No food.
Nov.					
1	Breakwater	Callionymus lyra	1	2	No food.
5	Off White Patch	Clupea harengus	4	11–18	,,
		Clupea sprattus	1	6	,,
		Syngnathus rostellatus	1	45	*Pseudocalanus elongatus*, Copepod remains, ova.
	Panther	Crystallogobius Nilssoni	1	21	No food.
6	West End of Breakwater	Clupea sprattus	1	5·5	,,
		Ammodytes tobianus	1	5	Copepod nauplii.
	Breakwater	,,	1	5	No food.
		Clupea harengus	2	8–13	,,
		Clupea sprattus	1	5	,,
19	Off White Patch	Ammodytes tobianus	1	4	,,
20	Off White Patch	Clupea sprattus	1	6	,,
	Panther	,,	1	5	*Thalassiothrix nitzschoides*.
		Clupea harengus	1	6	No food.
	Breakwater	Gadus luscus	1	4	,,
		Clupea sprattus	7	6–8·5	Green food remains, Copepod nauplii remains, *Pleurosigma* sp.
23	Off White Patch	Clupea harengus	6	6·5–9	No food.
	Panther	,,	1	6	,,
26	Panther	,,	1	9	,,
Dec.					
11	Off White Patch	,,	1	7	,,

A Preliminary Account of the Production of Annual Rings in the Scales of Plaice and Flounders.

By

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With Figures 1–10 in the Text, and Tables I to VI at the end.

It is only within comparatively recent times that it has been proved that the otoliths and scales of certain Teleostean fish can be used for the determination of their age.

Rings of growth, as they are called, are produced on these structures, and it is by counting the number that the age is ascertained, in much the same way as the approximate age of a tree may be determined by counting the annual rings.

In May, 1915, I was appointed as a temporary assistant naturalist to the Marine Biological Association at Plymouth, and at the suggestion of Dr. Allen decided to devote my time to an investigation of the otoliths and scales of Flounders and Plaice. My work on the otoliths I hope to publish at a future date.

It has often been asserted that the scales of these fish are of little or no value as age determiners. Thus Cunningham in 1905 stated that though summer and winter lines of growth are visible, yet "in most cases the zones are somewhat difficult to distinguish, and it would be by no means easy to form a confident judgment of the age of the fish by examination of the scales alone. The conclusion drawn from the scales must be confirmed or tested by examination of the otolith."

This preliminary account of my work is divided into two parts : in the first I hope to show that it is possible to ascertain the age of Flounders and Plaice by an examination of their scales, just as accurately as by the otoliths, in fact that the otolith growth rings and those found on the scales give identical results.*

* The annual rings on the otoliths of Flounders are not so distinct as those of the Plaice, indeed Wallace and other workers on otoliths hold that age determination is uncertain from Flounder otoliths. The scales which I have examined from these fish exhibit maxima and minima as regularly and distinctly as do those of the Plaice.

The second part will deal with experiments which were performed with a view to solving the problem of what are the conditions necessary to the production of these annual rings.

PART I.

METHODS.

A very few observations were sufficient to convince me that it was impossible to detect with any certainty rings on the scales of either Flounders or Plaice by the ordinary methods of examination. The sclerites, that is the thickened cells covering the scale, were apparently of such a uniform width that it was almost impossible to differentiate between the wide ones formed in the summer and the narrow winter ones.

In 1915 Winge published a paper on the scales of the cod, and described a new method which he had employed for his investigation.

His method was as follows: "A microscope stand with mechanical stage and ocular micrometer, and an objective having a focal diameter of about 8 mm. form the best combination. . . . One or more scales—fresh scales are especially suitable on account of their transparency—are placed on the object glass, their longitudinal axis about parallel with the longitudinal direction of the object glass itself. The micrometer is turned so as to fall parallel with the scales. . . . In order to obtain a curve for one of the scales the instrument is focussed to the centre of the one selected, and all sclerites in the longest radius of the scales then measured. . . . In order to provide a survey of the values thus obtained, the units are noted down on square-ruled paper. A horizontal axis is drawn, from which the measurements of the calcareous plates are marked off in a perpendicular direction, one by one, against each perpendicular line on the paper. On joining up the points thus obtained by straight lines, a curve is produced, which gives a distinct view of the variations in the breadth of the sclerite rings from the centre of the scale towards its periphery. Where the curve is low, the sclerites have been small, where it lies high, they have been large. A glance at the horizontal axis will show how many sclerites in all the scale contains, as also the number situate between each minimum, and the next. The growth rings are thus shown graphically as an alternation of maxima and minima."

The method given above is broadly the one which I employed in my investigations. The scales were examined in fresh water. The proportional width of successive sclerites is obviously the important factor to determine, thus making the absolute width of each sclerite of little importance. I used the distance between two degrees marked on the micrometer as the unit, each division being 10 μ.

The values so obtained were then plotted on squared paper as described above, ten units of the paper in a vertical direction, representing one division of the micrometer; thus fractions of a unit are easily plotted.

By this method small differences in the widths of successive sclerites

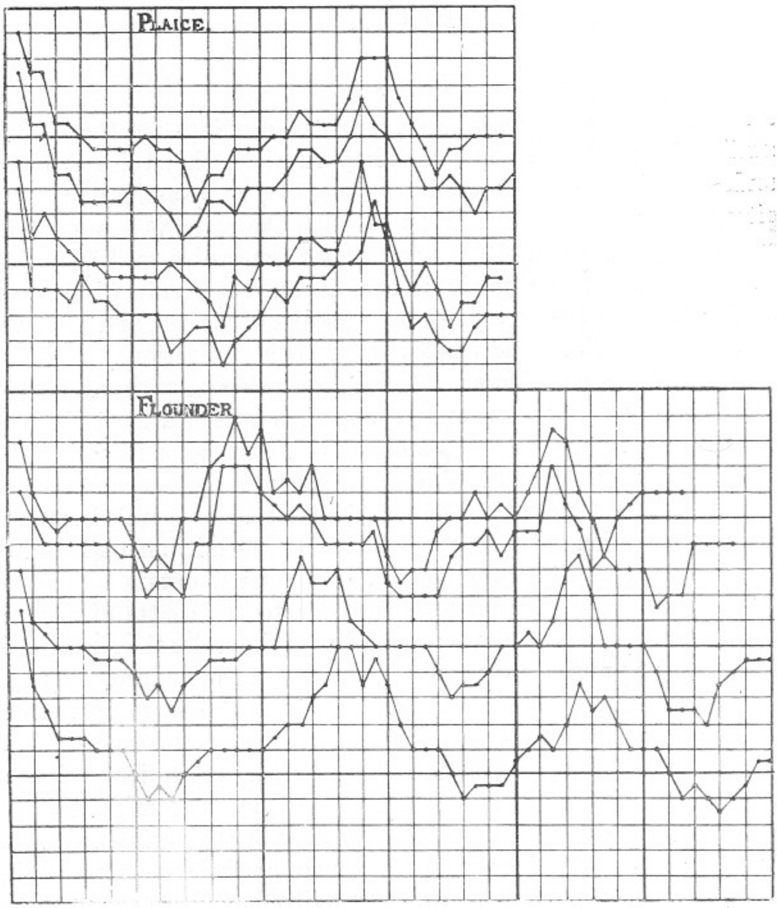

FIG. 1.—Scale curves from two fish, a Plaice and a Flounder. Four curves are drawn for each fish. Note the great resemblance between the four scale curves of each series.

are easily detected, and by it I found that growth rings on Plaice and Flounder scales are as distinctly shown as in the scales of other fishes.

SCALE INVESTIGATIONS.

The total number of fish examined was 137, of which 85 were Flounders and 52 Plaice. In order to determine if there were any marked

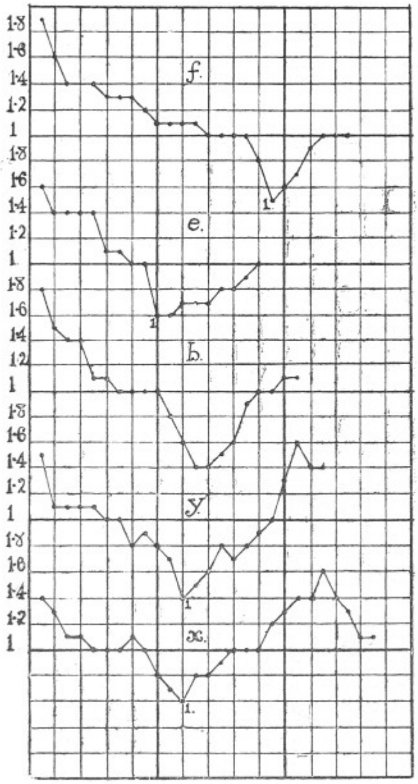

FIG. 2.—Scale curves of one year old fish. The letters refer to Table I. : the figures indicate the first winter's growth.

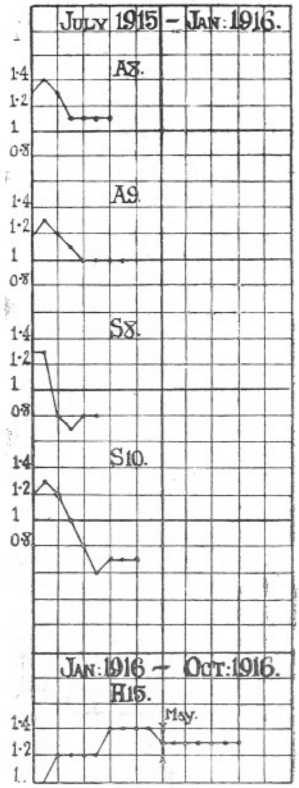

FIG. 10.—Partial curves of scales from fish in bad condition.
A = abundant tank.
S = scanty tank.
H = hot tank.
The numbers indicate the fish in the corresponding tables.

IN FIGURES 2 TO 10 THE DOTS ON THE CURVES REPRESENT THE WIDTHS OF THE SCLERITES OF THE SCALE. THESE ARBITRARY WIDTHS ARE GIVEN AT THE SIDE OF EACH CURVE.

IN FIGURES 5, 6, 7, 8, 9 THE FIRST DOT ON THE CURVES INDICATES THE WIDTH OF THE LAST SCLERITE ON THE SCALE BEFORE THE FISH WAS EXPERIMENTED UPON; THE SECOND DOT INDICATES THE WIDTH OF THE FIRST SCLERITE PRODUCED UNDER ARTIFICIAL CONDITIONS.

IN EACH FIGURE THE LINE DIVIDING A CURVE INTO TWO PARTS IS THE LINE OF DEMARCATION BETWEEN TWO PERIODS OF THE EXPERIMENT.

variation between scales taken from different parts of the body, four scales from various regions were examined in 45 cases. It will be seen by reference to Fig. 1 that, apart from minor variations, the scales from the

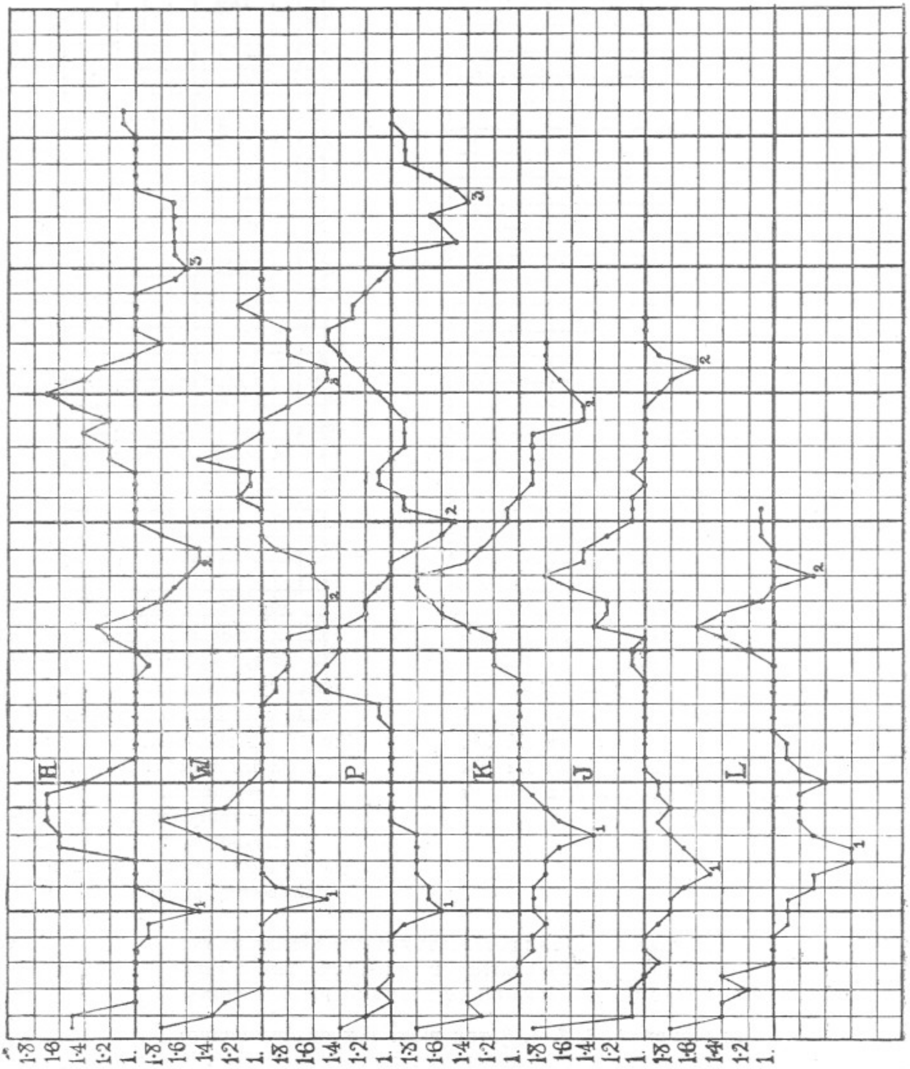

FIG. 3.—Scale curves from 2 and 3 year old fish. The letters indicate the same scales in Table I.; the numbers the successive winter zones.

same fish are very constant. The personal error was eliminated as far as possible by measuring these scales on different days, no reference being made to any previous measurements before the whole series had been completed.

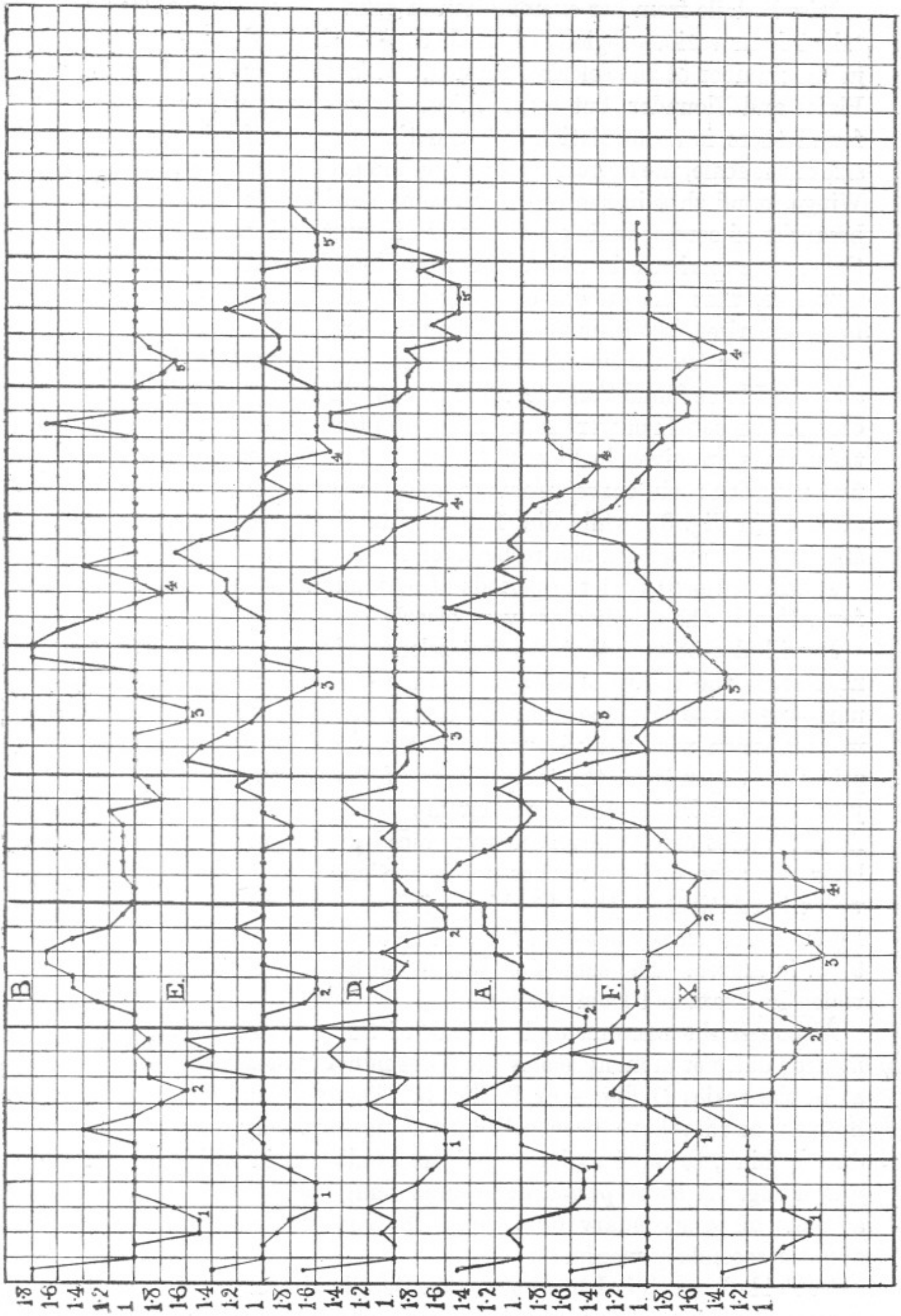

FIG. 4.—Curves from the sclerites of 4 and 5 year old fish. The letters refer to those given in Table I; the numbers indicate the successive winter zones of growth.

Miss Esdaile from her examination of salmon scales found that those taken from various regions of the body invariably show great changes in the number of the sclerites formed. This undoubtedly occurs in the Plaice and Flounder, but by no means to the same extent; when it is found there is a correlation between the number of sclerites and the size of the scale, the longest scale having the greatest number of sclerites. Winge found that in the cod there were considerable variations in the breadths of corresponding sclerites of different scales. I have not had the same experience in either Plaice or Flounder scales. It is obvious, therefore, that the growth of a big scale does not consist in making broad sclerites, but in increasing the number.

The scales from fishes of different ages have been examined, and in all cases I have found that the growth rings which they exhibit are identical with those which were seen on the otoliths. Scale curves exhibiting these rings are given in Figs. 2, 3 and 4. Fig. 2 shows curves from five first year fish: six curves from two and three year old fish respectively are seen in Fig. 3: while Fig. 4 represents six curves from three four and three five year old fish respectively.

It will be noted that the periods of maximum and minimum breadth formation in the sclerites are very clearly shown.

It will also be seen that the first sclerite of the scale, that is the one nearest to the centre is always broad, the succeeding ones becoming narrower as the distance from the centre increases. This is of interest in connection with the view that I hold, that the width of the scale primarily depends on the temperature of the surrounding water. The young of the Plaice and Flounder are usually born about the end of April: scales are, however, not produced until a month or six weeks later, thus the scale growth is not begun until the temperature of the water is relatively high. At this period the temperature of the sea at Plymouth is usually between 13° and 13·5° C., as compared with about 9° C. in March. The same fact was noted by Winge for the cod scales which he examined from the Faroes.

Although the maxima and minima of the curves are quite sharply marked out, yet in many scales one notes minor depressions or elevations as in the scales D Fig. 4 or H Fig. 3. These secondary maxima and minima, as they have been called by Winge, are very common and are due, I think, to local variations of the conditions in which the animal was living. A short period of lowered temperature being sufficient to account for a secondary minimum: the converse conditions bringing about a secondary maximum.

In Table I. (p. 491) I have given the details of some of the fish which I have examined. The first column gives the age as determined by the otolith, the second the length as measured from the tip of the snout to the

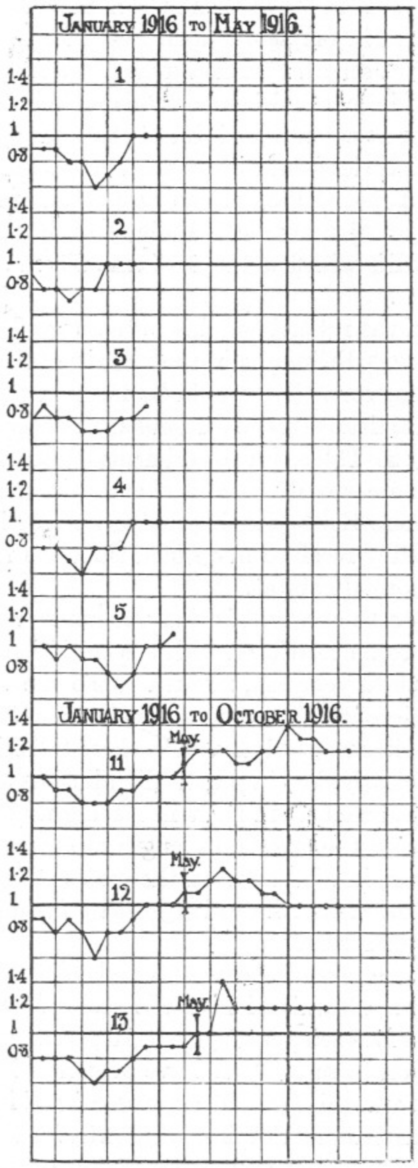

FIG. 5.—Partial curves of scales from control fish. The number over each scale curve indicates the corresponding scale in Table II.

end of the tail, and the third the number of annual rings which the scale exhibited. The figures in brackets are the number of sclerites produced towards the last and incomplete annual ring. In the fourth column is noted the number of sclerites formed during each year's growth.

The first point of interest arising from this table is the great variations in length that occur between fish of almost the same age; thus the length for second year fish varies from 7·9 to 9·6 cm., increasing as the fish enters on its third year of life, so that in one case a fish of 25·5 cm. in length was found to be but $2\frac{3}{4}$ years old. Again, I have enumerated fishes in their third year of life with lengths, 15·5 cm., 25 cm., 27·3 cm., and 32·1 cm. respectively.

It is true that in the normal conditions there would in all probability not be these enormous differences in the lengths of fish of the same age, because the external conditions would be more or less uniform for the fish of the same district. This condition has not been fulfilled, for a few of the animals in the Table, for experimental reasons, have been subjected to temperature variations and changes in the amount of food. In many cases, where the length is great in proportion to the age the animals have probably received more food than one would expect them to get from their normal habitat.

A further point to be observed is that the number of sclerites formed in the scale seems to be correlated with the condition and length of the fish; thus of the third year fish, marked †, the one 15·5 cm. long had but 28 sclerites, while of the others those with lengths 32 cm. and 32·1 cm. had 62, and 75 sclerites respectively. The three fish selected exhibit this phenomenon very clearly, but in practically all cases the same condition obtains. Thus I feel that I am right in stating that on the whole the sclerite formation and the growth in length are correlated.

J. Stuart Thomson, in his paper on the scales of the Gadidæ (p. 74), comes to the conclusion that intensive growth favours the production of a small number of sclerites.

To illustrate this he takes the case of a pollack three years of age and 27·62 cm. in length. Examination of the scales showed the following number of sclerites for each year: year I, 13; year II, 13; year III, 18. From this he goes on to say: "We have evidently here to deal with a rapidly grown fish, and this fact has expressed itself in the formation of the scale, in the small number of lines of growth for the first and second year. The more intensive the growth the smaller the number of the lines of growth. To compare with this we might take the case of a slower growing pollack, 44·40 cm. The scale of such a pollack shows the following lines: year I, 21; year II, 29; year III, 18; year IV, 2."

I do not quite understand this statement because, according to Thomson's Table, the first fish mentioned, of length 27·62, was small

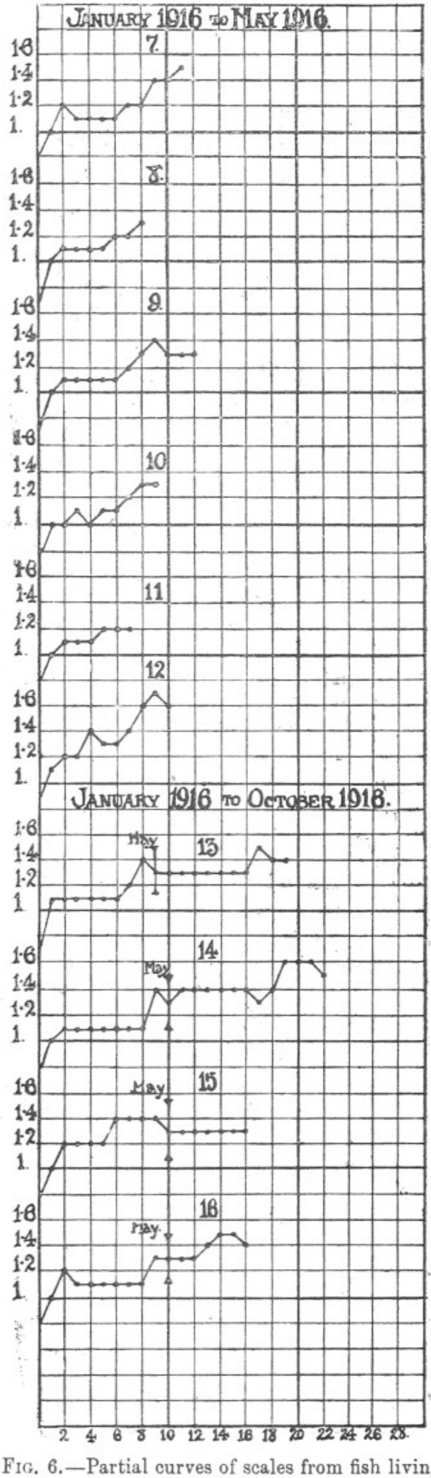

FIG. 6.—Partial curves of scales from fish living in hot water tank. In this and the following figure the vertical lines passing through some of the scales are the lines of demarcation between two periods of the experiment. The figure over each curve indicates the corresponding scale in Tables III. and IV.

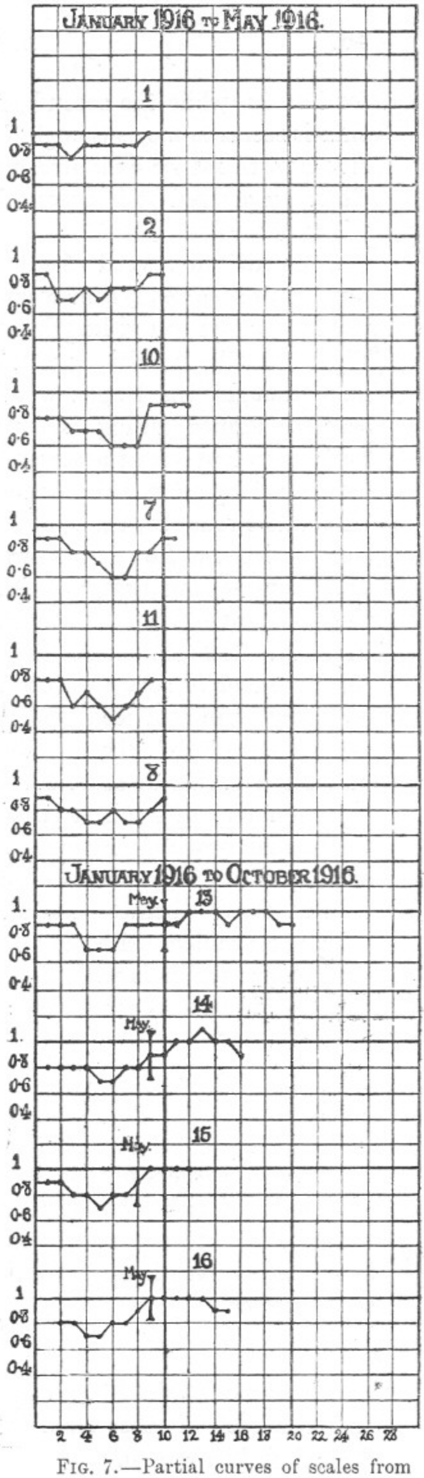

FIG. 7.—Partial curves of scales from fish living in cold water tank.

for its age, while the second one, of length 44·4 cm. was about normal, thus it seems to me as though the first fish instead of showing an intensive growth rather exhibited a slow one. If this is so the conclusion Thomson arrived at is practically reversed, and rather is in accordance with my results.

Cases are often seen where a fish is in good condition, but the total number of sclerites is somewhat small as is also the length ; such a one is the $4\frac{1}{2}$ year old fish of length 27·8 cm., the scale curve of which is seen in Fig. 4 A. The condition when examined was excellent, and one would have thought the length would have been greater. The number of sclerites formed during each year of growth is, however, instructive ; during the first year there were nine, the second eleven, but during the two following years this number was increased to twenty-four for the third and twenty for the fourth year. I should interpret this as meaning that during the first two years of life the conditions for growth were unfavourable, but that they improved later on. This is borne out by the four-year-old fish, of length 26·8 cm., whose scale curve is seen in Fig. 4 X. The condition of the animal was poor when examined and the total number of sclerites very few, thirty-four. During the first year only four were produced, and but six and five for the third and fourth years respectively. The number sixteen for the second year seems to indicate a period of more favourable conditions.

A summary of the first part of my investigations is that the age of Plaice and probably Flounders can be accurately ascertained by the examination of the scales without reference to the otoliths. Having seen that two distinct breadths of sclerites are produced during each year, the problem arises as to what are the factors concerned in their production, and it is with the experiments which I performed in order to ascertain this, that the next part of the paper deals.

PART II.

Previous workers on fish scales have assumed that the annual rings are produced either by seasonal variations in the temperature of the water, or by fluctuations in the food supply. I therefore resolved to ascertain by experiment what part these two factors actually played in scale growth.

METHODS.

Four tanks at the Plymouth Laboratory were placed at my disposal and into each of these from 12–16 fish were placed ; both Plaice and Flounders being used.

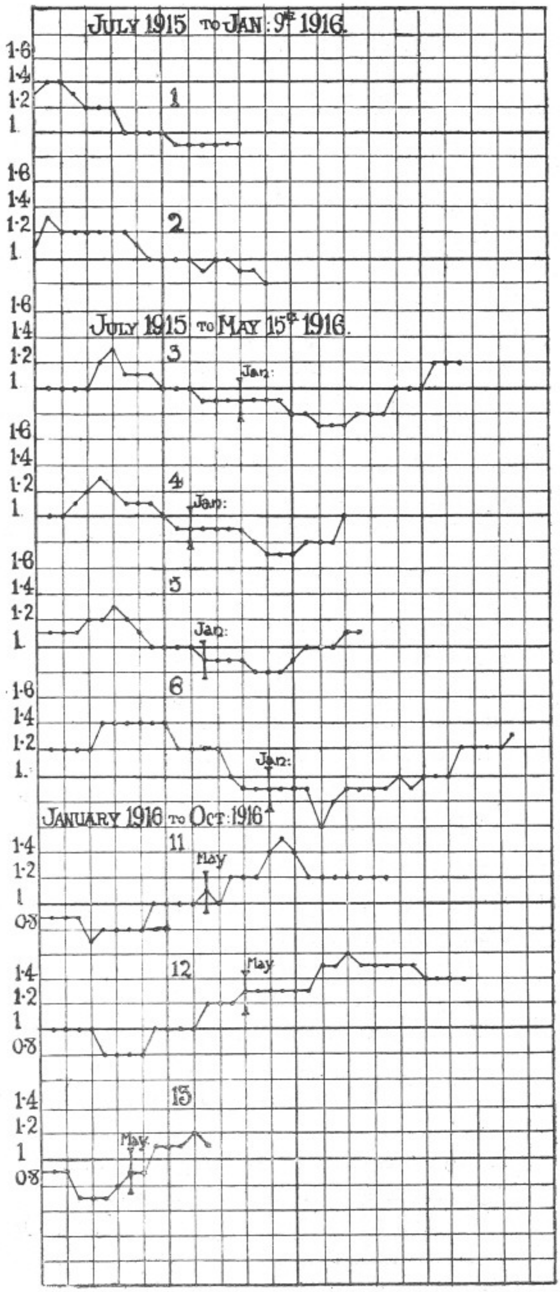

FIG. 8.—Partial curves of scales taken from fish which had been fed abundantly. The number over each curve indicates the corresponding scale in Table V.

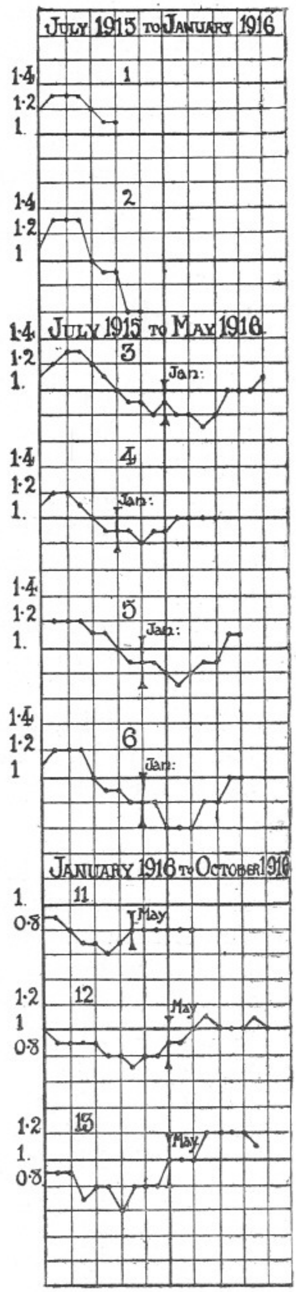

FIG. 9.—Partial curves of scales taken from fish which had been scantily fed. The number over each curve indicates the corresponding scale in Table VI.

Before putting the fish into the tanks scales were taken from the regions just above the pectoral fin and examined and scale curves made from each specimen.

The length of each fish was recorded and the animal marked. This was done by tying pieces of various coloured silks round the tail.

The experiments started about the middle of July, 1915. On January 9th, 1916, each fish was re-examined and scales taken from the same region as before, the length also being recorded.

The fish were then allowed to remain undisturbed until the following May, when about half a dozen from each tank were killed by chloroform, and scales again taken. This method of procedure was necessary because of my having, during the course of the experiments, removed from Plymouth to Manchester and I was unable to go to Plymouth in order to remove the scales from the living animals. The remaining fish were kept under experimental condition until the beginning of October, 1916, when they were killed, measured, and scale samples sent to me.

The experimental conditions under which the animals lived were as follows: the temperature of the water in two of the four tanks was varied, one being kept at a temperature as high or higher than the normal summer temperature of the sea water in the tanks at Plymouth, while the temperature of the other was kept as low as possible.

The remaining two tanks were used for feeding experiments, the temperature being that of the sea water in circulation in the tanks at Plymouth.

HOT AND COLD TANKS.

The temperature in the hot tank was obtained by running in sea water that had previously been heated. During the first part of the experiment, that is from July to January, the results were not very satisfactory, because the heating apparatus was turned off during the night and the tank water allowed to cool. Although it never reached the normal temperature yet there was a difference of 3–4° C. between the night and day temperatures. After January, however, a new apparatus was kindly devised by Mr. Matthews which maintained the water at a constant temperature day and night.

The artificial cooling of the cold tank was done by running sea water through glass tubes, which were surrounded by ice. This apparatus was quite successful in cooling the water, but as the ice was not renewed during the night the temperature of the tank rose a little. The result of this was a slightly fluctuating temperature, which was, however, not sufficient to nullify the experiments, the fluctuations not being more than 3° C. in the summer, and between 1° and 2° for the winter and autumn.

I give below the average temperature for each month of the hot and cold tanks, together with that of the sea water in the tanks at Plymouth.

	1915. July	August.	September.	October.	November.	December.
Normal.	15·5°	17·3	15·8	14·6	11·3	10·9
Hot.	18·6	19·7	19·5	19·8	15·9	17
Cold.	13·9	13·7	14·1	13·3	10·9	10·3

	1916. Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.
Normal.	11·8	10·8	9·7	11·2	13	13·2	15	17·5	16	14·6
Hot.	16·9	17·2	17·7	17·9	17·9	17·9	18	19·6	19·5	16·6
Cold.	10·3	9·5	8·6	9·8	11·6	12·4	13·6	13·7	14	13·6

It will be seen that as regards the hot tank the temperature throughout was practically as high or higher than the highest temperature recorded for the normal sea water. Also the temperature was fairly constant from month to month.

As I have already indicated the cold tank records are not as satisfactory : in every month the temperature was below that of the normal, but in some cases it was above the winter temperature of the normal sea water. It was, however, in all cases far below the corresponding one for the hot tank.

"ABUNDANT" AND "SCANTY" TANKS.

These two tanks were the ones in which feeding experiments were conducted and the temperature was undisturbed. In the abundant tank the fish were fed excessively, that is to say, twice a day they were given as much food as they would take. The food was varied, sometimes squid, at other times worms, etc.

The fish in the scanty tanks were by no means so well treated : they were given very little at a time and never more than once a day : it was common to feed every other day.

In January control fish were started whose scale growth was investigated in exactly the same way as the others.

These fish were kept in an aquarium tank together with other species and were treated in exactly the same way, being fed once a day neither abundantly nor scantily.

RESULTS OF THE EXPERIMENTS.

In Tables II, III, IV, V, VI (p. 494), I have given the details of the fish experimented upon : the ages as computed from both otolith and scale are found in column two ; and it is worth noting here, that the age was first determined from the scales and then confirmed by the otolith at the end of the experiments. In no case was there any discrepancy between the two results.

In the next column are given the details of the scale growth for the periods between the examinations. First there is the number of sclerites formed during each period, followed by the maximum and minimum breadth of the sclerites. Finally I have given the increase in length of the animals during the periods and their general condition.

Figures of partial scale curves are reproduced, the portion figured being that part of the scale produced during successive periods of experimental conditions. The micrometer unit employed was the same as that for the curves in Part I.

CONTROL FISH.

The control tank, Table II, shows how uniform was the growth of both scale and fish during the two periods of the experiment. With the exception of those fish whose condition was not very good the increase in length from January to May is remarkably constant, as is also the number of sclerites formed. Also the maximum breadth is between 0·9 and 1·1 and the minimum between 0·8 and 0·6. Fig. 5, which represents the scale curves of some of these fish, is interesting in showing how closely the curve follows the temperature changes. They all start with a relative breadth for the sclerites of 0·9 or 0·8, which falls to a minimum in about the middle of the curve, then gradually rises to either 0·9 or 1·1 When we remember that the temperature in January was 11·8° C. falling to 9·7° C, in March and gradually rising to 13° C, by May, these curves seem very significant.

The growth during the period from May, 1916, to October, 1916, is equally interesting. The increase in length is a little greater than during the previous portion of the experiment, as would be expected. As regards the sclerites we note that the maxima and minima are greater in accordance with the higher temperature during these months. The scale curves also follow very closely expectation, if we assume that temperature is the directive agent in the production of wide or narrow sclerites.

In the curves of scales figured for the period, January to October, I have drawn a line through the portion where the growth up to May ended. This procedure I have followed in all the scale curves reproduced in the figures.

HOT AND COLD TANKS.

At the commencement of the experiment great trouble was encountered in keeping the animals in the hot tank in good condition, and several times the experiment had to be restarted owing to the fish either dying or getting into extremely poor condition. This was possibly due to the daily rise and fall of the temperature caused by the imperfect apparatus employed, because, after January, when the new apparatus had been installed this difficulty was not encountered, the fish in most cases appearing in quite normal condition. On account of this the results of the experiments between July, 1915, and January, 1916, have not received much attention, and although scale curves were made from each fish they have not been reproduced. This is not because they at all contradict the results of subsequent experiment, but because in most cases the fish had not lived long enough to exhibit much scale growth.

Of the six fish which did survive through the whole period, only three were at all in good condition, the others being much emaciated (see Table III).

From January to May the increase in length was in most cases a little greater than in the control tank, though the number of sclerites produced was practically the same. What is of great interest and importance, however, is the difference in the maximum and minimum breadths as compared with the controls. In no case was the maximum below 1·2 and the smallest minimum was 1. Further, the difference in breadth between the maxima and minima is small, in only two cases exceeding 0·4. This is of course as it should be, as the difference in temperature during the period was never greater than 1° C.

The scale curves, Fig. 6 (p. 479), are interesting in showing great similarity ; there is for all a sudden rise from below the 1 unit standard to a breadth of from 1 to 1·2. This width is maintained for a number of sclerites until a second rise is observed near the end of the period. These two rises, I think, synchronise with the increased temperature : first from 11·8° C., the normal for January, to 16·9° C. ; and secondly, between the end of March and beginning of April when the temperature was raised 1° C.

A further point which must not be overlooked is that at this period of the year, fish living in untreated water would be forming narrow sclerites, and their scale curve would be one showing a minimum, not a maximum. This I have shown to be the case with the control fish ; a comparison of their scale curves with those of Fig. 6, exhibits this in a striking way.

Of those fish that remained alive until October, the width of the sclerite formed at the end of the May period is maintained constant until a still greater width is attained at the margin of the scale. This, I believe, was due to the water in the tank rising from 17·9° to 19·7° between July and August.

The part of the table dealing with this period of experiment for the hot tank is almost a repetition of that for January to May.

I should like to call attention at this point to the two scales No. 12 and No. 15. The first of these shows an abnormally high width, while the second, though normal as regards the width of its sclerites, is remarkably deficient in them.

The fish to which scale No. 12 belonged was in very good condition and young: this was not the case with the fish from which No. 15 was taken. I attribute these peculiarities to nutriment, but will deal especially with this aspect of the problem in a later part of the paper.

The growth of the fish in the cold tank was, on the whole, very good. Table IV, which deals with the details of the fishes experimented upon, seems to show that the increase in length was slightly greater than that of the animals in the hot tank. There are, however, possibilities of error, such as faulty measurements and the small number of fish experimented upon, which make it impossible to draw any definite conclusions.

The figures of the maxima and minima for the sclerites for each period are, however, striking when compared with those of the corresponding periods for the hot tank animals. The figures are also lower than those for the control tank, though the difference is not very marked. This is, however, to be expected when it is remembered that it was only possible to keep the temperature of the cold tank a few degrees below the normal.

The scale curves, Fig. 7 (p. 479), are very interesting in showing the marked difference between them and those of the hot tank for the period of January to May. In all cases, and this was found in scales not figured, the curve never rises above unity, while in the hot tank it never falls below that width.

For the period January to October, the curves have a tendency to rise; there is an increased width of sclerites for the months July to September, but the greatest width does not approach that of the hot tank fish for the same months.

Compared with the control scale curves, there is similarity, but we find that the widths are more uniformly low.

When considered in relation to the temperature for each month the curves follow very closely the varying changes in the degree of heat, which the water possessed in which the animals lived.

As in the case of the hot tank scale curves we note that these curves also follow one another very closely, only differing in minor degrees.

The results of the experiments on the scales of fishes living in artificially heated and cooled water seems to indicate clearly that the temperature of the water has a very marked effect on the width of the sclerites produced. It is well to remember in connexion with this that the feeding of the fish in the two tanks was exactly the same.

ABUNDANT AND SCANTY TANKS.

As I have already said in these two tanks the temperature of the water was not altered. The only difference in the way the fish were treated was as regards the amount of food given to them. As the experiment in the case of these two classes of animals progressed satisfactorily from the very beginning, that is from July, 1915, until October, 1916, I have included scale curves in the figures for the period, July, 1915, to January, 1916.

As regards the sclerites the Tables V and VI shows a uniformity among the fishes of the abundant tank which were in good condition ; of those in a bad condition at the end of the experiment I shall treat later.

Figs. 8 and 9 (p. 481) are scale curves of abundant and scanty fed fish respectively. They are very alike in their general aspect as regards the type of curve, and in each set the maxima and minima are produced at approximately the same time and in accordance with the rise or fall of temperature at that time. Further it will be noted that there is correspondence between the course of these curves and those of the control fish scales of the same period.

If food were the predominating cause of the winter and summer rings of the scales, the expectation would be that the scales from the two sets of fish would have been remarkably different : this, however, we see is not the case.

The increase in length of the fish, as shown in the table, is very different, the scantily fed animals not increasing to any great extent. Also the number of sclerites produced by the abundantly fed fish is in excess of those produced by the animals in any of the other tanks.

Figs. 8 and 9 show very clearly the great difference between the number of sclerites produced for a given period by fish in the two tanks.

The last scale figured, No. 13 of Fig. 8, is interesting in this connexion : the condition of the animal was never very good, and at the end of the experiment the increase in length was only 1 cm. ; that is, for a period of nine months this animal had only added 1 cm. to its length. In accordance with this we note that but 13 new sclerites had been added to the scale ; thus though the animal had been given the opportunity for feeding well it had for some reason not availed itself of it, and had thus become comparable with the fish of the scanty tank.

The converse of this occurred once or twice with the scantily fed fish, in that some of the more vigorous animals managed to obtain more than their share of the food given to them ; with the result that they increased in length much more than did their fellows and developed many more sclerites. Most examples of this have been omitted from the table, but scale No. 14 for the period of May to October exhibits the condition to a small extent.

In Fig. 10 (p. 473) are seen a few curves of the scales of fish from various tanks which were in bad condition. The first two curves are from two fish from the abundant tank, No. 8 and 9 in the table. In February, 1916, they both died in an apparently exhausted condition. The same applies to the scales S. 8, S. 10, being from fishes 8 and 10 of the scanty tank. It will be seen that the curves show the salient features of all those for that period taken from fish living in unheated water. They are characteristic, however, in showing the possession of very few sclerites, and in having the width of the sclerites slightly less than is usual.

Scale curve H. 15 is the most interesting in showing the predominance of temperature over nutrition in regard to sclerite form. It is a curve of a scale from a fish living in the hot tank, No. 15. From January to May the animal was in fairly good condition and produced 10 broad sclerites: from May to October, however, its condition was bad, but in spite of this six sclerites were produced and instead of being narrow, as might have been expected if food were the cause of width variation, they retained the broad width of 1·3.

In all cases the same effect is seen, that the lower nutrition, leading to a poor condition, results in the lessening of the number of sclerites produced, but does not affect the breadth.

Reference to the tables will show that where the condition of a fish is reported as poor, very thin, etc., the number of sclerites produced is small, but the maximum and minimum widths remain similar to those for fish in good condition.

CONCLUSIONS.

The conclusions which I draw from the result of these experiments on the scale growth of fish is, that the broad summer bands, which are caused by the sclerites formed during that period being wide, and the narrow winter bands, produced by narrow sclerites, are due to changes in the temperature of the water in which the animals are living. High temperatures, such as are found in the summer months, lead to the formation of broad sclerites, while the narrow ones are called forth by low winter temperatures.

Owing to the temperature of the water varying from month to month, or even from week to week, the scale curves do not show a continuous rise and fall, but exhibit at certain places secondary elevations or depressions, which I have termed secondary maxima and minima. These, I believe, to be due entirely to the above-mentioned variations in the monthly temperatures.

The amount of food which the fish consumes and its general condition does not affect the production of summer and winter bands: the only effect which poor nutrition seems to have on the scales is a tendency for the production of few sclerites. High food consumption leads to a high sclerite formation.

Thus the number of sclerites formed seems to follow hand in hand with the general metabolism of the animal.

Little experimental work on the cause of the appearance of winter and summer rings has been done. Winge came to the conclusion that external conditions were the causative agents, because of the identical appearance of the scales of cod captured off the Faroes.

On August 11th, 1911, six cod were captured and samples of scales taken. They were then liberated and were recaptured simultaneously nine months later. Of these, three fish of approximately the same size were selected, and from each fish five scales were taken, measured and a curve made. It was found that all the scale curves thus drawn were exceedingly alike, so much so as to include peculiar deviations in the course of the curves. Winge argues from this that external conditions were responsible for the form of the curves, because the fish must have lived together for the nine months before recapture, and must therefore have been subjected to similar external conditions, such as temperature and salinity. The supply of nourishment in the water must also have been the same for the three animals.

This experiment certainly indicates that it is the environment which controls the course of scale growth, but it does not show what particular factor is the principal agent.

J. Stuart Thomson in his paper on the scales of Gadidæ (p. 100) states that in his opinion it is the amount of food supply, rather than variation in temperature, which brings about the formation of annual rings in scales. His reasons for coming to this conclusion are two : The first rests upon the evidence afforded by a whiting which was kept in captivity in a tank at Plymouth from May, 1902, until July, 1903. The water in the tank was not treated in any way, and the animal was fed daily. When in July, 1903, the scales were examined the sclerites appeared of the same width, and no winter or summer rings were detected. The sclerites also seemed to be narrower than is the case with fish captured from the sea.

This result is in direct opposition to that which I have obtained, for my fish in the two tanks when the water was not artificially cooled or heated all showed distinct rings.

Also if food were the determining factor one would have expected that a fish fed daily, and which increased in length from 10–20 mm. to 21·5 cm. in fourteen months as Thomson records, would have exhibited broader, or at any rate as broad, sclerites as fish of the same age captured from the sea. Yet this is not so, the sclerites were narrower.

Again the total number of sclerites produced was about 50, but whiting from the sea of the same age showed about 43. This indicates that the animal experimented upon was in good condition and corresponded to my fish which were abundantly fed.

The second piece of evidence (p. 57) that Thomson adduces for his opinion is that deep-sea fishes are not exposed to seasonal variations of temperature and should not, therefore, show annual rings on their scales. In order to determine if this were so he examined scales from a haddock captured from 8–14 fathoms depth of water, and compared them with others taken from a haddock from 60–80 fathoms. The annual rings were as clearly marked in the latter as in the former.

It should be pointed out that 60–80 fathoms is not really deep water, and that seasonal variation does not disappear until a depth of 100 fathoms is reached. Indeed according to some oceanographers the variation would seem to extend to a slight extent to much greater depths.

In conclusion I wish to express a great gratitude to Dr. Allen for the interest he has taken in my work and for the many suggestions he has made to me : also for the facilities he has given me to enable the experimental part of the work to be carried out. I must also express my thanks to Mr. D. J. Matthews for suggestions regarding the apparatus used for the heating and cooling of the water in the tanks. My thanks are also due to Mr. A. J. Smith for the feeding and care of the fish during the period when I was away from Plymouth.

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TABLE I

Age by otolith.	Length in cm.	No. of annular rings.	Average number of sclerites in successive years. I.	II.	III.	IV.	V.	VI.	Species.	Condition of fish.	Date scale was taken from fish.	
f1	2·6	1(+6)	19	—	—	—	—	—	not determined	very good	June 12, 1915	*captured
e1	2·7	1(+8)	10	—	—	—	—	—	,,	,,	,,	,,
b1	3	1(+8)	13	—	—	—	—	—	,,	,,	,,	,,
y1$\frac{1}{2}$	3·9	1(+11)	12	—	—	—	—	—	,,	,,	,,	,,
x1$\frac{3}{4}$	7·1	1(+15)	12	—	—	—	—	—	Plaice	good	July 28, 1915	,,
2	7·9	2	12	20	—	—	—	—	Flounder	very good	,,	,,
2	7·9	2	10	26	—	—	—	—	,,	,,	,,	,,
K2	8·2	2(+6)	16	32	—	—	—	—	,,	,,	May 28, 1915	,,
J2	8·9	2(+4)	13	39	—	—	—	—	Plaice	,,	,,	,,
L2	9·1	2(+5)	14	22	—	—	—	—	,,	good	,,	,,
2	9·1	2(+3)	12	30	—		—	—	Flounder	very good	,,	,,
2	9·6	2(+7)	11	36	—	—	—	—	,,	,,	,,	,,
2$\frac{3}{4}$	14·9	2(+16)	11	14	—	—	—	—	,,	good	,,	,,
2$\frac{3}{4}$	17·5	2(+18)	14	19	—	—	—	—	Plaice	very good	June 12, 1915	,,
2$\frac{3}{4}$	17·6	2(+11)	8	18	—	—	—	—	,,	,,	May, 1916	*H. Jan.–May, 1916
2$\frac{1}{2}$	19	2(+2)	15	17	—	—	—	—	Flounder	,,	Sept., 1915	captured
2$\frac{1}{2}$	20·2	2(+21)	14	32	—	—	—	—	Plaice	excellent	May 28, 1915	,,
2$\frac{3}{4}$	25·5	2(+26)	16	16	—	—	—	—	Flounder	,,	May 12, 1916	A. July, 1915–May, 1916
†3	15·5	3	6	10	12	—	—	—	Plaice	fair	Aug., 1915	captured
3	20	3(+2)	10	12	6	—	—	—	Flounder	,,	May 28, 1915	,,
3$\frac{3}{4}$	21·3	3(+12)	8	10	18	—	—	—	Plaice	good	Jan. 9, 1916	C. July, 1915–Jan., 1916

TABLE I—*continued.*

Age by otolith.	Length in cm.	No. of annular rings.	Average number of sclerites in successive years. I.	II.	III.	IV.	V.	VI.	Species.	Condition of fish.	Date scale was taken from fish.	
3	21·5	3	8	20	19	—	—	—	Flounder	good	Aug., 1915	captured
H3¼	22·6	3(+12)	10	27	23	—	—	—	Plaice	,,	May 28, 1915	,,
3	25	3(+12)	11	24	19	—	—	—	,,	,,	Jan., 1916	C. July, 1915–Jan., 1916
3½	25·2	3(+6)	14	24	20	—	—	—	,,	,,	Aug., 1915	,,
3	27·3	3	16	22	25	—	—	—	Flounder	,,	Jan., 1916	,,
3½	27·6	3(+6)	11	16	22	—	—	—	Plaice	,,	May, 1915	,,
3	28·3	3(+15)	6	32	26	—	—	—	Flounder	,,	,,	,,
3¼	28·4	3(+18)	9	24	31	—	—	—	,,	excellent	Sept., 1915	,,
3¾	28·6	3(+20)	7	17	12	—	—	—	Plaice	,,	Jan. 9, 1916	A. July, 1915–Jan., 1916
3	29·6	3	9	21	28	—	—	—	Flounder	,,	Aug., 1915	,,
3	29·6	3(+1)	7	28	25	—	—	—	,,	,,	June, 1915	,,
3¾	30·6	3(+10)	15	24	32	—	—	—	Plaice	,,	May, 1916	A. July, 1915–May, 1916
W3¾	30·5	3(+8)	11	23	17	—	—	—	Flounder	good	June 12, 1915	captured
3½	30·2	3(+6)	11	22	16	—	—	—	,,	,,	July, 1915	,,
3½	31	3(+8)	14	14	20	—	—	—	,,	fair	May, 1915	,,
P3	32	3(+7)	10	30	25	—	—	—	Plaice	excellent	June 12, 1915	,,
†3	32·1	3	16	26	20	—	—	—	,,	,,	May, 1915	A. July, 1915–May, 1916
†3	32·1	3	21	26	28	—	—	—	,,	,,	June, 1915	captured
4½	24·7	4(+3)	6	16	6	10	—	—	,,	poor	May, 1915	,,
4¼	25·5	4(+2)	8	8	27	24	—	—	Flounder	fair	Aug., 1915	,,
4	26·7	4(+2)	8	22	14	14	—	—	,,	,,	,,	,,
4	27	4(+2)	12	17	12	18	—	—	Plaice	,,	Sept., 1915	S. July, 1915–Sept., 1915

$4\frac{1}{2}$	27·8	4(+6)	9	11	24	20	—	—	Plaice	excellent	Jan., 1916	captured
$4\frac{3}{4}$	28	4(+8)	8	10	15	16	—	—	Flounder	good	Sept., 1915	,,
$4\frac{1}{2}$	28·5	4(+5)	6	14	7	15	—	—	,,	,,	May, 1915	,,
$4\frac{1}{2}$	29·4	4(+15)	8	20	20	19	—	—	,,	very good	Aug., 1915	,,
$4\frac{1}{4}$	29·5	4	12	30	16	24	—	—	,,	excellent	Sept., 1915	,,
$4\frac{1}{4}$	30	4(+5)	10	12	16	18	—	—	,,	good	June, 1915	,,
4	30	4	13	10	13	31	—	—	,,	very good	Sept., 1915	H. July–Sept., 1915
$4\frac{1}{2}$	30·5	4(+6)	19	10	9	34	—	—	Plaice	,,	June, 1915	captured
4	30·6	4(+4)	18	12	12	17	—	—	Flounder	good	May, 1915	,,
4	30·6	4(+6)	14	10	15	8	—	—	Plaice	,,	Jan., 1916	A. July, 1915–Jan., 1916
4	30·6	4(+5)	18	18	22	22	—	—	,,	,,	Aug., 1915	captured
4	33	4(+7)	4	23	18	14	—	—	Flounder	very good	Jan., 1916	S. July, 1915–Jan., 1916
$4\frac{3}{4}$	33·5	4(+10)	8	24	30	14	—	—	Plaice	good	Sept., 1915	C. July, 1915–Sept.,1915
F4	35·6	4(+10)	12	17	18	25	—	—	,,	excellent	May 28, 1915	captured
X4	26·8	4(+3)	4	16	6	5	—	—	,,	poor	Jan. 9, 1916	,,
$5\frac{1}{4}$	30·5	5(+3)	10	8	10	12	15	—	,,	fair	,,	,,
E5	31·2	5(+3)	8	15	24	18	16	—	Flounder	good	,,	,,
D5	32·5	5(+15)	12	17	14	18	17	—	Plaice	,,	May 28, 1915	,,
B5	35	5(+7)	5	10	30	9	18	—	,,	very good	,,	,,
$6\frac{1}{2}$	34·5	6	6	8	7	7	12	6	Flounder	fair	,,	,

* In the last column the word captured means the animal was taken straight from the sea, and did not live under experimental conditions before the scales were examined. A denotes that the animal lived in abundant tank; S in the scanty; H in the hot, and C in the cold tank before the scales were examined.

TABLE II

Control Tank

			January, 1916–May, 1916.						May, 1916–October, 1916.					
	Age in years.	Species.	No. of sclerites.	Max.*	Min.	Length in cm.	Increase in length.	Condition.	No. of sclerites.	Max.	Min.	Length.	Increase in length.	Condition.
1	3	Flounder	10	1	·6	25·4–25·6	0·2	very good	—	—	—	—	—	—
2	3	,,	8	1	·7	25–25·1	0·1	good	—	—	—	—	—	—
3	3¾	,,	9	·9	·7	28·9–29	0·1	,,	—	—	—	—	—	—
4	3½	,,	10	1	·6	29·6–29·7	0·1	,,	—	—	—	—	—	—
5	4½	Plaice	11	1·1	·7	30·6–30·7	0·1	,,	—	—	—	—	—	—
6	3¾	,,	4	1	·5	28·9–28·9	0	fair	—	—	—	—	—	—
7	4	,,	7	·9	·8	28·9–29	0·1	good	—	—	—	—	—	—
8	4	,,	5	1	·7	30·5–30·6	0·1	fair	—	—	—	—	—	—
9	3	,,	7	1·1	·7	25·2–25·3	0·1	good	—	—	—	—	—	—
10	2¾	Flounder	9	1	·8	23·9–24	0·1	,,	—	—	—	—	—	—
11	4	,,	12	1·1	·8	30·0–30·1	0·1	,,	13	1·4	1·1	30·1–31·1	1	excellent
12	4	,,	12	1·1	·6	29·8–30	0·2	,,	12	1·3	1	30–31	1	,,
13	3	,,	13	1	·6	26–26·1	0·1	,,	10	1·4	1	26·1–27	0·9	,,
14	3½	Plaice	12	1	·7	28–28·2	0·2	,,	14	1·5	1·1	28·2–29	0·8	,,
15	3	,,	10	1·1	·8	27·5–27·6	0·1	,,	9	1·5	1·1	27·6–27·8	0·2	fair
16	3	,,	11	1	·6	27·1–27·2	0·1	,,	12	1·4	1	27·2–28	0·8	good

* In the columns labelled Max. and Min. are given the maximum and minimum widths of the sclerites for the period.

TABLE III

Hot Tank

	Age in years.	Species.	July, 1915–January, 1916 No. of sclerites.	Max.	Min.	Length in cm.	Increase in length.	Condition.	January, 1916–May, 1916 No. of sclerites.	Max.	Min.	Length in cm.	Increase in length.	Condition.	May, 1916–October, 1916 No. of sclerites.	Max.	Min.	Length in cm.	Increase in length.	Condition.
1	3	Flounder	11	1·8	1·3	24·6–25·5	0·9	good	—	—	—	—	—	—	—	—	—	—	—	—
2	4	,,	18	1·6	1·1	30·6–32·1	1·5	very good	—	—	—	—	—	—	—	—	—	—	—	—
3	3½	Plaice	8	1·6	1·1	26·2–27	0·8	good	—	—	—	—	—	—	—	—	—	—	—	—
4	3	,,	4	1·4	1·2	27·5–27·2	-0·3	poor	—	—	—	—	—	—	—	—	—	—	—	—
5	3	Flounder	5	1·5	1·3	28–27·8	-0·2	,,	—	—	—	—	—	—	—	—	—	—	—	—
6	2¾	,,	8	1·4	1	24·6–24·6	0	fair	—	—	—	—	—	—	—	—	—	—	—	—
7	4	,,	—	—	—	—	—	—	11	1·5	1	28–28·3	0·3	good	—	—	—	—	—	—
8	4	Plaice	—	—	—	—	—	—	8	1·3	1	29·5–29·6	0·1	fair	—	—	—	—	—	—
9	3	Flounder	—	—	—	—	—	—	12	1·4	1	26·2–26·8	0·6	good	—	—	—	—	—	—
10	2¾	Plaice	—	—	—	—	—	—	9	1·3	1	15·5–15·7	0·2	fair	—	—	—	—	—	—
11	4	Flounder	—	—	—	—	—	—	7	1·2	1	32·5–33·5	1	good	—	—	—	—	—	—
12	2½	,,	—	—	—	—	—	—	10	1·7	1·1	17·6–18·4	0·8	very good	—	—	—	—	—	—
13	3	,,	—	—	—	—	—	—	9	1·4	1·1	25·9–26	0·1	fair	10	1·5	1·3	26–26·8	0·8	very good
14	3½	Plaice	—	—	—	—	—	—	10	1·4	1	29·9–32·5	2·6	very good	12	1·6	1·3	30·9–32·5	1·6	excellent
15	4	,,	—	—	—	—	—	—	10	1·4	1	30·5–30·9	0·4	fair	6	1·3	1·3	30·9–30·7	-0·2	poor
16	4	,,	—	—	—	—	—	—	10	1·3	1	30–30·5	0·5	good	6	1·5	1·3	30·5–30·8	0·3	good

TABLE IV

Cold Tank

	Age in years.	Species.	July, 1915–January, 1916 No. of sclerites.	Max.	Min.	Length in cm.	Increase in length.	Condition.	January, 1916–May, 1916 No. of sclerites.	Max.	Min.	Length in cm.	Increase in length.	Condition.	May, 1916–October, 1916 No. of sclerites.	Max.	Min.	Length in cm.	Increase in length.	Condition.
1	3	Plaice	9	1	·8	24·2–25	0·8	very good	9	1	·8	25–25·5	0·5	good	—	—	—	—	—	—
2	3	,,	4	1	·8	28·3–28·3	0	,,	10	·9	·7	28·3–28·5	0·2	,,	—	—	—	—	—	—
3	3	Flounder	5	1	·9	25·2–25·5	0·3	good	—	—	—	—	—	—	—	—	—	—	—	—
4	3½	,,	12	1	·8	26·8–28·5	1·7	excellent	—	—	—	—	—	—	—	—	—	—	—	—
5	2½	Plaice	7	1	·8	21·7–22·2	0·5	good	—	—	—	—	—	—	—	—	—	—	—	—
6	4	,,	8	1	·9	30·5–31	0·5	,,	—	—	—	—	—	—	—	—	—	—	—	—
7	3	Flounder	6	1	·8	26·9–27·4	0·5	fair	11	·9	·6	27·4–27·8	0·4	very good	—	—	—	—	—	—
8	4	,,	8	1	·7	30·8–31·5	0·7	good	10	·9	·7	31·5–31·8	0·3	good	—	—	—	—	—	—
9	3½	,,	12	1	·8	26·8–28·5	1·7	very good	6	·8	·5	28·5–29·5	1	,,	—	—	—	—	—	—
10	3	Plaice	—	—	—	—	—	—	12	·9	·6	28–28·5	0·5	,,	—	—	—	—	—	—
11	4	,,	—	—	—	—	—	—	9	·8	·5	33–33·1	0·1	fair	—	—	—	—	—	—
12	2¾	,,	—	—	—	—	—	—	6	·9	·5	20·5–20·9	0·4	good	—	—	—	—	—	—
13	2	Flounder	—	—	—	—	—	—	10	·9	·7	19–21·5	2·5	very good	10	1	·9	21·5–24	2·5	very good
14	3	,,	—	—	—	—	—	—	9	·9	·7	24·5–24·7	0·2	good	7	1·1	·9	24·7–26·2	1·5	,,
15	2¾	,,	—	—	—	—	—	—	8	·9	·7	20·5–20·9	0·4	fair	4	1	·9	20·9–21·2	0·3	poor
16	3	,,	—	—	—	—	—	—	9	1	·7	25–25·6	0·6	good	6		·9	25·6–26·3	0·7	good

TABLE V

Abundant Tank

			July, 1915–January, 1916						January, 1916–May, 1916						May, 1916–October, 1916					
	Age in years.	Species.	No. of sclerites.	Max.	Min.	Length in cm.	Increase in length.	Condition.	No. of sclerites.	Max.	Min.	Length in cm.	Increase in length.	Condition.	No. of sclerites.	Max.	Min.	Length in cm.	Increase in length.	Condition.
1	$2\frac{3}{4}$	Flounder	16	1·4	·9	25·5–29·1	3·6	very good	—	—	—	—	—	—	—	—	—	—	—	—
2	2	,,	18	1·3	·8	24·5–28·3	3·8	,,	—	—	—	—	—	—	—	—	—	—	—	—
3	3	Plaice	16	1·3	·9	25·5–29·1	3·6	,,	17	1·2	·7	29·1–29·9	·8	very good	—	—	—	—	—	—
4	$3\frac{3}{4}$	,,	12	1·3	·9	27·9–29·9	2	,,	12	1	·7	29·9–30·6	·7	,,	—	—	—	—	—	—
5	$3\frac{1}{2}$	Flounder	13	1·3	·9	27·2–28·6	1·4	,,	12	1·1	·8	28·6–29	·4	,,	—	—	—	—	—	—
6	4	Plaice	18	1·4	·9	32·1–33·5	1·4	,,	19	1·3	·6	33·5–34	·5	excellent	—	—	—	—	—	—
7	$2\frac{3}{4}$	Flounder	6	1·1	·9	24–24	0	very thin	11	1·5	·9	24–24·6	·6	fair	—	—	—	—	—	—
8	4	,,	6	1·4	1·1	31–30·9	–0·1	,,	—	—	—	—	—	—	—	—	—	—	—	—
9	$3\frac{1}{4}$	,,	7	1·3	1	26–26	0	poor	—	—	—	—	—	—	—	—	—	—	—	—
10	4	,,	20	1·3	·8	32–33·1	1·1	excellent	12	1·1	·8	33·1–33·7	·6	excellent	—	—	—	—	—	—
11	2	Plaice	—	—	—	—	—	—	13	1·1	·7	15·2–16·2	1	very good	14	1·5	1	16·2–18	1·8	excellent
12	$3\frac{1}{2}$	Flounder	—	—	—	—	—	—	16	1·3	·8	26–27·3	1·3	,,	17	1·6	1·3	27·3–29	1·7	,,
13	$2\frac{3}{4}$	Plaice	—	—	—	—	—	—	7	·9	·7	17·5–17·6	·1	fair	6	1·2	·9	17·6–18·5	0·9	very thin
14	$4\frac{1}{2}$	,,	—	—	—	—	—	—	6	1	·8	27–27	0	,,	15	1·3	1	27–29·1	2·1	very good
15	4	Flounder	—	—	—	—	—	—	18	1·1	·8	28·3–29·7	1·4	excellent	24	1·3	·9	29·7–33·2	3·5	excellent

TABLE VI

Scanty Tank

			July, 1915–January, 1916						January, 1916–May, 1916						May, 1916–October, 1916					
	Age in years.	Species.	No. of sclerites.	Max.	Min.	Length in cm.	Increase in length.	Condition.	No. of sclerites.	Max.	Min.	Length in cm.	Increase in length.	Condition.	No. of sclerites.	Max.	Min.	Length in cm.	Increase in length.	Condition.
1	$4\frac{3}{4}$	Flounder	6	1·3	1·1	31·5–31·5	0	very thin	—	—	—	—	—	—	—	—	—	—	—	—
2	$3\frac{3}{4}$	,,	8	1·3	0·6	28·5–28·6	0·1	,,	—	—	—	—	—	—	—	—	—	—	—	—
3	$2\frac{3}{4}$	,,	10	1·3	0·8	20·2–22·4	2·2	good	8	1·1	0·7	22·4–23	0·6	fair	—	—	—	—	—	—
4	$4\frac{1}{2}$	Plaice	6	1·2	0·9	33·5–34	0·5	fair	8	1	0·8	34–34·2	0·2	,,	—	—	—	—	—	—
5	3	,,	8	1·2	0·9	21·3–21·5	0·2	,,	8	1·1	0·7	21·5–21·8	0·3	,,	—	—	—	—	—	—
6	$3\frac{3}{4}$	Flounder	8	1·2	0·8	26–26·6	0·6	,,	8	1	0·6	26·6–26·9	0·3	,,	—	—	—	—	—	—
7	$4\frac{1}{2}$	,,	10	1·4	0·9	30·5–31·3	0·8	good	—	—	—	—	—	—	—	—	—	—	—	—
8	$2\frac{3}{4}$	,,	5	1·3	0·7	24·9–24·9	0	very thin	—	—	—	—	—	—	—	—	—	—	—	—
9	4	,,	4	1·2	0·5	30–29·9	–0·1	,,	—	—	—	—	—	—	—	—	—	—	—	—
10	2	,,	8	1·3	0·6	20·5–20·6	0·1	,,	—	—	—	—	—	—	—	—	—	—	—	—
11	—	—	—	—	—	—	—	—	7	0·9	0·6	33·5–33·6	0·1	fair	5	0·8	0·8	33·6–34	0·4	very poor
12	—	—	—	—	—	—	—	—	10	0·9	0·7	24·6–25	0·4	good	8	1·1	0·9	25–25·5	0·5	fair
13	—	—	—	—	—	—	—	—	10	1	0·6	30·5–31	0·5	,,	7	1·2	1	32–32·9	0·9	good
14	—	—	—	—	—	—	—	—	9	0·9	0·7	13·5–13·7	0·2	,,	12	1·3	1	13·7–16	2·3	very good
15	—	—	—	—	—	—	—	—	8	1	0·8	21·3–21·5	0·2	fair	9	1·2	0·9	21·5–22·5	1·5	good

A List of the Maritime, Sub-Maritime and Coast-frequenting Coleoptera of South Devon and South Cornwall, with especial reference to the Plymouth District.

By

James H. Keys, F.E.S.

PREFATORY REMARKS.

It may perhaps be well to say that by maritime species are meant those Beetles whose habitats are covered by the sea for a considerable time during the flow and ebb of the tide. By sub-maritime species are meant the dwellers at high-tide mark or thereabouts, subjected to occasional wettings by the sea, and the species inhabiting brackish pools and wet places in salt-marshes. The coast species comprise individuals living under stones and rejectamenta, as a rule safe from the reach of high tide, and those peculiar to the roots, leaves and flowers of plants attached to the coast, as well as inhabitants of wooden piles on the shore and the denizens of the ooze of fresh-water trickles on the cliffs—excepting species equally obtainable inland.

The Maritime Beetles included in the list comprise eight species, and are preceded by a double dagger (‡) for the sake of distinction; the Sub-Maritime amount to fifty-four species and are preceded by a single dagger (†); the Coast Species number eighty-nine, and are preceded by an asterisk (*).

The Plymouth District has been regarded as including any locality which in a day conveniently admits of four or five hours' collecting, in addition to the journey thither and back. Roughly speaking this embraces the coast line from Slapton Ley on the east to the Seaton Valley (Downderry) on the west.

The writer is fully conscious of the fact that his work necessarily falls considerably short of being a complete catalogue of the species indigenous to the district, as much of the extensive coast line has never been examined by any collector, whilst his own work at the foreshores of the several estuaries and at the numerous tidal creeks has been limited to a few localities of easy access. A large proportion of the country still awaits the attention of the Coleopterist. That it would repay careful research there need be little doubt, as the writer has seldom ventured into a locality previously unknown to him without having been rewarded by the capture of one or more species new to the district.

The obscure and unobtrusive habits of Beetles must in this connection be remembered. These characteristics, taken in conjunction with the fact that many species abundant in a favourable season may not be discoverable at all in the following year, render it desirable that likely places should receive frequent visits at suitable intervals, if the local Coleopterous Fauna is to be completely enumerated.

The absolute failure of the compiler to secure in the Plymouth area even a single exponent of the genus *Bledius*—and consequently of the genus *Dyschirius* which preys upon it—the ubiquitous *D. globosus* excepted—has long been a source of regret to him, and he cannot but think that they will yet be found in one or other of the creeks in the district, and particularly so as more than one member of both the genera have been taken in numbers at Dawlish Warren on the one side, and at several places in Cornwall on the other side of Plymouth.

Of the truly Maritime and Sub-Maritime Coleoptera there is little doubt as to the species which should be included in such a list as the present; but with respect to coast species the matter is not so readily determined. The main cause of doubt lies in the fact that the life-histories of so many beetles are not yet understood, and experience seems to show that species peculiar to the coast in one district are equally at home inland in another. A hard and fast line of demarcation in the matter of habitat is therefore not yet possible. But inasmuch as it is desirable to have authority in support of one's ruling, the writer, in the main, has adopted Fowler's Coleoptera of the British Isles as the guide for the inclusion of the coast species. A little discretionary power has been reserved however, and a few interesting species which occur with us only on the coast have been inserted in the list, although not definitely asserted by Fowler to be of that habit.

One must not omit to record the successful work of Commander J. J. Walker, R.N., at Whitsand Bay in the seventies and early nineties. With him rests the honour of having first discovered there such rarities as *Harpalus tenebrosus* and *Psammobius porcicollis*, as well as a long list of other uncommon Coleoptera, and the writer heartily acknowledges his obligation to Commander Walker for kindly having shown him the habitats of those species. In later years Mr. Philip de la Garde, R.N., did splendid work in the South Devon District, and several additions were made to the British List by him; but perhaps his most notable contribution to the local fauna was the capture at Dawlish of the much-desired *Arena octavii*. It will be long ere the lamentable breach caused by his untimely death can possibly, if ever, be filled.

In conclusion the writer wishes to acknowledge his indebtedness for the assistance he has received in compiling this catalogue to an incompleted manuscript list of the Devonshire Coleoptera, the work of his late lamented friend, Mr. Philip de la Garde, R.N., and he also has to thank his friend, Mr. E. A. Newbery, for valued suggestions and help.

October, 1917.

GEODEPHAGA.

*CICINDELA GERMANICA L. Seaton, June, 1895, de la Garde.

†DYSCHIRIUS ARENOSUS Steph. (THORACICUS Rossi). Exmouth Warren, Parfitt, not uncommon; de la Garde, three specimens iv/07, common vii/09.

†D. SALINUS Schaum. Exmouth Warren, Parfitt, very rare; de la Garde iv/07 and viii/07. Dawlish, G. C. Champion, August–September, 1907. Par, Vic. Hist. Corn.

*PANAGÆUS BIPUSTULATUS Fab. (4-PUSTULATUS Sturm.). Whitsand Bay, May, 1890, one under stone on the slopes; Tregantle, March, 1905, one. Penlee Point, May, 1902, one running on pathway, E. E. Lowe. Dartmouth, spring, 1908, H. St. J. K. Donisthorpe. Shaldon, April, 1909, one in moss, de la Garde.

*CHLÆNIUS VESTITUS Payk. Slapton Ley; Wembury Beach, June, 1898, several by the rivulet; Lipson Marsh, April, 1900; Compton Fields, 1901. Shaldon, de la Garde, one under the cliff. Has not occurred to me at inland marshes.

*C. NIGRICORNIS F. and var. MELANOCORNIS Dej. Slapton Ley. The latter a single specimen only.

*BROSCUS CEPHALOTES L. Whitsand Bay.

*BEMBIDIUM CONCINNUM Steph. Abundant on the shore near Puslinch, estuary of the Yealm, August, 1900; several examples on the shore, Newton Ferrers, June, 1916; in great abundance in the bed of the river near the mouth of the Tavy, 1917.

†B. SAXATILE Gyll. Shaldon, de la Garde. Exmouth, G. C. Champion.

†B. VARIUM Ol. Downderry, August, 1900; Lipson Marsh, May, 1910.

†B. MINIMUM F. Exminster, Parfitt; muddy places by the Exe. Topsham, de la Garde, April and August, 1912.

†B. NORMANNUM Dej. Wivelscombe Creek, June, 1915, six examples. Dawlish Warren, in numbers, March, 1907, de la Garde (a small form).

†LIMNÆUM NIGROPICEUM Marsh. Rare. Batten, December, 1888, one; August, 1889, one; August, 1890, one; September, 1890, two,

deep in the shingle. Rame Head, April, 1902, three examples. Shaldon, one, de la Garde. Torcross, August–September, 1907, G. C. Champion. Side of the Exe, rare, Parfitt.

‡CILLENUS LATERALIS Sam. Millbrook Creek and mouth of the Yealm, in numbers. Wivelscombe Creek and Bere Ferrers, a few specimens. Dawlish Warren, one example, February, 1908, de la Garde.

†TACHYS PARVULUS Dej. Four specimens, in shingle just below high water, about half a mile beyond Bovisand, June, 1905.

‡AËPUS MARINUS Ström. Generally distributed all along the coast from the Yealm to Cremyll, also found in the estuaries at Wivelscombe, Bere Ferrers, etc. Some seasons abundant. At Batten, October, 1909, quite 200 under one boulder, 70 were captured. Once only I found them in numbers in the roll of rejected seaweed at high-water mark at Millbrook Creek, their usual habitat being under stones embedded an inch or two in clayey shores. They occur practically all the year round and their larvæ may often be taken with them. In 1888 the insect could be obtained at Tinside and in coves between the rocks under the Citadel. Shaldon, de la Garde and G. C. Champion, August-September, 1907.

‡A. ROBINII Laboulb. This species is very like the preceding, but, besides its well-known specific differences, is of more robust build. It occurs all along the coast and may be taken in company with *marinus*, but I have not found it in the estuaries.

In 1889 and 1890 this species occurred to me more commonly than did *A. marinus*.

Probably there are alternating but gradual periods of abundance and scarcity in the occurrence of the two species; and I indeed noted that, in 1909, when *marinus* could be obtained in greater numbers than ever I saw it before, *robinii* did not occur to me at all. It is not easy to appreciate the cause of a definite struggle for existence between these two species, because, although occasionally met with together, the natural habitat of *robinii* seems to be much nearer the Laminarian zone than that of *marinus*. It was in the domain of the latter species that the submarine Hemipteron *Aëpophilus* was first discovered, and it has always been in that region that I have taken it in any quantity at Batten. In my experience it will be only by the lucky capture of stray individuals that *Aëpophilus* will be obtained where *marinus* abounds, i.e. in the upper reaches of the shore, below high-water mark.

NOTE.—Professor Miall, in his Natural History of Aquatic Insects, 1895, p. 376, speaking of *Aëpus*, says: "The eyes are very curious. A chitinous plate protects and almost entirely covers them, leaving only a small round central hole. The form of this plate suggests that it may be employed as a kind of pin-hole camera. Mr. Hammond, who called my attention to this peculiarity, has drawn it in Fig. 114." I have never been able to find this protecting cover to the eyes in any of the Plymouth examples, and recently (in 1916) I called the attention of my friend, Mr. R. J. Baker, to the subject. He dissected out the eyes of several specimens and very soon presented me with a pin-hole plate mounted in balsam on a slide. At the same time he called my attention to the fact that this plate was at the back of the eye and not in front, as the description in Miall would lead one to suppose; and pointed out that the illustration of the eye in section in the work in question depicted the plate at the extreme back of the eye. If, therefore, Mr. Baker is right in assuming the drawing to be correct and the text not so, the supposed curiosity is nothing more than the ordinary optic foramen found probably in all beetles with organs of vision.

*PERILEPTUS AREOLATUS Creutz. Two specimens, Stoke Bay, June 10th, 1917, in shingle by a rill of fresh water. It was in quantity, but I did not recognize it. July 15th, very scarce at the rill, but I discovered it in numbers nearer the sea, where the shingle ended and the rocks commenced, by throwing the shingle into pools formed by the rill, and in which the seaweed *Enteromorpha intestinalis* (kindly named for me by Mr. T. V. Hodgson) was growing. This species is not usually considered a coast insect, but its occurrence under the conditions noted appears to warrant its inclusion in this list. Dr. Cameron, R.N., tells me that "*Perileptus* is common in shingle stream banks in the Eastern Mediterranean right down to the coast." The beetle is rare in England.

†TRECHUS FULVUS Dej. (LAPIDOSUS Daws). Three specimens on the beach at Rame Head, April, 1902; one, Bovisand, July, 1905.

*T. SUBNOTATUS Dej. Introduced by Mr. Newbery as British on a single specimen taken by de la Garde, at Shaldon. The insect was shaken out of a tuft of grass evidently dislodged from the cliffs and lying on the beach. Ent. Mo. Mag., Vol. XLVI. (1910), p. 131.

†POGONUS CHALCEUS Marsh. Mouth of the Erme, September, 1906; Wivelscombe Creek, June, 1915; Budshead Creek, Tamerton, June, 1916. Dawlish Warren, abundant, de la Garde.

*HARPALUS TENEBROSUS Dej. This rare species was first discovered in the Plymouth district by Mr. J. J. Walker at Whitsand Bay in 1875, who showed me the exact locality, where it may still be obtained in spring and autumn. Batten, one male, April, 1904. Slapton Ley, Wollaston, 1852.

*H. TARDUS Panz. Mothecombe, September, 1905, three females. Dawlish, de la Garde.

*H. ATTENUATUS Steph. One specimen, Whitsands, June, 1902, but abundant in the following August. One only Millbrook Creek, July, 1902. Dawlish Warren, April, 1907, one only, de la Garde.

†DICHIROTRICHUS OBSOLETUS Dej. Three near Cargreen in rejectamenta on the shore, October, 1912.

†D. PUBESCENS Payk. Near mouth of the Erme, September, 1906, in abundance. Cargreen, October, 1912, one only. Wivelscombe Creek, June, 1915, several. Dawlish, de la Garde.

*AMARA OVATA F. Whitsand Bay, not rare. Downderry, E. A. Newbery. Woodbury Common, scarce, Parfitt.

Ab. ADAMANTINA Kol. Tregantle, one specimen, August, 1902. Apparently the only British record of this brilliant variety.

*A. LUCIDA Duft. Whitsand Bay. Frequent.

*CALATHUS MOLLIS Marsh. Torcross, August, 1895. Dawlish, de la Garde.

†LIONYCHUS QUADRILLUM Duft. The first record of this rare species for Devonshire was made by Mr. T. V. Wollaston, who discovered it at Slapton Ley. In The Zoologist, 1851–2, p. 3619, he says: "Its habits are very remarkable . . . it selects the driest and most barren shingle at a distance from the beach, so loose and bare that even weeds are unable to exist upon it—where the insect may be seen darting from beneath in the clear sunshine, and as suddenly disappearing. . . . It is difficult to speculate on what a voracious insect like the present can feed in such a position; for the smaller animals in a pebble ridge, so dry and shifting as to refuse nourishment to even a blade of grass, and having more the appearance in fact of a recently opened gravel-pit than anything else, cannot be very numerous." I have several times searched for the insect in the shingles on the marine side of the Ley in vain; but I have taken it on two or three occasions in the shingle, close up to the rocks on the shore from Torcross to the Beesands, in the months of August and May. The examples were almost entirely the aberrant forms, none was a well-marked typical *quadrillum*.

In May, 1915, I discovered *Lionychus* at Downderry, Cornwall, darting about amongst the shingle at the foot of the sloping slaty rocks at high-tide mark. Seven typical forms, six with the posterior pair of spots very small, one with the latter just discernible, and two aberrations were taken. Remembering Wollaston's remarks, I watched the behaviour of the insects very carefully. They not only appeared and disappeared with rapidity in the gravel, but also darted about like flashes of light in the sunshine on the rocks close above it. When hard pressed in the chase, they made for joints in the slate in a way which convinced me they were quite familiar with the shelter to be obtained between the layers; and it was not always easy to dislodge them without injury when once they had reached their goal. It was not convenient for me to visit this locality again until August, 1916, when a most careful and prolonged search for some hour and a half failed to reveal a single specimen; but, by opening up the lamellæ of the slate rock below high-tide mark, I secured some half-dozen mature examples. There is little doubt that these specimens had bred there.

Ab. BIPUNCTATUS Heer. Slapton, Wollaston; Torcross; Downderry.

Ab. UNICOLOR Schill. Torcross.

*MICROLESTES (BLECHRUS) MAURUS Sturm. Bovisand; Wembury; Whitsands.

*DROMIUS NIGRIVENTRIS Thoms. Dawlish, May, 1906, one only.

*D. VECTENSIS Rye. On the shore between Torcross and Beesands, one only, May, 1901; at roots same locality, G. C. Champion and myself, about a dozen examples, August, 1907. Seaton, Power.

HYDRADEPHAGA.

*CŒLAMBUS INÆQUALIS F. Common. Lipson Marsh; Chelson Meadows; Downderry; Slapton Ley.

*BIDESSUS MINUTISSIMUS Germ. Slapton Ley, in quantity at times. First recorded by Wollaston.

*HYDROPORUS (DERONECTES) ASSIMILIS Payk. Slapton Ley, de la Garde one only, October, 1907.

*H. LINEATUS F. Exminster, de la Garde.

*AGABUS CONSPERSUS Marsh. Plentiful in a pool by the mouth of the R. Seaton, near Downderry.

*GYRINUS ELONGATUS Aubé. Slapton Ley.

*G. MARINUS Gyll. Powderham, Parfitt.

PALPICORNIA.

†HELOPHORUS MULSANTI Rye. In numbers by the R. Teign, near Teignmouth, June, 1909, de la Garde and myself.

†OCHTHEBIUS MARINUS Payk. In numbers in salt marsh, Insworke Barton, near Millbrook, June, 1909; Slapton Ley, April, 1913. By the R. Teign, de la Garde.

*O. VIRIDIS Peyr. Botusfleming, one specimen, ex coll. Rev. T. A. Marshall. Downderry, in swarms, edges of muddy pool, August, 1900; again in August, 1916.

†O. LEJOLISI Muls. et Rey. In brackish pools on the rocks between Penlee Point and Rame Head, 55 specimens, September, 1901.

*O. PYGMÆUS F. Slapton Ley, April, 1897, in abundance; by the Teign, June, 1909, one only.

*O. IMPRESSICOLLIS Lap. (BICOLON Steph.). Lipson Marsh, May, 1899, one only, May, 1910, in swarms; Chelson Meadow, August, 1907; May, 1908, one specimen caught in sweep net, Cawsand to Rame. By the Teign, abundantly, de la Garde.

*O. METALLESCENS Rosenh. *var.* POWERI Rye. Seaton, Dr. Power, one specimen, the original capture of this species. One specimen only, in fresh-water trickle on face of rocks on the shore at Bovisand, July, 1912. Subsequent search has failed, both in spring and autumn. Exmouth district, G. C. Champion, a single example in the summer of 1915; later in the year, having discovered the habits of the insect, he took it in some numbers. *Vide* Ent. Mo. Mag., Vol. LI., pp. 309–10.

*LACCOBIUS PURPURASCENS Newbery. Discovered by de la Garde, May, 1906, crawling in swarms among the slimy ooze where water had trickled down the red sandstone cliffs at Shaldon. Exmouth, G. C. Champion.

†CERCYON LITTORALIS Gyll. Generally abundant in the line of rejected seaweed at high-tide mark on the shore.

Var. BINOTATUM Steph. Frequent, with the type form.

†C. DEPRESSUS Steph. Found with the above, and not uncommon at Batten and other places in the Plymouth district. De la Garde records it from Shaldon only in the Teignmouth and Dawlish districts.

BRACHELYTRA.

†ALEOCHARA GRISEA Kr. Batten; Jennycliff; Bigbury Bay; Tregantle; Shaldon; but I never met with it in numbers. Dawlish Warren and Shaldon, de la Garde.

†A. ALGARUM Fauv. Common in decaying seaweed all around the coast.

†A. OBSCURELLA Er. With the above, but not so common.

*OXYPODA EXOLETA Er. Downderry, October, 1900, a single specimen.

†HETEROTA (ALIANTA) PLUMBEA Wat. Under seaweed; occurs with us from Wembury to Tregantle, but is not common. Exmouth, very rare, Parfitt. Shaldon, de la Garde. Abundant, August–September, 1907, G. C. Champion.

*ATHETA THINOBOIDES Kr. (LONGULA Heer). Slapton Ley, in the wet shingle and sand at edge of the water, sometimes in profusion; Wembury beach, several specimens, June and July, 1916; Downderry; Stoke Bay, June, 1917. Mount Edgcumbe shore, E. A. Newbery. Shaldon, de la Garde.

†A. VESTITA Grav. Very common under seaweed on the coast, and often in the estuaries, in small numbers.

†A. FLAVIPES Thoms. (HALOBRECTHA Shp.). Common under seaweed and in shingle.

*A. PUNCTICEPS Thoms. (ALGÆ Hardy). A single specimen at Downderry, October, 1900. Shaldon, de la Garde.

*A. TRIANGULUM Kr. Slapton Ley; Cremyll; in seaweed. Shaldon, de la Garde.

*A. INDUBIA Sharp. Millbrook Creek, several, May, 1906.

*A. FUNGI *var.* ORBATA Er. Burrow Island, May, 1911, one specimen at roots. Dawlish, de la Garde.

†MYRMECOPORA BREVIPES. Butl. In seaweed and shingle, generally distributed around the coast, and also in the estuaries; often in quantity. Shaldon and Dawlish Warren, de la Garde. It appears to replace *M. uvida* Er. with us and was considered to be that species until separated by Mr. E. A. Butler, who observes: ". . . the two insects do not overlap, but *M. brevipes* belongs to Devon and Cornwall, while *M. uvida* extends along the rest of the south coast from Hants to Kent and the estuary of the Thames. The area of *M. brevipes* therefore stands at present as Brittany, Jersey and the two south-western counties of England, while *M. uvida* is generally distributed."—Ent. Mo. Mag., XLV. (1909), p. 30.

†M. SULCATA Kies. Of similar habit to the above, but occurs in greater numbers.

‡ACTOCHARIS MARINA Fauv. (READINGI Shp.). Originally found at Plymouth by Mr. J. J. Reading. I searched in vain for years for it in the Batten district, which I understood was its habitat. It was rediscovered by Dr. M. Cameron at Millbrook Creek, in October, 1900, who obtained several specimens under seaweed. A few days later by carefully examining the shingle we together obtained some

40 specimens. July, 1901, 23 specimens; July, 1902, 9 specimens. The species is gregarious, but its minute size, $1\frac{1}{2}$ mm., makes it easily overlooked. Mr. J. J. Walker has taken it on several occasions at Falmouth.

†SIPALIA TESTACEA Bris. Batten beach under stones below high tide, and Millbrook Creek in the shingle at roots of rushes at high-tide mark. I have taken this rare species from March to September.

‡ARENA OCTAVII Fauv. Dawlish Warren, de la Garde, April, 1907, one specimen under dry tidal rubbish, and a few specimens in later years.

†PHYTOSUS SPINIFER Curt. Tregantle in April and May and again in August, occasionally in considerable numbers; Bovisand, one only, July, 1912, and one only, May, 1913; Stoke Bay, June, 1916, one only. De la Garde, Shaldon, February; Dawlish Warren, April. G. C. Champion, August–September, 1907.

†P. BALTICUS Kr. Under seaweed and in the sand below it with the above species, often in numbers, at Tregantle. Dawlish Warren, plentiful, March, 1907, and later years, de la Garde. August–September, 1907, G. C. Champion.

†P. NIGRIVENTRIS Chevr. With the above at Tregantle, but not so abundant. Dawlish Warren, de la Garde, March, 1907, and later years.

‡DIGLOTTA MERSA Hal. Batten, once only, a single specimen in April, 1892; under stones much below high water, Millbrook Creek, very sparingly, in May, 1900, 1907, 1909. De la Garde has taken it freely at Dawlish Warren. In June, 1909, at the latter locality I obtained a large specimen, $2\frac{1}{2}$ mm. long, possessed of fully developed wings, the length of each being 2 mm. with a maximum breadth of 1 mm. Apparently this form is extremely unusual. *Vide* G. C. Champion's remarks thereon, Ent. Mo. Mag., Vol. XXXV., pp. 264–5.

†HETEROTHOPS BINOTATA Er. Jennycliff; Batten; Downderry. Shaldon, de la Garde.

*QUEDIUS UMBRINUS Er. This uncommon species, which Fowler (Col. Brit. Isles, Vol. II., p. 241) says: "Appears to be chiefly found in wooded and hilly or mountainous districts," I once found in considerable numbers at Millbrook Creek in the little salt marsh beyond Palmer's Point in August, 1900. G. C. Champion also records it from damp places on the cliffs, Shaldon (Ent. Mo. Mag., 1908, p. 33).

*Q. SEMIÆNEUS Steph. Slapton; Tregantle; single specimens frequently, Millbrook Creek; by the Yealm. Shaldon, de la Garde.

*OCYPUS ATER Grav. Bovisand; Batten; Millbrook Creek, in some numbers; Tregantle. Shaldon, de la Garde. Looe, Vict. Hist. Corn.

*PHILONTHUS CRUENTATUS Gmel. Batten and probably all along the coast.

*P. PUNCTUS Grav. Slapton Ley (where it was first discovered by Mr. Wollaston) in May and June, in sundry years. G. C. Champion, August–September, 1907, very rarely. Mr. Bridgman's record in Fowler is an error, although he looked for it continuously for some years, as he told me, *in lit.*, Oct., 1897.

†CAFIUS FUCICOLA Curtis. In decaying seaweed; as a rule, local and rare; abundant with us at Batten and Jennycliff, Millbrook Creek, Tregantle. Dawlish district, one record by Mr. Rendel. A large-headed form of the male occurs commonly. In fine specimens the head is as wide as apex of elytra.

†C. XANTHOLOMA Grav. All around the coast, very common.

Var. VARIOLOSUS Shp. Not uncommon with the type form in the Plymouth district; Shaldon, de la Garde.

Var. VARIEGATUS Er. Batten, Jennycliff, etc., not uncommon.

†C. SERICEUS Holme. Generally distributed with the above, but much less abundant. Shaldon, de la Garde.

NOTE.—The *Cafii* may be found almost throughout the year and larvæ with them.

*SCOPÆUS MINIMUS Er. (RYEI Woll.). In April, 1897, in numbers at Slapton Ley, its only British locality, under smallish flat stones amongst herbage several yards from the edge of the Ley towards the sea, but I have not again met with it. Mr. Wollaston took it originally in May, 1869. G. C. Champion, August–September, 1916.

†MEDON POCOFER Peyr. Batten, two specimens only; Torcross, one only in May, 1901.

†M. RIPICOLA Kr. Batten, July, 1890, two in February, 1897, and in the following May I secured it in quantity in rotting seaweed at Jennycliff; August, 1902, one only on the beach beyond Bovisand.

*ASTENUS (SUNIUS) FILIFORMIS Latr. Whitsand Bay, single specimens occasionally; Tregantle; Downderry, August, 1900, six examples, and at various times since; Bigbury Bay, two specimens, May, 1911. Dawlish, one only, de la Garde.

*STENUS ATRATULUS Er. Downderry, August, 1905, E. A. Newbery and myself.

†BLEDIUS SPECTABILIS Kr. One specimen, Dawlish, de la Garde.

†B. UNICORNIS Germ. Dawlish Warren, de la Garde.

†B. SECERNENDUS Joy. Dawlish Warren, in quantity, de la Garde. This species appears in our latest List as a synonym of the var. *subniger* of Schneider, but as he considered his insect to be nothing more than a monstrosity, Joy's name must probably stand.

NOTE.—It is apparently strange that in the immediate neighbourhood of Plymouth the genus *Bledius* should be unrepresented. *Dyschirius*, which preys upon the larvæ and pupæ of *Bledius*, is, however, also as far as I can discover almost absent, its sole exponent being the widely distributed and common little *D. globosus*. Suitable habitats both on the coast and in the estuaries are still perhaps awaiting investigation.

†OXYTELUS PERRISI Fauv. (MARITIMUS Thoms.). In spring and autumn at Tregantle. First taken there by Mr. J. J. Walker. In May, 1902, the *var.* with testaceous elytra occurred in some numbers. Dawlish, de la Garde.

*O. COMPLANATUS Pand. Batten, Millbrook, etc.

‡TROGOPHLŒUS HALOPHILUS Kies. Millbrook Creek, two only, May, 1900; in June, on the South Down side, in numbers; July, 1916, several between lamellæ of slate on the shore, creek at Brixton.

†T. UNICOLOR Shp. (ANGLICANUS Shp.). This species was extra-European, being known from New Zealand only, until I found the first specimen under a stone at about half-tide near Palmer's Point, Millbrook Creek; after much search my second example was found on the opposite bank of the creek, near South Down, in a similar situation. In July Dr. M. Cameron, R.N., captured two specimens in the roll of seaweed at high tide near my original locality, and in August we together took 17 specimens in the seaweed. The insect has persisted in the locality to the present time, occurring frequently in considerable numbers; in July, 1905, for example, it was swarming, and I secured 180 specimens in an hour and a half! My second specimen, noted above, cost me 40 hours' work grubbing for it!

There was considerable difference of opinion amongst authorities as to the probable origin of this Staphylinid in England. M. Fauvel held that the species was identical with that from N.Z. Dr. D. Sharp inclined to the "opposite opinion, and to the conclusion that we have here to do with two species almost identical in structure and general character, produced independently in the two antipodes of the world, but under very similar conditions." He also stated: "As, however, *T. anglicanus* belongs to one of the most neglected and unattractive groups of Coleoptera, I shall not be surprised to hear of its discovery elsewhere on the coasts of Western Europe" (*Vide* Ent. Mo. Mag., Vol. XXXVI., pp. 230 *et seqq.*). In 1908 Mr. Horace Donisthorpe recorded the capture of two examples of this species, one under seaweed at Bembridge and another on the sea wall at St. Helens, Isle of Wight (Ent. Mo. Mag., Vol. XLIV., p. 255).

*LESTEVA FONTINALIS Kies. First discovered by de la Garde in wet moss on the face of the cliffs at Shaldon in February, 1908, and added to the British List by Newbery (Ent. Mo. Mag. XLVI (1910), p. 109). Exmouth, July–August, 1916, G. C. Champion.

‡MICRALYMMA MARINUM Stroem. (BREVIPENNE Gyll.). Yealm, Batten, Millbrook Creek, and Wivelscombe; one specimen by the R. Teign in June, 1909. In July, 1897, at Batten with Mr. Newbery and his nephew, the latter called attention to *Micralymma* crawling amongst the Acorn Barnacles, and by scraping these off the rocks we secured a considerable number of the beetle. In June, 1900, at Millbrook Creek, I took 20 examples, with *Podura maritima*, between slates used in an old landing-stage. Again at Batten in September and October, 1907, I found *Micralymma* with larvæ and numbers of *Poduræ* by scraping off the rocks little patches of lichen (*Lichina pygmæa*—teste E. M Holmes). There is considerable superficial resemblance between *Micralymma* and *Podura*, and as they are so commonly found in association, it would be interesting to ascertain the reason.

†HOMALIUM LÆVIUSCULUM Gyll. Seaweed, common.

†H. RIPARIUM Thoms. With the above, common.

CLAVICORNIA.

*ABLATTARIA (SILPHA) LÆVIGATA F. Bovisand; Tregantle, at roots. I have found it in single specimens only.

†BRACHYGLUTA (BRYAXIS) WATERHOUSEI Rye. Slapton Ley; in rejectamenta on the shore near Cargreen, October, 1912. On the shore, Hooe Lake, near Radford, A. V. Mitchell.

†PTENIDIUM PUNCTATUM Gyll. Generally distributed from Bigbury Bay to Downderry, in great profusion at times under large stones on or close to decaying seaweed, at Batten in particular. Dawlish Warren, de la Garde.

*CORYLOPHUS SUBLÆVIPENNIS Duv. One specimen only at roots in the sand, Downderry, August, 1905. Slapton, August–September. 1907, G. C. Champion.

*Micraspis 16-punctata L. Wivelscombe Creek, June, 1915. The only locality in the Plymouth district at which this species has occurred to me. Dawlish, de la Garde.

*Subcoccinella (Lasia) 24-punctata. Frequently met with on the coast, but in August, 1916, I found it in numbers, both pupæ and mature insects, at the roots of *Silene* on the shore at high-tide mark at Downderry.

*Carcinopis minima Aubé. Slapton Ley in April, 1900, and May, 1901, by sifting debris near the water's edge.

†Pachylopus (Saprinus) maritimus Steph. Tregantle under seaweed and in the sand, sometimes in numbers. Dawlish Warren, de la Garde.

†Acritus punctum Aubé. Tregantle, in May, 1902, in some numbers; of late years single specimens only have occurred to me. First taken there by J. J. Walker. Exminster, one example, de la Garde.

*Meligethes exilis Sturm. Tregantle, on *Armeria*, etc. First taken there by J. J. Walker.

*Corticaria crenulata Gyll. Batten, at roots on the beach, once only; abundant at Slapton Ley. Dawlish, de la Garde.

*C. impressa Ol. (denticulata Gyll.). Penlee Point, on gorse attacked by the dodder, May and June, 1910; Whitsand Bay, Slapton Ley, Dawlish.

*Dermestes undulatus Brahm. Slapton Ley, not uncommon at times in small carrion.

*Georyssus crenulatus Ross. (pygmæus F.). In the trickles of water in the cliff face, July–August, 1916, Exmouth, G. C. Champion.

†Heterocerus flexuosus Steph. Exmouth Warren, Parfitt, rare; Dr. Allen, July, 1900.

*H. fenestratus Thun. (lævigatus Pz.). Slapton Ley, August, 1895, and June, 1897.

LAMELLICORNIA.

*Aphodius nitidulus F. Dawlish Warren, rare, Parfitt. Whitsands, near Rame, in numbers, July, 1890; very abundant, July, 1899.

*Psammobius porcicollis Ill. Tregantle, apparently the only British locality, where the species was discovered by J. J. Walker. I have obtained it in March, August, and September in various years.

†Ægialia arenaria F. Whitsands, not common. Dawlish Warren, a single specimen, de la Garde. Exmouth Warren, "plentiful in dung of animals, etc.," Parfitt.

MALACODERMATA.

*PSILOTHRIX CYANEUS Ol. (NOBILIS Brit. Cat.). Slapton Ley, often in abundance.

PHYTOPHAGA.

*CHRYSOMELA BANKSI F. Generally distributed throughout the Plymouth district.

*C. HÆMOPTERA L. Whitsand Bay.

*PSYLLIODES MARCIDA Ill. Bovisand ; Tregantle, on *Cakile maritima*. First discovered there by J. J. Walker. Dawlish Warren, a single specimen, de la Garde.

*CASSIDA VITTATA Vill. Millbrook Creek, one only, May, 1900. Exmouth, Parfitt.

*C. NOBILIS L. On July 21st, 1917, A. V. Mitchell took a specimen of a Cassida apparently referable to this species on the underside of a pebble amongst low plants on Wembury Beach, just at high-tide mark but well within range of a stormy sea, and on showing it to me we together searched carefully for some considerable time, eventually securing about a dozen specimens each as well as the fully fed larvæ and pupæ. Dwarfed plants of a species of Atriplex seemed to me to be a likely food plant, and the perfect insects ate this quite readily in captivity until the end of September, when they ceased feeding, and at the time of writing are resting on the sides of the plaster cage in which they are confined.

RHYNCOPHORA.

*APION LÆVICOLLE Kirby. Whitsands, April, 1900. Bank of the Exe, near Topsham, two specimens, August, 1912, de la Garde.

*APION SCHÖNHERRI Boh. One specimen, Bovisand, July, 1902.

*A. ONONICOLA Bach. (BOHEMANNI Thoms.). On *Ononis*, Tregantle, August, 1902, several examples.

*A. CONFLUENS Kirby. Tregantle, J. J. Walker, on *Matricaria* on the slopes above high-water mark. I have occasionally taken it in numbers.

*A. HOOKERI Kirby. With us on the coast only, on *Matricaria*.

*A. ATOMARIUM Kirby. Whitsand Bay, J. J. Walker, at roots of thyme, sometimes in quantity.

*Otiorrhynchus atroapterus De G. Bigbury Bay, May, 1911. Dawlish Warren, de la Garde.

*O. rugifrons Gyll. Batten, single specimens in July, 1890, and June, 1895; Tregantle, often in numbers. Dawlish, April, 1895, J. J. Walker; one, de la Garde, June, 1907. Torcross, G. C. Bignell, May, 1885.

†Polydrusus chrysomela Ol. Several examples, Wivelscombe Creek, 10th June, 1915, by sweeping the banks just above high water. The specimens were rather abraded.

*Cneorrhinus plagiatus Schall. (geminatus Fab.). Burrow Island, May, 1911, in abundance, but did not find it on the mainland; Tregantle, common. Dawlish, de la Garde.

*Sitones waterhousei Walt. Batten, at roots of low plants, September, 1897; near Yealmpton, May, 1911; Whitsand Bay, frequently, in spring and autumn. First recorded therefrom by J. J. Walker.

*Gronops lunatus L. Dawlish Warren, de la Garde, one example, August, 1908. Woodbury Common, July–August, 1916, G. C. Champion.

*Tychius schneideri Herbst. Recorded in Fowler's Col. Brit. Is. as occurring at Whitsand Bay.

*Rhinocyllus conicus Fröh. Seaton, Major J. N. Still, May and June, 1895, on the slender thistle (*Carduus pycnocephalus*) in some numbers, but in a very restricted area.

*Smicronyx jungermanniæ Reich. Abundant in some years on the dodder of the gorse at Penlee Point, in May and June; also at Tregantle.

*Sibinia sodalis Germ. Dawlish, on flowers of *Armeria*. First discovered there by Felix A. Newbery, and afterwards taken in some numbers by de la Garde.

*Mecinus circulatus Marsh. Tregantle, at roots of low plants in April and May in various years. First recorded therefrom by J. J. Walker.

*Ceuthorrhynchus terminatus Herbst. Bovisand, August, 1902, one specimen at roots on the shore; one specimen, Tregantle, June, 1905. Shaldon, de la Garde.

*C. dawsoni Bris. Bovisand, Batten, Whitsands; often in abundance on *Plantago*.

†Limnobaris t-album L. This weevil is not a recognized salt-marsh species. Fowler says (Col. Brit. Is., Vol. V., p. 379): "Marshy places on aquatic plants; also by general sweeping; local but not uncommon in many districts." It has occurred to me in some

numbers at Wivelscombe Creek, June, 1915, and on the shore at Bere Ferrers, June, 1916, by sweeping sedges, etc. As both of these localities would be covered with salt water for a brief period at spring-tides, and as there are as yet no other records of the capture of this species in Cornwåll or Devon, its habit with us seems to render its inclusion in our list desirable.

†Codiosoma spadix Herbst. Batten, in an old wooden pile on the shore, May, 1892; South Down, in old piles stuck into the mud flats, larvæ and perfect insects in numbers, May, 1909.

Note.—In July, 1917, amongst a considerable quantity of beetles collected at random, by my friend Mr. N. Micklewood, in the Lizard district, where he was spending a holiday, and given to me, I detected an example of a *Cathormiocerus* which will probably prove to be new to Britain. The species cannot unfortunately at present be determined, but the insect has been submitted to Mr. G. C. Champion, who observed, "It is certainly a *Cathormiocerus*. . . . It seems to come nearest to *curviscapus* Seidl. The thorax is abnormally shaped and vestiture (except setae) abraded, so I doubt if you will make much of it." Further examples of the Weevil are therefore desirable.

HETEROMERA.

*Crypticus quisquilius L. Lizard district, July, 1917, several specimens, collected by N. Micklewood.

*Phylan (Heliopathes) gibbus F. Whitsand Bay, frequent. Dawlish Warren, de la Garde.

*Hopatrum sabulosum Gyll. Whitsands; Downderry.

*Microzoum tibiale F. Looe, —. Thomas, Vic. Hist. Corn.

†Phaleria cadaverina F. Tregantle, often abundant; Downderry. Dawlish Warren, three examples, April, 1907, de la Garde.

*Ctenіopus sulphureus L. Budleigh Salterton, July–August, 1916, G. C. Champion. Plentiful in the Lizard district and about Hayle. Vic. Hist. Corn.

*Anoncodes (Nacerdes) melanura Schmidt. Cattedown, one specimen, caught in the road; three specimens bred from old timber from a cellar at Stonehouse.

*Mordellistena parvula *var.* inæqualis Muls. Tregantle, July, 1900, three specimens.

†Anthicus angustatus Curt. Bigbury Bay, April 1st, 1907, abundant under seaweed at high-tide mark, under stones and in the sand; I obtained 96 specimens. In the shingle, Blackpool, Slapton, August–September, 1907, G. C. Champion.

A Trematode Larva from Buccinum undatum and Notes on Trematodes from Post-Larval Fish.

By Marie V. Lebour, D.Sc.
Naturalist at the Plymouth Laboratory.

With Figures 1 to 7 at the end.

ON May 30th, 1916, a number of large *Buccinum undatum* were brought in from the trawling grounds ; 40 of these were examined and 34 were found to contain larval Trematodes. Another lot in the spring of 1917 contained about the same percentage of infected Mollusks. Two species of Trematodes were present, both contained in the digestive gland, which was absolutely riddled with them.

The first, which was in 4 out of 40 *Buccinum*, was identified as *Cercaria neptuni* Lebour (1912), previously found in both *Neptunea antiqua* and *Buccinum undatum* from the Northumberland coast. This is a thick-tailed cercaria contained in long colourless rediæ which are tightly packed in the digestive gland and give to this organ a characteristic sickly grey appearance quite unlike its ordinary healthy state, so that infected specimens can easily be recognized by cutting a small aperture in the spire of the shell and examining the portion of digestive gland exposed. The further life history of this cercaria is unknown.

The second species occurs much more commonly and was found in 30 out of 40 *Buccinum* examined. The colour of the infected digestive gland is this time an unhealthy pinkish yellow, which is characteristic. The cercariæ are contained in sporocysts which occupy almost the whole of the spire of the shell.

The anatomy of this cercaria shows it to be almost certainly a larval stage of *Zoogonus viviparus* (Olsson), the life history of which is so far unknown (Odhner, 1902). This Trematode in the adult state lives in the intestine of many common fish. It has been recorded from 11 different species, 9 of which are from the Channel—*Zeus faber*, *Blennius gattorugine*, *Blennius ocellaris*, *Solea vulgaris*, *Solea variegata*, *Pleuronectes limanda*, *Pleuronectes microcephalus*, *Pleuronectes platessa* and *Callionymus lyra*. Nicoll (1914) regards *Callionymus lyra*, *Pleuronectes* spp. and *Solea* spp. as undoubtedly their chief hosts, all of these being common on the trawling grounds where the *Buccinum* were caught.

An intermediate host has not yet been identified, but from the structure of the cercaria, which is able to modify the posterior end of its body as a sucker-like organ, it is probable that the intermediate host is an actively swimming animal, as in all probability the sucker is used by the cercaria for fixing the hind end of its body whilst the free part waves about in order to catch a host. The stylet on the head and its glands opening beside it show that the cercaria bores into its host.

STRUCTURE OF SPOROCYST AND CERCARIA.

The sporocyst is faintly yellow in colour and measures from 0·5 to 1 mm. in length and is from 2 to 4 times as long as it is broad. Inside the sporocyst are germ cells and cercariæ in various stages, from 1 to 8 in each sporocyst (Fig. 1).

The full grown cercaria is colourless and transparent, measuring 0·33 mm. to 0·48 mm. in length according to the extent of contraction or expansion (Figs. 2 and 3). The anterior end is rather more rounded than the posterior end and usually the greatest width is in front of the oral sucker, although when the body is greatly extended the width is nearly equal for the whole length, a great amount of extension being possible. The oral sucker is a little more than half the width of the ventral sucker. Oral sucker 0·06 mm., ventral sucker 0·10 mm. Both are well developed and conspicuous. The whole surface of the body is covered with minute spines which enlarge towards the posterior end and are greatly elongated round that portion which is capable of forming the round disc in the middle of which opens the excretory bladder. The posterior end can, however, change its shape so that the disc is not always present (Fig. 6).

The oral sucker bears at its anterior end dorsally a thick stylet, 0·015 mm. long, with a long central and two small lateral points. On each side of the spine opening dorsally are situated a pair of long curved ducts (Fig. 5) connected with a mass of large gland cells on each side, the stylet glands, which occupy the space between the oral and the ventral sucker. The oral sucker has a large circular aperture ventrally placed near the anterior end of the body which leads to a short pre-pharynx, which in the expanded state may be as long as the pharynx but is usually much shorter. Then follows a conspicuous muscular pharynx, 0·03 mm. long, a thin-walled œsophagus and short intestinal diverticula reaching to about the centre of the ventral sucker. In transverse section the tubes of the diverticula are seen to be composed of very few cells, sometimes only two, with large nuclei (Fig. 7).

The ventral sucker is large and muscular with a somewhat oval centre. Immediately behind it and to the sides are the testes, which are well developed compact oval masses of cells with large nuclei. Ovary and vitellaria are not as yet differentiated, although masses of nuclei probably represent these in the process of formation.

The excretory vesicle is an oblong sac with very thick walls composed of large cells. It is conspicuous at the hind end of the body reaching to about the level of the posterior margin of the testes and opening at the extreme hind end in a small papilla.

These features show it to be very like the structure of *Zoogonus viviparus* (see Lebour, 1908), allowing for growth and development especially of the region behind the ventral sucker and of the reproductive organs. The fact also that it is the only really common fish Trematode of these parts with such short intestinal diverticula supports the view. The relationship of this cercaria to the stumpy-tailed forms seems obvious, the stumpy tail in this case being replaced by the peculiar sucker-like disc. The thick-walled excretory vesicle is common to this species and to all in the group and also the boring spine and glands. Except for the peculiarly modified hind end it fits very well into Dollfus' group (1914) of Cotylocercous cercariæ, which are all developed in sporocysts in marine gastropods. None of their life histories are so far known.

I have to thank my colleague, Miss G. E. Webb, for making the sections which were used in working out the structure of the cercaria in order to determine points not easily seen in the living material.

TREMATODES IN POST-LARVAL FISH.

Whilst investigating the food of young fish a number of Trematodes were found. Some of these were immature, others adult and containing ova. Those most frequently found were *Derogenes varicus* and *Pharyngora bacillaris*. *Derogenes varicus* is a common parasite of many fish, notably the Pleuronectids, and in an immature state was found in several fish, particularly *Arnoglossus* and *Scophthalmus norvegicus*. The only intermediate hosts so far known for this species are *Sagitta* and *Harmothoë*, so it is somewhat difficult to say how the worm enters the small fish as they almost certainly do not eat these worms. The most likely explanation seems to be that by the death of the worm host the young Trematode is set free and is then swallowed along with other food by tiny fish in which it afterwards matures.

Derogenes varicus was found in the following fish :—

Arnoglossus sp.	23	*Solea variegata*	4
Scophthalmus norvegicus	18	*Gadus minutus*	2
Pleuronectes limanda	11	*Gadus merlangus*	1
Pleuronectes microcephalus	4	*Callionymus lyra*	1

Pharyngora bacillaris, which inhabits the Mackerel and a few other fish in the adult state, when immature is found abundantly in the tow-nettings both free and in Medusæ, Ctenophores and *Sagitta*. It is the only common Trematode of the plankton and might easily be swallowed by small fish. It occurred in a few sprats, in 3 *Onos mustela* and in one *Rhombus lævis*.

Podocotyle atomon, another common fish Trematode, occurred in 3 specimens of *Gasterosteus spinachia*, and in all cases contained ova.

An encysted Trematode occurred in the peritoneum of 2 specimens of *Syngnathus rostellatus*.

The Horse Mackerel, *Caranx trachurus*, on one occasion contained a mature Trematode, probably *Lecithaster* sp.

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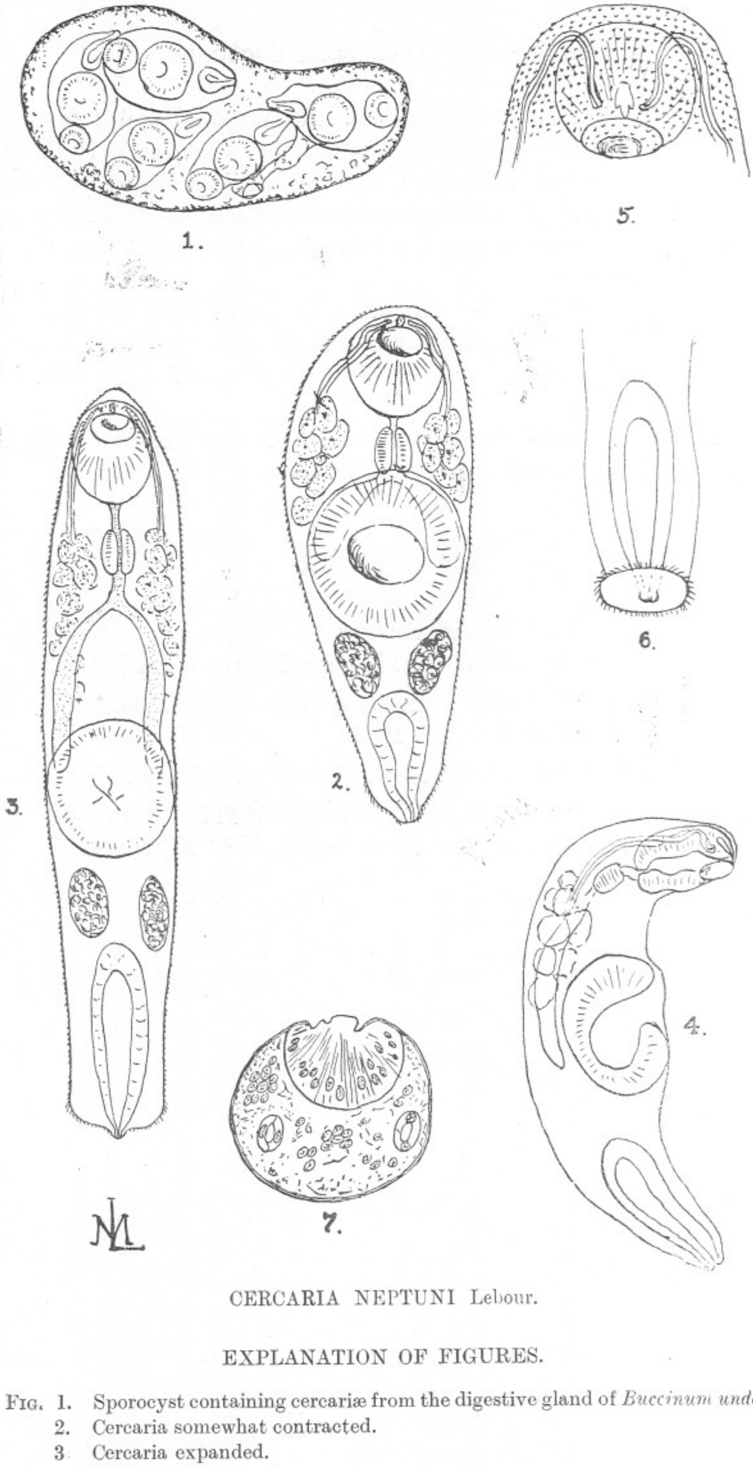
1908. *Lebour, M. V.* "Fish Trematodes of the Northumberland Coast." North Sea Fish. Rep. for 1907.

1912. —. "A Revision of the Marine Cercariæ." Parasitology, No. 4.

1914. *Nicoll, W.* "The Trematode Parasites of Fishes from the English Channel." Journ. Mar. Biol. Assoc., N.S., X., No. 4.



CERCARIA NEPTUNI Lebour.

EXPLANATION OF FIGURES.

FIG. 1. Sporocyst containing cercariæ from the digestive gland of *Buccinum undatum.*
2. Cercaria somewhat contracted.
3. Cercaria expanded.
4. Side view of cercaria.
5. Head of cercaria bent forward to show stylet and glands.
6. Spiny disc at posterior end of cercaria.
7. Transverse section of cercaria through the ventral sucker and intestinal diverticula.

Marine Biological Association of the United Kingdom.

Report of the Council, 1917.

The Council and Officers.

The Council has met four times during the year, the meetings having been held in the Rooms of the Royal Society. The Council desires to express the thanks of the Association to the Royal Society for the accommodation provided. The average attendance at the meetings has been nine, and a Committee of three members of the Council visited and inspected the Laboratory at Plymouth.

The Council has to record with regret the death of the Earl of Portsmouth, who for a number of years was a Governor, representing the Worshipful Company of Fishmongers. Lord Portsmouth showed much interest in the work of the Plymouth Laboratory.

The Plymouth Laboratory.

The new gas-engine supplied last year by Messrs. Crossley Bros., for circulating sea-water through the tanks, has worked smoothly and continuously, but unfortunately has consumed considerably more gas than the old engine. This, at the present high price of gas, has led to a marked increase in our working expenses. With a view to more economical working, it will be advisable, when conditions are more favourable after the war, to reconsider the whole of our pumping arrangements and try to reach greater efficiency.

The Boats.

The steamer *Oithona* has again not been used this year. The vessel, however, has just been requisitioned by the Admiralty for service in connection with the war. What collecting work was possible under the restricted conditions imposed by the naval and military authorities has been done with the eighteen-foot sailing boat *Anton Dohrn*, and many specimens have been obtained from the commercial fishing boats.

The Staff.

The Council regrets that Mr. D. J. Matthews, who has been employed by the Association for part of his time since the International Investigations were transferred to the Board of Agriculture and Fisheries in 1910, left the service of the Association early in the year.

Miss M. V. Lebour has been granted the degree of D.Sc. by the University of Durham, and has been appointed a permanent member of the Laboratory staff.

Miss G. E. Webb, of Oxford, has been appointed an Assistant Naturalist for the duration of the war, and commenced work at the Laboratory in August.

Messrs. E. W. Nelson, L. R. Crawshay, J. H. Orton, R. S. Clark, and E. Ford are still serving with H.M. Forces.

Occupation of Tables.

The following Naturalists have occupied tables at the Plymouth Laboratory during the year :—

W. De Morgan, Plymouth (Pomatoceros).
Mrs. E. W. Sexton, Plymouth (Gammarus).
Dr. C. Shearer, F.R.S., Cambridge (Dinophilus).

The Easter Vacation Course in Marine Biology for University students was not held this year.

General Work at the Plymouth Laboratory.

Dr. Allen, the Director of the Plymouth Laboratory, has been engaged during a considerable part of the year in carrying out special experiments for the Admiralty Board of Invention and Research. Since his return to the Laboratory he has been continuing his work on the conditions necessary for the successful growth and reproduction of certain marine plants and animals under experimental conditions.

Following on her researches on the plankton and microplankton of the Plymouth district, Dr. Lebour has made the central feature of her work for the year a study of the food actually eaten by fishes in their larval and youngest stages. This is a subject which has been but little studied and results of great interest have been obtained. A report on these appears on page 433. General work on the plankton has also been continued by Miss Lebour, who has been assisted in this by Miss Webb.

Two numbers of the Journal have been published during the year. The first, which was issued in May, contained three papers by Miss Lebour on the microplankton of Plymouth Sound, on the Peridiniales of Plymouth and on some parasites of Sagitta. The first of these papers contained the results obtained from the examination of centrifuged samples of sea-water taken at regular intervals during one complete year, so that seasonal variations are shown. In the same number appears Dr. Allen's report on the larval and young stages of fishes collected during the summer of 1914, this report being a continuation of work carried out for 1913 by Mr. R. S. Clark and reported upon by him in an earlier number of the Journal. Mr. D. J. Matthews contributes the second part of his paper on the amount of phosphoric acid in the sea-water off Plymouth Sound, in which the seasonal variations in the amount of that substance are recorded.

The second number of the Journal, issued in December, contains a detailed report, by Dr. Allen and Mrs. E. W. Sexton, of experiments on the inheritance of eye-colour and the loss of the eye-pigment in the Amphipod *Gammarus chevreuxi*. Three papers of a general character by Dr. Allen, in which the results of work done at the Laboratory are set forth in a more popular form, complete the number. These papers are entitled, "Heredity in Plants, Animals, and Man," "Food from the Sea," and "The Age of Fishes and the Rate at which they Grow."

The Library.

The thanks of the Association are again due to numerous Government Departments, Universities, and other institutions at home and abroad for copies of books and current numbers of periodicals presented to the Library. The list is similar to that published in the Reports of Council of former years. Thanks are due also to those authors who have sent reprints of their papers for the Library.

Donations and Receipts.

The receipts for the year include a grant from H.M. Treasury of £500, and one from the Fishmongers' Company (£600). In addition to these grants there have been received Annual Subscriptions (£123), Rent of Tables in the Laboratory, including £25 from the University of London, and £20 from the Trustees of the Ray Lankester Fund (£45); Sale of Specimens (£371) and Admission to Tank Room (£84).

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1918–19:—

President.

Sir E. RAY LANKESTER, K.C.B., LL.D., F.R.S.

Vice-Presidents.

The Duke of BEDFORD, K.G.
The Earl of DUCIE, F.R.S.
The Earl of STRADBROKE, C.V.O., C.B.
Lord MONTAGU OF BEAULIEU.
Lord WALSINGHAM, F.R.S.
The Right Hon. A. J. BALFOUR, M.P., F.R.S.
The Right Hon. AUSTEN CHAMBERLAIN, M.P.
W. ASTOR, Esq., M.P.
G. A. BOULENGER, Esq., F.R.S.
A. R. STEEL-MAITLAND, Esq., M.P.
Rev. Canon NORMAN, D.C.L., F.R.S.
EDWIN WATERHOUSE, Esq.

COUNCIL.

Elected Members.

Prof. W. M. BAYLISS, D.Sc , F.R.S.
L. A. BORRADAILE, Esq.
E. T. BROWNE, Esq.
W. C. DE MORGAN, Esq.
Prof. F. W. GAMBLE, D.Sc., F.R.S.
E. S. GOODRICH, Esq., D.Sc., F.R.S.
S. F. HARMER, Esq., Sc.D., F.R.S.
E. W. L. HOLT, Esq.
Prof. E. W. MACBRIDE, D.Sc., F.R.S.
H. G. MAURICE, Esq., C.B.
P. CHALMERS MITCHELL, Esq., D.Sc. F.R.S.
F. A. POTTS, Esq.
C. TATE REGAN, Esq., F.R.S.
Prof. D'ARCY W. THOMPSON, C.B., F.R.

Chairman of Council.

A. E. SHIPLEY, Esq., D.Sc., F.R.S.

Hon. Treasurer.

GEORGE EVANS, Esq.

Hon. Secretary.

E. J. ALLEN, Esq., D.Sc., F.R.S.,
The Laboratory, Citadel Hill, Plymouth.

The following Governors are also members of Council:—

G. P. BIDDER, Esq., Sc.D.

R. L. TOWGOOD, Esq. (Prime Warden of the Fishmongers' Company).

T. T. GREG, Esq. (Fishmongers' Company).

The Hon. NATHANIEL CHARLES ROTHSCHILD (Fishmongers' Company).

GEORGE EVANS, Esq. (Fishmonger Company).

Prof. G. C. BOURNE, D.Sc., F.R.S. (Oxford University).

A. E. SHIPLEY, Esq., D.Sc., F.R.S. (Cambridge University).

Prof. W. A. HERDMAN, D.Sc., F.R.S. (British Association).

THE MARINE BIOLOGICAL ASSOCIATION

Dr. *Statement of Receipts and Payments for*

	£ s. d.	£ s. d.
To Balance from Last Year:—		
Cash at Bankers	927 16 6	
Cash in hand	11 0 2	938 16 8
,, Current Receipts:—		
H.M. Treasury for the year ending 31st March, 1918	500 0 0	
The Worshipful Company of Fishmongers	600 0 0	
Annual Subscriptions	123 6 8	
Rent of Tables (including Ray Lankester's Trustees, £20; University of London, £25)	45 0 0	
Interest on Investments	12 6 4	
,, Deposit	9 16 7	1,290 9 7
,, Extraordinary Receipts:—		
Donation, G. H. Fox	0 10 6	
Naval Bank—Dividend	1 19 10	2 10 4
,, Laboratory Boats and Sundry Receipts:—		
Sales of Apparatus	3 19 4	
,, ,, Specimens	371 4 2	
,, ,, Nets, Gear, etc.	13 4 8	
Other Items	10 0	388 18 2
		£2,620 14 9

The Association's Bankers hold on its behalf £410 14s. 8d. New Zealand 4% Stock, 1943–63.

the Year ending 31*st December*, 1917. **Cr.**

	£ s. d.	£ s. d.
By Salaries and Wages—		
Director	300 0 0	
Hydrographer	62 10 0	
Senior Naturalist	51 12 6	
Additional ,,	131 15 6	
,, ,,	165 6 6	
Assistant ,,	13 2 6	
,, ,, (temporary)	12 13 3	
,, ,, ,,	50 7 0	
,, ,, ,,	10 0 0	
Salaries and Wages	427 4 1	1,224 11 4
,, Travelling Expenses		12 12 11
,, Library	42 12 7	
Less Sale of Duplicate	1 6 0	41 6 7
,, Journal	211 10 2	
Less Sales	7 1 10	204 8 4
,, Buildings and Public Tank Room—		
Gas, Water, and Coal	235 17 1	
Stocking Tanks and Feeding	27 8 6	
Maintenance and Renewals	43 0 4	
Rent, Rates, Taxes, and Insurance	47 8 10	
	353 14 9	
Less Admission to Tank Room	84 12 10	269 1 11
,, Laboratory, Boats, and Sundry Expenses—		
Glass, Apparatus, and Chemicals	50 1 1	
Purchase of Specimens	56 4 11	
Maintenance and Renewal of Boats, Nets, etc.	99 9 4	
Boat Hire and Collecting Expenses	6 16 11	
Stationery, Office Expenses, Carriage, Printing, etc.	80 4 6	292 16 9
,, Balance :—		
Cash at Bankers	568 15 10	
Cash in hand	7 1 1	575 16 11
		£2,620 14 9

Examined and found correct,

(Signed) N. E. Waterhouse.
Thomas T. Greg.
J. O. Borley.

3 *Frederick's Place,*
Old Jewry, London, E.C.
31*st January*, 1918.

OBJECTS
OF THE
Marine Biological Association
OF THE UNITED KINGDOM.

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

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

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. XI., No. 4.

NOTICE.

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

TERMS OF MEMBERSHIP.

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

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

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