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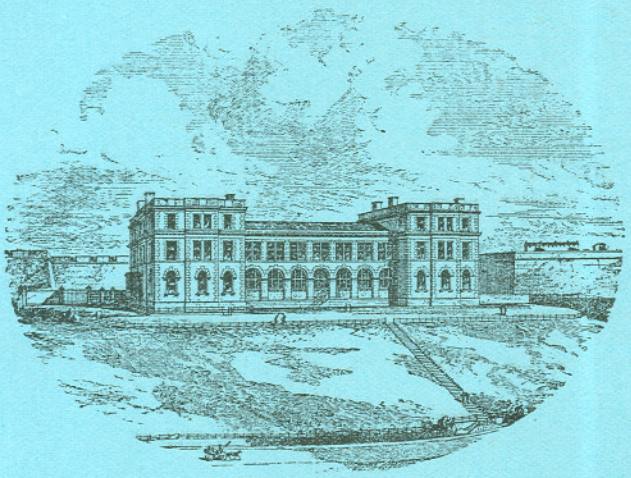

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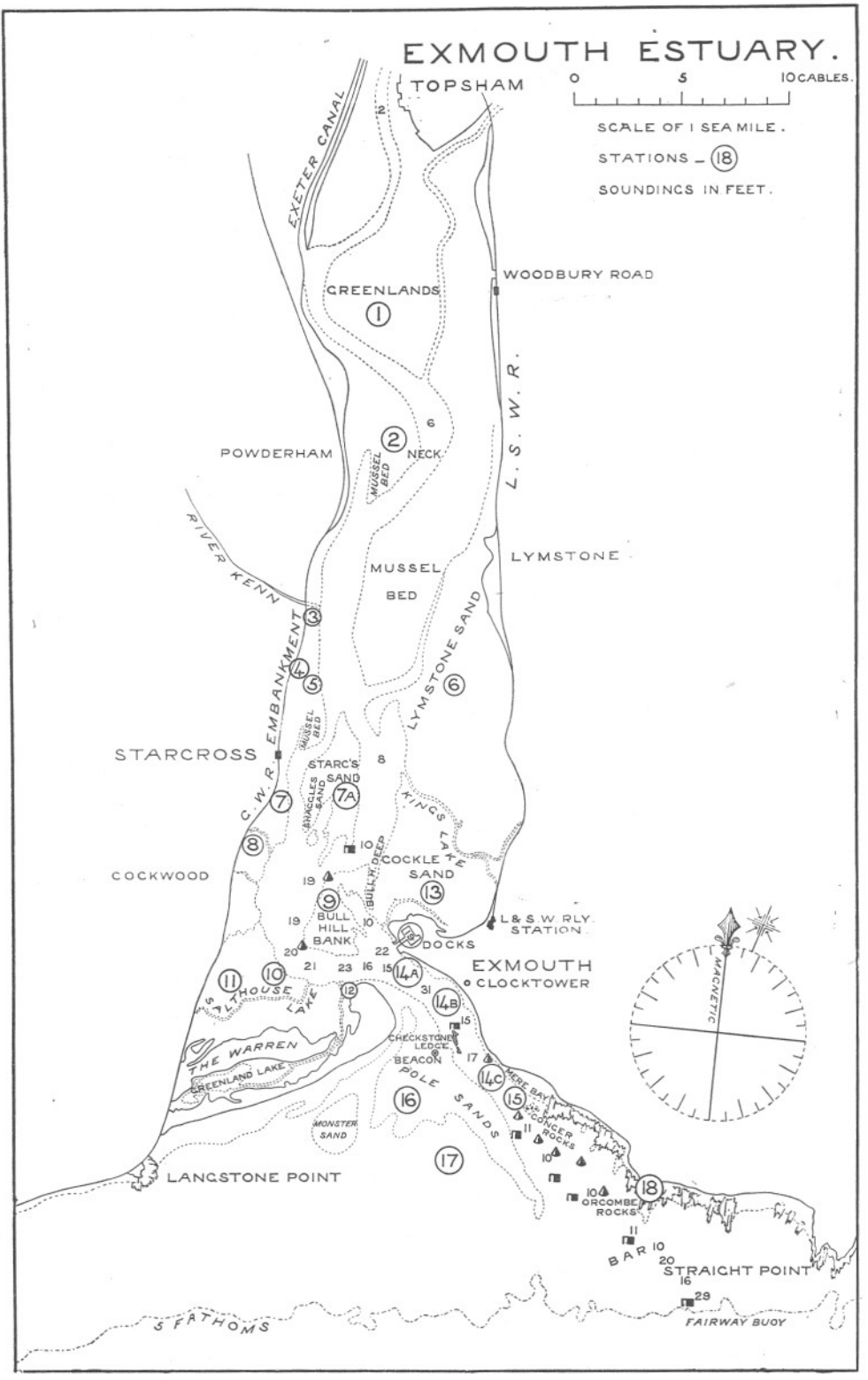

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Journ. Mar. Biol. Assoc. VI.

The Fauna of the Exe Estuary.

By

E. J. Allen, D.Sc., and R. A. Todd, B.Sc.

(With a Chart.)

I. Introduction.

In continuation of the scheme commenced last year for making a detailed survey of the marine fauna in the estuaries on the Devon and Cornish coasts, an examination has been undertaken during the present summer (1901) of the Exe estuary. For this purpose the floating laboratory boat *Dawn*, which has been generously placed at our disposal and maintained by Mr. J. W. Woodall, was towed to Exmouth and moored in the dock there, where she remained from July to September.

The principal means of collecting were hunting and digging on the shore between tide-marks; the use of a small trawl with a beam about four feet long fitted with a bag of mosquito netting; and the use of the dredge. The estuary, however, is not favourable for the use of the last-named instrument, as the ground is only suitable in the main channel, and the great strength of the tide makes the operation of dredging difficult excepting at slack water. Mr. Todd is almost entirely responsible for the collecting work, Dr. Allen only having paid occasional visits to Exmouth.

We have been able to combine with the collections made this summer the detailed records kept by Mr. E. W. L. Holt of some hauls with seine nets taken in the Exe estuary during two visits to Exmouth in the *Busy Bee* in 1897.

As regards the identification of the species, Dr. Allen is specially responsible for the Polychætes, Mr. Todd for Crustacea and Molluscs. An account of the examination by Mr. Worth of some samples of sand from the estuary, especially as regards the Foraminifera which they contained, is published in the present number of the Journal as a separate paper.

The estuary of the Exe differs markedly from the Salcombe estuary, which we examined last year (*vide Journ. Mar. Biol. Assoc.*, vol. vi. p. 151), both as regards its physical characteristics and the nature of its fauna, and a comparison of the two is interesting in several

respects. Looking at the two faunas as a whole, it must be noted that that of the Exe estuary is very much more limited in number of species than that of Salcombe. This is particularly obvious when we exclude from the list of Exe species those which were obtained on the seaward side of the Polesands, a region which is really outside the estuary.

This limitation in the number of species living in the Exe estuary seems to a large extent to be due to the following causes. In the first place, the banks uncovered in the Exmouth estuary are left dry for a very long time between two tides, and in most parts of the estuary there is little difference in the area uncovered by the spring and neap tides. The banks of the low-water stream are generally steep, especially in the lower parts of the estuary, and the spring tides merely uncover a few additional feet of these steep banks. Hence it follows that the banks uncovered at Exmouth must really be regarded as belonging to a higher tidal level than the rich low-water banks exposed at spring tides in such harbours as Salcombe and Plymouth. When this is borne in mind the differences in fauna become far less striking, as these higher tidal levels are nowhere very rich in number of species. The actual rise and fall of tide at Exmouth is also less than at either Salcombe or Plymouth. The following figures are from King's *Pilot's Handbook for the English Channel* (12th edition):—

Exmouth. Springs rise 12¼ feet, neaps 8½ feet, and neaps range 5 feet.

Salcombe.* Springs rise 15 feet, neaps 11½ feet, and neaps range 6¾ feet.

The second point of importance is the very great strength of the tidal stream at Exmouth, both when it is running over the banks and to a still greater extent in the main channel when the banks are uncovered. The evidences of the great scour produced by the tide are numerous, and the soil of the banks is in many cases subject to such great disturbance that it is rendered practically barren so far as animal life is concerned.

A third point which requires consideration is the quantity of fresh water which enters the estuary. A proper knowledge of this question could only be arrived at by systematic observations carried out during the entire year, and more especially during the more rainy parts of the year. The following information, however, supplied to us by

* The figures for heights of tides given in the "Report on the Fauna of the Salcombe Estuary" (this Journal, vol. vi. p. 151) were taken from the Plymouth Tide Table, as information gathered locally led to the conclusion that the maximum rise inside the estuary was about 17 feet, which is practically the same as at Plymouth.

Mr. R. H. Worth, will be useful in comparing the Exe estuary with that of Salcombe. The watershed area draining to the Exe estuary is 584 square miles, the area draining to the Salcombe estuary is 33¼ square miles, and the rainfall over the two areas is about the same. It would not, however, be correct to say that with any given rainfall the flow of fresh water passing into the Salcombe estuary would therefore be only one-seventeenth of that passing into the Exe estuary, for both in summer and winter, but more especially in summer, the larger catchment would give a greater ordinary flow per unit area, whilst in time of exceptional flood this condition might be reversed and the smaller catchment would yield from twice to, in extreme cases, four times as much water per square mile. It would probably not be exaggerating the difference between the two estuaries to assume that the fresh water flowing into the Salcombe estuary is in summer one-thirtieth that flowing into the Exe estuary, in winter one-twentieth, at times of considerable flood one-tenth, and at times of great flood one-fifth. On the other hand, each flood of the Exe would last for a longer time than a flood at Salcombe.

The area of the Salcombe estuary at high tide is about half that of the Exe estuary, whilst at low tide, taking the whole length of each estuary, the two are more nearly equal in area. The Salcombe low-water channel is much the deeper, and the average rise and fall of tide is somewhat greater at Salcombe than at Exmouth. On the whole, therefore, it appears that the water of the Exe estuary must, at certain times at any rate, be of much less density than any which even in times of flood runs through the Salcombe estuary.

These conclusions are confirmed by the following observations of the density of the water in different parts of the estuary, made by Mr. Todd in December, after a night of heavy rain following a period of average rainfall (all samples taken at the surface):—

December 12th, 1901. High tide at Exmouth, 7.16 a.m. Neap tides.
[Height of tide at Plymouth, 14 ft. 11 ins.]

STARCROSS (Pier), 11.15 a.m. Temperature, 9·2° C.; density at that temperature, 1·021.

EXMOUTH (north side of Pier), 11.40 a.m. Temp., 9·7° C.; density, 1·0248.

EXMOUTH DOCK, 12.25 p.m. Temp., 9·4° C.; density, 1·0235.

EXMOUTH (south side of Pier), 12.35 p.m. Temp., 8·6° C.; density, 1·021.

" " " 12·50 p.m. Temp., 8.4° C.; density, 1·0208.

" " " 1.5 p.m. Temp., 8·4° C.; density, 1·0204.

TOPSHAM, 2 p.m. Temp., 11·9° C.; fresh water.

WOODBURY ROAD, 3.45 p.m. Temp., 8° C.; fresh water.

EXMOUTH (south side of Pier), 5.30 p.m. Temp., 9·8° C.; density, 1·0259.

STARCROSS (Pier), 6.5 p.m. Temp., 9·5° C.; density, 1·0262.

In order to illustrate the more striking differences between the faunas of the two estuaries, the following list of animals, which were common and characteristic species in the upper parts of Salcombe estuary (above Snape's Point), but are absent from the Exmouth fauna, may be given :—

Hymeniacidon sanguineum.
Sagartia bellis.
Carinella superba.
Phascolosoma pellucidum.
Nereis cultrifera.
Notomastus latericius.
Amphitrite Johnstoni.
Sabella pavonina.
Branchiomma vesiculosum.
Myxicola infundibulum.
Tapes pullastra.
Pecten opercularis.
Pecten maximus.
Calyptræa sinensis.
Scalaria communis.
Clavelina lepadiformis.
Morchellium argus.

Melinna adriatica, which occurred in immense profusion in the soft mud-flats in the upper parts of Salcombe estuary, was only represented at Exmouth by very occasional specimens. *Audouinia tentaculata*, which was very common above half-tide mark in the Salcombe estuary, was met with only at Orcombe Rocks, quite at the mouth of the Exe.

On the other hand, the following species from the Exe estuary above Exmouth town were either absent or represented only by occasional specimens at Salcombe :—

Nereis diversicolor.
Phyllodoce teres.
Eteone pusilla.
Nephthys cirrosa.
Ophelia bicornis.
Mytilus edulis.
Tellina balthica.
„ tenuis.
Hydrobia ulvæ.
Pleuronectes platessa (young specimens).

Cockles (*Cardium edule*) and *Scrobicularia piperata* were also very much more abundant at Exmouth than at Salcombe. On the sand-flats at Exmouth *Ulva* and *Enteromorpha* were very abundant, whilst *Zostera*, which was abundant and well grown at Salcombe, was less plentiful and generally had a much stunted habit.

II. Description of the Fauna found in different localities in the Exe Estuary.

Station 1. GREENLANDS ZOSTERA BANK.

(See Chart.)

The highest part of the estuary examined was the Greenlands Zostera Bank, which is situated between Topsham and Powderham. The bank is about half a mile across, and is composed of fine mud almost entirely covered with zostera. The latter grows thickly together, but is small and stunted. The four abundant species are forms which are generally met with in estuarine waters of low density.

List of Species. Shore Collecting.

AUGUST 15TH, 1901.

POLYCHÆTA.

Nereis diversicolor. Very common. | Arenicola marina. One.

CRUSTACEA.

Carcinus mænas. A few.

MOLLUSCA.

Scrobicularia piperata. Abundant.
Littorina littorea. Abundant.
Hydrobia ulvæ. Abundant.

STATION 2. SAND BANK EAST OF POWDERHAM MUSSEL BEDS.

This bank is composed of smooth, fine sand with some admixture of mud, and possesses a very limited fauna.

List of Species. Shore Collecting.

AUGUST 16TH, 1901.

POLYCHÆTA.

Nereis diversicolor. Several. | Scoloplos armiger. Several.
Nephthys Hombergii. Fairly common. | Arenicola marina. Very common.

CRUSTACEA.

Carcinus mænas. A few.
Crangon vulgaris. A few.
Gammarus locusta. A few.

List of Species. Mosquito Net Trawl.

JULY 25TH, 1901.

CRUSTACEA.

Carcinus mænas. A few. | Neomysis vulgaris. Thirteen.
Crangon vulgaris. A few. | Gammarus locusta. Several.
Macromysis flexuosa. Abundant.

PISCES.

Gobius minutus. Four, 2·4-2·8 cm. | Syngnathus rostellatus. Four, 12·3–15·7 cm.
Pleuronectes platessa.

STATION 3. SAND OFF MOUTH OF KENN RIVER, SOUTH OF POWDERHAM.

The sand here is more muddy than that found on the last bank described, and there are also patches of gravel. The fauna is increased by the addition of several molluscs, whilst *Scoloplos armiger* was not found.

List of Species. Shore Collecting.

JULY 16TH, 1901.

POLYCHÆTA.

Nereis diversicolor. Numerous, large.
Nephthys Hombergii. One.
Arenicola marina. Very common.

CRUSTACEA.

Crangon vulgaris. Small, common.
Macromysis flexuosa. Many.

MOLLUSCA.

Mytilus edulis. Several attached to stones.
Cardium edule. Common.
Tellina balthica. One.
Scrobicularia piperata. Common.
Littorina littorea. Not uncommon.

PISCES.

Gobius minutus. Small, common.

STATION 4. GRAVEL BETWEEN POWDERHAM AND STARCROSS.

Between STATION **3** and Starcross, close to the railway embankment, the ground is composed of muddy gravel, and the Polychæte fauna increases in richness. The estuarine *Nereis diversicolor* is still abundant, *Lanice conchilega* becomes plentiful, whilst *Arenicola marina*, the ground being gravel, is not so common.

List of Species. Shore Collecting.

SEPTEMBER 2ND, 1901.

POLYCHÆTA.

Nereis diversicolor. Very common.
Nephthys Hombergii. Several.
Glycera convoluta. Several.
Phyllodoce teres. Two.
Scoloplos armiger. A few.
Arenicola marina. A few.
Lanice conchilega. Common.
Melinna adriatica. Two.

MOLLUSCA.

Cardium edule. Common.
Tellina balthica. One.
Scrobicularia piperata. Not uncommon.

STATION 5. SAND BANK ABOVE STARCROSS.

On the bank of clean fine sand outside the gravel of STATION **4** the characteristic species of the upper parts of the estuary almost disappear, and we get a typical fauna characterised by *Nephthys cirrosa*, *Phyllodoce teres*, *Eteone pusilla*, *Haustorius arenarius*, and *Tellina tenuis*

List of Species. Shore Collecting.

SEPTEMBER 2ND, 1901.

POLYCHÆTA.

Nephthys Hombergii. Common.
„ cirrosa. Common.
Phyllodoce teres.
Eteone pusilla. One.
Pygospio seticornis.
Arenicola marina. Very common.

CRUSTACEA.

Haustorius arenarius. One.

MOLLUSCA.

Cardium edule. A few.
Tellina tenuis. Not uncommon.

List of Species. Shrimp Trawl.

JULY 12TH, 1901.

CRUSTACEA.

Carcinus mænas. A dozen.
Crangon vulgaris. A few.
Gammarus locusta. Many small.

MOLLUSCA.

Sepiola atlantica. One.

PISCES.

Syngnathus acus. Two.

STATION 6. SAND AND MUD SOUTH OF LYMPSTONE MUSSEL BEDS.

List of Species. Shore Collecting.

AUGUST 6TH, 1901.

POLYCHÆTA.

Scoloplos armiger. Common.
Ophelia bicornis. One.
Arenicola marina. Very common.

MOLLUSCA.

Mytilus edulis. Common.
Cardium edule. Common.
Tellina balthica. A few lying on the surface of the mud.
Tellina tenuis. Common at L.W.M. in sand.
Scrobicularia piperata. Very common in stiff mud.
Littorina littorea. Common on weed.
Hydrobia ulvæ. Very common on Enteromorpha and Zostera.

List of Species. Mosquito Net Trawl.

JULY 20TH, 1901.

CRUSTACEA.

Carcinus mænas. One.
Crangon vulgaris. Small, common.
Macromysis flexuosa. Many.
Schistomysis Helleri. One or two.

PISCES.

Gobius minutus. One.

Station 7. BETWEEN STARCROSS AND COCKWOOD.

In the first half the ground consists of gravel and shell débris, with a thin ($\frac{1}{2}$ to 2 inches) layer of muddy sand. As on the gravel of Station **4**, *Lanice conchilega* is very abundant, whilst *Arenicola marina* is not frequent.

List of Species. Shore Collecting.

September 3rd, 1901.

POLYCHÆTA.

Arenicola marina. Occasional. | Lanice conchilega. Very common.

CRUSTACEA.

Carcinus mænas. Not uncommon.
Crangon vulgaris. Small, common.
Gammarus locusta. Common under stones, weed, etc.

MOLLUSCA.

Ostræa edulis. Three, near Starcross, on gravel.
Mytilus edulis. Several.
Cardium edule. Common.
Tapes pullastra. Shells only.
Tellina balthica. Two.
Scrobicularia piperata. Shells.
Littorina littorea. Common.
Hydrobia ulvæ. Shells very common.

Station 7a. SAND BANK OFF STARCROSS.

List of Species. Mosquito Net Trawl.

July 10th, 1901.

PORIFERA.

Leucosolenia sp. | Sycon ciliatum (?). One or two.

CRUSTACEA.

Carcinus mænas. Several.
Crangon vulgaris. Small, common.
Macromysis flexuosa. Many.
Idothea balthica. Two.
Bathyporeia pelagica. Twenty.
Gammarus locusta. A few.

PISCES.

Agonus cataphractus. One, 4·4 cm.
Gobius minutus.
Rhombus lævis. One, about 2 cm.
Pleuronectes platessa. Four, 4·3–6·0 cm.
Syngnathus rostellatus. One.

Station 8. BETWEEN STARCROSS AND COCKWOOD.

The ground now described lies to the south of Station **7**, and differs from it in being more sandy and less muddy. The soil consists of gravel and shell débris, covered with about six inches of sand. In consequence of this change in the character of the soil there is a considerable increase in the Polychæte fauna, whilst Molluscs almost disappear.

List of Species. Shore Collecting.

SEPTEMBER 3RD, 1901.

POLYCHÆTA.

Nephthys Hombergii. Many.
Phyllodoce maculata (?).
Eteone pusilla.
Pygospio seticornis.
Scoloplos armiger. Common.
Aricia Latreillii. One small one.
Arenicola marina. Very common.
Praxilla sp. Small, with irregular papillæ on anus.
Lanice conchilega. Not uncommon.
Melinna adriatica. Two.

MOLLUSCA.

Patella vulgata. Not uncommon on stones.

STATION 9. BULLHILL BANK.

On this bank the soil varies considerably. Where first uncovered it is composed of coarse and loose sand, and here practically the sole inhabitant is *Ophelia bicornis*. At lower levels the sand is finer and firmer, whilst in places it only thinly covers a soil of coarse gravel. There was a large quantity of Enteromorpha growing on the bank.

List of Species. Shore Collecting.

JULY 4TH, 1901.

POLYCHÆTA.

Nereis longissima. One.
Nephthys Hombergii. One or two.
„ cæca. Several large specimens.
Nephthys cirrosa. Many in the sand, one or two fairly large.
Glycera convoluta. Two.
Pygospio seticornis. Plentiful in the sand.
Nerine cirratulus. Two.
Scoloplos armiger. Several.
Arenicola marina. Several.
Ophelia bicornis. Common in loose [sand.
Lanice conchilega. Fairly common.

CRUSTACEA.

Carcinus mænas. Occasional.
Crangon vulgaris. Small, very common.

MOLLUSCA.

Mytilus edulis. Young ones swarmed on Enteromorpha.
Cardium edule. Common on the fine sand to the north.
Tapes decussata. Several.
Tellina tenuis. Several.
Solen vagina. One in sand.
Littorina littorea. Very common on weeds at extreme north.

PISCES.

Gobius minutus. Common.

List of Species. Mosquito Net Trawl.

JULY 8TH, 1901.

CRUSTACEA.

Carcinus mænas. Several.
Crangon vulgaris. Small, common.
Macromysis flexuosa. Common.
Schistomysis Helleri. Common.
Idothea balthica. Common.
Bathyporeia pelagica. One.
Gammarus locusta. Common.

MOLLUSCA.

Cardium edule. One.
Tellina tenuis. One.
Hydrobia ulvæ. A few.

PISCES.

Gobius minutus. Four, 1·2–5·7 cm.
Gasterosteus spinachia. Four small.
Pleuronectes platessa. One, 4·7 cm.

BULLHILL BANK. GRAVEL ON WEST SIDE.

List of Species. Mosquito Net Trawl.

JULY 26TH AND 28TH, 1901.

CRUSTACEA.

Crangon vulgaris. A few.
Pagurus Bernhardus. Several young.
Gastrosaccus spinifer. Nine.
Macromysis flexuosa. A dozen.
Idothea linearis. One small one.
Sphæroma serratum. Common.
Synchelidium sp. One.
Gammarus locusta. Several young.
Melita palmata. One.

PISCES.

Gobius minutus. One, 2·7 cm.
Blennius pholis. One, 2·1 cm.

BULLHILL DEEP PIT.

List of Species. Mosquito Net Trawl.

JULY 26TH, 1901.

CRUSTACEA.

Stenorhynchus phalangium. Three.
Carcinus mænas. Several.
Crangon vulgaris. A few.
Hippolyte varians. Several small.
Palæmon serratus. Four large.
Macromysis flexuosa. Four.
Gammarus locusta.

MOLLUSCA.

Mytilus edulis. Young ones common.
Elysia viridis. Three.

PISCES.

Gobius minutus. One, 5·0 cm.
Labrus maculatus. Five, 1·4–3·0 cm.
Crenilabrus melops. Four, 1·2–2·5 cm.

BULLHILL BANK.

List of Species. Professional Seine.

APRIL 7TH, 1897. FROM RECORDS MADE BY MR. E. W. L. HOLT.

PISCES.

Cottus bubalis. Several.
Agonus cataphractus. Ten.
Motella mustela. One.
Pleuronectes platessa. Sixty-three. (For details see p. 333.)
Pleuronectes flesus. One, 12·5 cm.
Clupea harengus. Two, 26 and 29 cm.

List of Species. Laboratory Tuck Net.

MAY 31ST, 1897. E. W. L. H.

MOLLUSCA.

Doris tuberculata. One.

PISCES.

Cottus bubalis. One.
Trigla hirundo. Five, 14–23 cm.
Agonus cataphractus. Several.
Trachinus vipera. Two.
Callionymus lyra. One.
Mugil chelo. One, 24 cm.
Pleuronectes platessa. One hundred and thirty-one. (For details see p. 334.)
Pleuronectes limanda. Eleven, 9·5–13 cm.
Pleuronectes flesus. Four, 9·5–17 cm.
Clupea sprattus (?). Six, of 5 cm.

STATION 10. SAND WEST OF THE MOUTH OF SALTHOUSE LAKE.

Immediately to the west of the entrance to Salthouse Lake the soil consists of fine sand with some admixture of mud. This is the only locality where *Solen vagina* was found.

List of Species. Shore Collecting.

JULY 15TH, AUGUST 31ST, 1901.

POLYCHÆTA.

Evarne impar. One under a tile.
Nephthys Hombergii. Small, common.
Phyllodoce teres.
Eteone pusilla. A few.
Pygospio seticornis. Numerous.
Heteromastus filiformis. A few.
Nerine coniocephala. A few.
Scoloplos armiger.
Arenicola marina. Common.
Clymenids. (Praxilla.) Probably two species; in clean sand.
Lanice conchilega. In sand.

MOLLUSCA.

Cardium edule. Common.
Solen vagina. Not uncommon.
Littorina littorea. Common.

Station 11. MUD NORTH OF SALTHOUSE LAKE.

To the west of Station **10** along the bank of the stream a considerable quantity of mud is met with, which in some places is soft and sticky, in others hard and of a more clayey nature.

List of Species. Shore Collecting.

July 15th, 1901.

Nereis diversicolor. Common where mud was hard.
„ longissima. One.
Nephthys Hombergii. Common, small.
Nerine coniocephala. Not uncommon in hard mud.
Scoloplos armiger. Not uncommon in hard mud.
Arenicola marina. Common.

CRUSTACEA.

Carcinus mænas. Many young.
Crangon vulgaris. Many young.
Macromysis flexuosa. One.
Corophium grossipes. Common burrowing in hard mud.

MOLLUSCA.

Cardium edule. Common.
Tellina balthica. One.
Scrobicularia piperata. Common.
Littorina littorea. Common.

List of Species. Mosquito Net Trawl.

July 24th, 1901.

CRUSTACEA.

Carcinus mænas. Several.
Crangon vulgaris. Small, very common.
Macromysis flexuosa. A dozen.
Schistomysis Helleri. Many.

PISCES.

Gobius minutus. Twenty, 1·2–4·5 cm.

SALTHOUSE LAKE.

List of Species. Shrimp Net.

July 18th, August 5th and 31st, 1901.

CRUSTACEA.

Carcinus mænas. Common.
Crangon vulgaris. Common.

PISCES.

Gobius minutus. Common.
Ammodytes tobianus. One, 9·3 cm.
Rhombus lævis. Three, 2·8–3 cm.
Pleuronectes platessa. About 130, from 4–16 cm. in length. (See p. 334.)
„ flesus. Four, 13·5–14 cm.
Syngnathus acus. Several.

BETWEEN THE WARREN AND COCKWOOD.

List of Species. Professional Seine.

APRIL 7TH, 1897. FROM RECORDS MADE BY MR. E. W. L. HOLT.

PISCES.

Labrax lupus. One, 15·5 cm.
Cottus bubalis. Ten.
Agonus cataphractus. Three.
Gobius minutus. Two.
Gasterosteus spinachia. Two.
Rhombus maximus. One, 14 cm.
„ lævis. One, 14 cm.
Pleuronectes platessa One hundred and sixty-five. (For details see p. 333.)
Pleuronectes limanda. One, 9 cm.
Clupea harengus. Six, 23·5–32·5 cm.
„ sprattus. Six, 5·5–7 cm.
Syngnathus acus. Two.

List of Species. Laboratory Tuck Net.

MAY 29TH, 1897.

PISCES.

Labrax lupus. Two, 8 and 72 cm.
Cottus bubalis. One.
Agonus cataphractus. Four.
Callionymus lyra. One.
Rhombus lævis. Two, 17 and 21·5 cm.
Pleuronectes platessa. Seventy-seven. (For details see p. 334.)
Pleuronectes limanda. Eight, 9·5–11·5 cm.
Pleuronectes flesus. Two, 13 and 30·5 [cm.

STATION 12. NORTH SIDE OF WARREN. EAST BANK OF STREAM DRAINING GREENLAND LAKE.

At the north-eastern end of the Warren the shore is composed of loose gravel, which is practically barren on account of the great force of tide to which it is exposed. Along the bank of the stream which drains Greenland Lake, however, the soil becomes firmer, and consists of muddy sand with a large proportion of gravel mixed with it. As on the grounds higher up the estuary, this mixture of sand and gravel affords specially suitable soil for *Lanice conchilega*, which occurs in very great profusion, whilst in patches near low-water mark the Gephyrean *Phascolosoma vulgare* is abundant, this being the only spot in the estuary at which it has been found. Ground of this nature is also favourable to *Tapes decussata*.

List of Species. Shore Collecting.

AUGUST 4TH, 1901.

GEPHYREA.

Phascolosoma vulgare. Common in patch at low-water mark.

POLYCHÆTA.

Nephthys Hombergii. Several.
Arenicola marina. Common in sand.
Ophelia bicornis. One in clean sand.
Lanice conchilega. Extremely common at low-water mark, and in the bed of the stream.

CRUSTACEA.

Haustorius arenarius. One in clean sand.

MOLLUSCA.

Cardium edule. Several.
Tapes decussata. Common.
Tellina tenuis. One in sand.
Scrobicularia piperata. A few in muddy sand.
Trochus cinerarius. A few.
Littorina littorea. Not uncommon.

POLYZOA.

Loxosoma phascolosomatum. Not uncommon on the posterior end of *Phascolosoma*.

Station 13. COCKLESAND.

The soil on this bank consists of sand and sandy mud of varying consistency, covered in places with Zostera and Enteromorpha, the fauna being very similar to that of grounds of this character already described. This bank remains uncovered for a considerable time between each tide.

List of Species. Shore Collecting.

July 7th, 13th, 22nd, 1901.

POLYCHÆTA.

Nereis diversicolor. Not uncommon in muddy sand.
Nephthys cirrosa. One.
„ Hombergii. Several taken.
Pygospio seticornis. Very common in sand.
Nerine cirratulus. A few.
Scoloplos armiger. A few.
Arenicola marina. Abundant.
Ophelia bicornis. One in clean sand.
Lanice conchilega. A few.
Melinna adriatica. A few in Zostera bed.

CRUSTACEA.

Carcinus mænas. Small, not uncommon among weed.
Crangon vulgaris. Small, common.
Schistomysis Helleri. Three.
Talitrus locusta. Common in sand and weed at high tidal levels.

INSECTA.

Heterocerus femoralis. Common burrowing in fine, loose sand.

MOLLUSCA.

Mytilus edulis. Several.
Cardium edule. Very common on or just below the surface.
Tapes decussata. Several where the ground was coarse.
Tellina balthica. Common lying on the surface of the mud.
„ tenuis. Not uncommon in sand.
Scrobicularia piperata. Very common in stiff mud.
Littorina littorea. Very common on weed.
Hydrobia ulvæ. Very common among weed.

List of Species. Mosquito Net Trawl.

JULY 22ND, 1901.

CRUSTACEA.

Carcinus mænas. Small and medium-sized ones common in Kingslake ; a few on Cocklesand.
Crangon vulgaris. Small, common.
Palæmon serratus. One small one, Kingslake.
Macromysis flexuosa. Common.
Schistomysis Helleri. Common, Kingslake.
Idothea balthica. Several, Cocklesand.
Gammarus locusta. Several small, Kingslake.

MOLLUSCA.

Littorina littorea. A few. | Hydrobia ulvæ. A few.

PISCES.

Gobius minutus. One or two.
Ammodytes tobianus. One, Kingslake.

CHANNEL BETWEEN BULLHILL BANK AND COCKLESAND.

List of Species. Mosquito Net Trawl.

JULY 19TH, 1901.

CRUSTACEA.

Stenorhynchus phalangium. One.
Carcinus mænas. Common.
Pagurus Bernhardus. One or two.
Crangon vulgaris. Common.
Hippolyte varians. Two.
Palæmon serratus. One.
Macromysis flexuosa. Several.
Schistomysis Helleri. One or two.
Paratylus Swammerdami. Four.
Gammarus locusta. Small, common.

MOLLUSCA.

Mytilus edulis. Several.
Cardium edule. One.
Littorina littorea. A few.
Hydrobia ulvæ. A few.
Aplysia punctata. Spawn.

PISCES.

Cottus bubalis. Four, 4·0–11·7 c.m.
Gobius minutus. Several, 1·8-5·3 c.m.
Labrus maculatus. Two, 2·0–2·5 c.m.
Crenilabrus melops. Eleven, 1·0–2·1 cm.

STATION 14. CHANNEL BETWEEN PIER AND MOUTH OF HARBOUR.

The fauna in the channel of the estuary now under consideration consists of a very limited number of species. From the pier to a point about half-way towards the Checkstone Ledge the dredge brought up a number of rounded stones, obviously much worn by the scour of the tide, and with very few animals living amongst them. The tidal stream is here very rapid.

STATION 14A. FIRST HALF OF CHANNEL FROM PIER TO CHECKSTONE LEDGE.

List of Species. Dredge.

JULY 9TH, 1901.

HYDROZOA.

Sertularia argentea. Common on stones.

ECHINODERMA.

Echinus miliaris. One small.

CRUSTACEA.

Pagurus Bernhardus. Two small. | Aora gracilis. Two.
Amphithoë rubricata. Two. |

MOLLUSCA.

Mytilus edulis. One large ; many very small.
Tapes pullastra. Shells.
Buccinum undatum. Three small.

Proceeding down the estuary, the portion between that last described and the Checkstone Ledge was found to be occupied by large masses of the sponge *Halichondria panicea*, with which the dredge was almost filled. A limited fauna was associated with this sponge, as detailed below.

STATION 14B. SECOND HALF OF CHANNEL FROM PIER TO CHECKSTONE LEDGE.

[Sponge Ground off Clock Tower.]

List of Species. Dredge.

JULY 9TH, 1901.

PORIFERA.

Halichondria panicea. The dredge came up filled with large masses of this sponge.

HYDROZOA.

Tubularia sp. Several very small colonies.

ECHINODERMA.

Amphiura elegans. One or two.
Ophiothrix fragilis. Several small.

TURBELLARIA.

Leptoplana tremellaris. One.

POLYCHÆTA.

Euphrosyne foliosa. One. | Polymnia nebulosa. Small specimens.
Nereis pelagica. Several specimens. |

CRUSTACEA.

Cancer pagurus. One very small one.
Carcinus mænas. Very small, common.
Porcellana platycheles. One.
Dexamine spinosa. A few.
Gammarus locusta. Several.
Amphithoë rubricata. One.
Aora gracilis. Two.

MOLLUSCA.

Mytilus edulis. Young, very common.
Tapes virginea. One small one.
Rissoa parva. One.
Nassa incrassata. One.

POLYZOA.

Scrupocellaria scruposa. Several colonies on sponge.

Below the Checkstone Ledge the bottom of the channel is covered with large masses of mussels (*Mytilus edulis*), which afford a regular fishery to a number of small boats (cf. p. 326). The mussels are often united together into large masses eight inches or a foot in diameter. Only a few other species are associated with the mussels.

STATION 14C. MUSSEL BANK.

List of Species. Dredge.

JULY 9TH, 1901.

ECHINODERMA.

Amphiura elegans. One.

TURBELLARIA.

Leptoplana tremellaris. One.

POLYCHÆTA.

Sthenelais boa. One.

CRUSTACEA.

Carcinus mænas. Several.
Pagurus Bernhardus. One.
Melita palmata. One.

MOLLUSCA.

Mytilus edulis. Abundant.
Buccinum undatum. One small.

Beyond the mussel bed the dredge brought up only clean stones.

STATION 15. MERE BAY.

List of Species. Mosquito Net Trawl.

AUGUST 7TH, 1901.

CRUSTACEA.

Stenorhynchus phalangium. One.
Crangon vulgaris. Common.
Palæmon serratus. Several small.
Macromysis flexuosa. Many.
Gammarus locusta. Common.

PISCES.

Gobius minutus. Four, 2·0–5·0 cm.
Blennius pholis. Two, 2·0–2·5 cm.
Gasterosteus spinachia. One, 5·2 cm.
Labrus maculatus. One small one.
Crenilabrus melops. Twenty-four, 2–3·1 cm.

List of Species. Professional Seine.

APRIL 8TH, 1897. FROM RECORDS MADE BY MR. E. W. L. HOLT.

PISCES.

Cottus bubalis. Several.
Ammodytes (tobianus ?). Many.
Rhombus lævis. Two, 18 cm.
Pleuronectes platessa. Seventy-three. (For details see p. 333.)
Salmo sp. One, 34 cm.

STATION 16. POLESANDS.

Polesands is a large triangular sand bank, situated at the mouth of the Exmouth estuary, which is uncovered at low water. The bank, along its north-eastern edge, forms the border of the main channel of the estuary, and is consequently under the influence of the full force of the tidal stream. The sand on this side is somewhat coarse and loose, and the edge of the bank at low water is steep. In this loose sand the only animal found was the Polychæte *Ophelia bicornis*, which lives there in great abundance.

The southern side of the Polesands faces the open water of the English Channel, and is therefore at times subject to the influence of powerful wave-action. The sand is here fine but firm, and shelves very gently, leaving extensive flats uncovered at low spring tides. In spite of the exposed situation, many interesting sand-burrowing animals are found, forming a fauna which differs much from that of the sand banks inside the estuary. The most characteristic species are *Aricia Latreillii, Portunus holsatus, Portumnus variegatus, Tellina tenuis, Donax vittatus, Mactra solida, Solen ensis, Solen siliqua,* and *Natica catena.* A large Nemertine, at present unidentified, was also found here.

List of Species. Shore Collecting.

JULY 14TH, 17TH, AUGUST 3RD, SEPTEMBER 1ST, 1901.

HYDROZOA.

Perigonimus repens. A few colonies growing on *Donax.*
Sertularia argentea. A few pieces.

ECHINODERMA.

Echinocardium pennatifidum. A few broken pieces.

POLYCHÆTA.

Nephthys Hombergii. Common.
,, cirrosa. Common.
Aricia Latreillii. Not uncommon.
Arenicola marina. One or two.
Ophelia bicornis. Common in coarse loose sand.

CRUSTACEA.

Carcinus mænas. Not uncommon.
Portunus holsatus. Two.
Portumnus variegatus. Eight buried in sand; many cast shells.
Corystes cassivelaunus. One ♀ in berry.
Pagurus Bernhardus. One.
Crangon vulgaris. Common.
Haustorius arenarius. Common; buried in the sand.

MOLLUSCA.

(LIVING.)

Anomia ephippium. Three on shell of Mytilus edulis. Several. [*Trochus magus.*
Cardium echinatum. Three.
„ norvegicum. Two.
Venus gallina. One.
Tellina tenuis. Very common at low-water mark, 2–3 inches below the surface.
Donax vittatus. Very common at low-water mark.
Mactra solida. Common.
Solen ensis. Not uncommon.
„ siliqua. Not uncommon.
Trochus umbilicatus. One.
Natica catena. A dozen.
Purpura lapillus. One.

(SHELLS ONLY.)

Ostræa edulis.
Pecten maximus.
„ opercularis.
Diplodonta rotundata.
Cardium aculeatum.
Venus chione.
Mactra stultorum.
Lutraria elliptica.
Trochus magus.
Turritella terebra.
Buccinum undatum.
Cypræa europæa.

EAST BANK OF POLESANDS.

List of Species. Professional Seine.

JULY 14TH, 1901.

PISCES.

Labrax lupus. One or two.
Trachinus (vipera ?). One.
Mugil chelo. One.
Ammodytes tobianus. Very many.
Rhombus lævis. One.
Pleuronectes limanda. One or two.
„ platessa. One or two.
Belone vulgaris. One.

STATION 17. GROUNDS OUTSIDE POLESANDS.

BETWEEN POLE AND MONSTER SANDS.

List of Species. Mosquito Net Trawl.

JULY 23RD, 1901.

CRUSTACEA.

Crangon vulgaris. A few.
Schistomysis Parkeri. One.
Paratylus Swammerdami. Two.
Gammarus locusta. Several.

MOLLUSCA.

Hydrobia ulvæ. Several.

PISCES.

Agonus cataphractus. One, 4·8 cm.
Gasterosteus spinachia. One.
Syngnathus rostellatus. Two, 7·4 and 13·4 cm.

QUARTER-MILE SOUTH OF POLESANDS.

List of Species. Mosquito Net Trawl.

JULY 19TH, 1901.

CRUSTACEA.

Stenorhynchus phalangium. Four.
Carcinus mænas. One small one.
Portunus depurator. One.
Pagurus Bernhardus. One.
Crangon vulgaris. Many large.
Hippolyte varians. One.
Leptomysis mediterranea. Two.
Leptomysis lingura. One.
Macromysis flexuosa. One.
Idothea balthica. Several.
„ linearis. A few.
Paratylus Swammerdami. Four.
Gammarus locusta.

MOLLUSCA.

Trochus magus. One small one.
Philine aperta. One.

PISCES.

Syngnathus rostellatus. Seven, 5·9–14·9 cm.

THE BAR.

List of Species. Mosquito Net Trawl.

JULY 27TH, 1901.

CRUSTACEA.

Carcinus mænas. Three, two with *Sacculina*.
Crangon vulgaris. Many, some large.
Hippolyte varians. One.
Idothea linearis. Several.
„ balthica.
Paratylus Swammerdami. Several.
Gammarus locusta. Common.
Sacculina carcini. Two on *Carcinus*.

PISCES.

Syngnathus rostellatus. Seven, 5·8–11·5 cm.

STATION 18. ORCOMBE ROCKS.

The rocks are of red sandstone, and are so situated that, although often exposed to the full force of the Channel seas, their fauna must be largely influenced by the water flowing out of the estuary of the Exe.

List of Species. Shore Collecting.

AUGUST 17TH, 1901.

PORIFERA.

Sycon compressum. Common.
Halichondria panicea. Very common.

HYDROZOA.

Sertularia pumila. Common.

ACTINOZOA.

Actinia mesembryanthemum. Common.
Anthea cereus. Common.

ECHINODERMA.

Amphiura elegans. Common.

POLYCHÆTA.

Lepidonotus clava. Not uncommon.
Marphysa sanguinea. One or two.
Nereis cultrifera. One.
„ fucata. One in shell with *Eupagurus Bernhardus.*
Nereis irrorata. One.
Eulalia viridis. A few.
Audouinia tentaculata. One.
Sabellaria alveolata. Very common.
Pomatoceros triqueter. Several.

CRUSTACEA.

Cancer pagurus. Small.
Portunus puber. A few.
Porcellana platycheles. Common.
Pagurus Bernhardus. Small, common.
Gnathia maxillaris.
Idothea balthica.

MOLLUSCA.

Mytilus edulis. Young, very common.
Kellia suborbicularis. One.
Saxicava rugosa. Common.
Pholas dactylus. Common.
„ parva. Common.
Patella vulgata. Very common.
Trochus cinerarius. Shells.
Rissoa parva. One.
Purpura lapillus. Very common.
Buccinum undatum. Shells.
Cypræa europæa. A few.

POLYZOA.

Membranipora membranacea. Common.
Bugula turbinata. Common.

PISCES.

Blennius pholis. Common.
Ammodytes tobianus. One.

Station 19. EXMOUTH DOCK.

As the *Dawn* was moored in Exmouth Dock opportunities were constantly offered for observations on the fauna there found. The dock gates are opened daily, generally about an hour before high water. The dock itself being small, the water in it is in this way very frequently changed, and a considerable number of animals flourish in the sheltered situation which it provides. During the present summer one of the most interesting features of this dock fauna was the immense profusion of the Ascidian *Ciona intestinalis*, which covered the wall and piles underneath the Engineering Company's stage on the eastern side of the dock. The two walls immediately inside the dock gates were also covered with these Ascidians (cf. also p. 330). The Polyzoan *Bugula turbinata* covered the bottom of the *Dawn* and other boats which remained in dock during the summer, and considerable numbers of *Ascidiella aspersa* and *Ciona intestinalis* were found in the same situation.

List of Species.

PORIFERA.

Sycon ciliatum (?). Common on the piles.

HYDROZOA.

Hydractinia echinata. On shell inhabited by *Pagurus* from prawnpot.

POLYCHÆTA.

Small *Nereids*, probably young *N. diversicolor*.
Polymnia nebulosa. Small specimens from amongst the Ascidians under stage.

CRUSTACEA.

Cancer pagurus. A few small ones seen.
Carcinus mænas. Common.
Portunus puber. Several small and large seen.
Pagurus Bernhardus. One caught in prawnpot.
Homarus vulgaris. Not uncommon in holes in the dock walls.
Palæmon serratus. Common.
Macromysis flexuosa. Common.
Schistomysis Helleri. One.
Ligia oceanica. Common on the walls above water-level.
Dexamine spinosa. One or two.
Gammarus locusta. Not uncommon on the piles, among weed, etc.
Notopterophorus gibber. Not uncommon in pharyngeal cavity of *Ciona*.
Bopyrus squillarum. Two parasitic on *Palæmon*.

MOLLUSCA.

Anomia ephippium. One on dock wall.
Elysia viridis. One or two on piles.
Antiopa cristata. Several on walls, piles, and boats in dock.

POLYZOA.

Bugula turbinata. Common underneath stage and on boats.

TUNICATA.

Ciona intestinalis. Extremely common on the piles and wall underneath the Engineering Company's stage, on the dock walls between the swing bridge and the dock gates, and in less quantity on the bottoms of various boats.
Ascidiella aspersa. Common in same situations as *Ciona*.

PISCES.

Gobius Ruthensparri. Common, one caught. 5·3 cm.
„ paganellus. Several caught in prawnpot. 10·1, 7·2, 5·9, 5·1, 8·0 cm.
Blennius pholis. Common in crevices in wall.
Atherina presbyter. A shoal seen (Aug. 16th); those captured measured ·7–1·1 cm.
Mugil chelo. Large ones common; a shoal of young ones seen (Aug. 16th, 1901).
Gasterosteus aculeatus. One caught (Aug. 16th) among young grey mullet (Mugil [chelo).
„ spinachia, 2·5 cm.
Labrus maculatus. One caught, 15·0 cm. long.
Crenilabrus melops. Several caught, 7·7 cm.
Gadus pollachius. One caught, 4 cm. long.
Ammodytes tobianus. Shoals common.
Anguilla vulgaris. Two caught, about 23 cm.
Conger vulgaris. One of about 4 lbs. seen.
Syngnathus rostellatus. Several caught.

III. A Complete List of the Species Identified, with an Account of their Local Distribution.

ACTINOZOA.

[Nomenclature: Gosse, *British Sea Anemones and Corals.*]

Anthea cereus (*Ellis and Solander*). Not uncommon among Orcombe Rocks.

Actinia mesembryanthemum, *Ellis and Solander*. Common among Orcombe Rocks.

Anemones were only found at Orcombe Rocks at the mouth of the harbour. None were seen within the estuary itself. The absence of *Sagartia bellis*, which is so common on the mud-flats at Salcombe and in the Yealm, is noteworthy, but is probably explained by the fact that a stony ground, covered with a moderately thin layer of mud, such as this species requires, is not met with in the Exe.

PORIFERA.

Halichondria panicea, *Pallas*. Dredged in large quantities in the channel between the pier and Checkstone Ledge (sta. 14B). The sponge occurred in large masses, less dense in structure and with a looser and more fibrous skeleton than the variety of this species commonly found on rocks on the shore. (See note by Mr. Bidder, p. 380, to whom we are indebted for the examination and identification of the specimens.) The shore variety occurred at Orcombe Rocks.

Sycon compressum, found at Orcombe Rocks, and S. ciliatum (?) in Exmouth Dock.

HYDROZOA.

[Nomenclature: Hincks, *British Hydroid Zoophytes.*]

Hydractinia echinata (*Fleming*). A colony from the dock on *Buccinum* shell inhabited by *Pagurus Bernhardus*.

Perigonimus repens (*T. S. Wright*). A few colonies on the posterior ends of *Donax vittatus*, from Polesands.

Sertularia pumila, *Linn.* Common at Orcombe Rocks.

Sertularia argentea, *Ellis and Solander*. Dredged in channel (sta. 14B): found on Polesands.

ECHINODERMA.

[Nomenclature: Jeffrey Bell, *Catalogue of British Echinoderms in the British Museum.*]

Ophiothrix fragilis (*O. F. Müller*). A few small ones dredged on the sponge ground in the channel (sta. 14B).

Amphiura elegans (*Leach*). Common under stones at Orcombe Rocks. A few dredged on the sponge ground (sta. 14B).

Echinus miliaris (*Gmelin*). One dredged in the channel off the pier (sta. 14A).

GEPHYREA.

PHASCOLOSOMA VULGARE, *Blainville.* Common in a small patch of muddy sand with large gravel, at low-water mark, on the east side of the stream draining Greenland Lake (sta. 12). Many of the specimens had colonies of *Loxosoma phascolosomatum* growing on the posterior end. As at Salcombe, the ground where this species was found was very limited in size, but the number of specimens obtained was considerable. The nature of the soil, however, in which the species lived at Exmouth differed considerably from the stiff clay-gravel lying on hard clay in which it was found at Salcombe.

TURBELLARIA.

LEPTOPLANA TREMELLARIS (*O. F. Müller*). One dredged on the sponge ground off the Clock Tower (sta. 14B), and one on the mussel bank (sta. 14C).

POLYCHÆTA.*

[Nomenclature: DE SAINT-JOSEPH, "Les Annélides Polychètes des Côtes de Dinard," *Ann. Sci. Nat. Zoologie*, 1887-95; "Les Annélides Polychètes des Côtes de France (Manche et Océan)," ditto, 1898.]

EUPHROSYNE FOLIOSA, *Audouin et Edwards.* One specimen only dredged on the sponge ground (sta. 14B).

LEPIDONOTUS CLAVA, *Montagu.* Not uncommon on the shore at Orcombe Rocks.

EVARNE IMPAR, *Johnston.* One specimen was found hiding under a tile on the sand west of the mouth of Salthouse Lake (sta. 10).

STHENELAIS BOA, *Johnston.* One specimen was dredged on the mussel bed in the channel below Checkstone Ledge (sta. 14C). It was never met with on the shore between tide-marks, as at Salcombe and Plymouth.

MARPHYSA SANGUINEA, *Montagu.* One specimen only, from Orcombe Rocks.

NEREIS CULTRIFERA, *Grube.* Only met with at Orcombe Rocks, quite at the mouth of the estuary, and there but one specimen was found. This is noteworthy, as *N. cultrifera* is one of the commonest species found on the shore both in Plymouth Sound and in the Salcombe estuary.

NEREIS PELAGICA, *Linn.* A few specimens amongst the masses of sponge (*Halichondria panicea*) dredged in the main channel below the pier (sta. 14B).

NEREIS FUCATA, *Savigny.* Found once in a shell inhabited by *Eupagurus Bernhardus* taken at Orcombe Rocks.

* By E. J. ALLEN.

NEREIS DIVERSICOLOR, *O. F. Müller*. Very common in the upper parts of the estuary, especially in the mud at Greenlands (sta. 1), at the mouth of Kenn River (sta. 3), below Powderham (sta. 4), and on the mud north of Salthouse Lake (sta. 11). A few were taken east of Powderham mussel beds (sta. 2) and in muddy sand at Cocklesand (sta. 13). As is usually the case, this species is most abundant where the water is of low density.

NEREIS IRRORATA (*Malmgren*). One specimen only outside the estuary at Orcombe Rocks.

NEREIS LONGISSIMA, *Johnston*. One specimen on Bullhill Bank, and one on the mud north of Salthouse Lake (sta. 11). The rarity of this species is noteworthy, as it was abundant in fine muddy sand in the upper parts of Salcombe estuary.

NEPHTHYS CÆCA (*Fabricius*). Several large specimens from Bullhill Bank (sta. 9).

NEPHTHYS HOMBERGII, *Audouin et Edwards*. As at Salcombe, this species was commonly found in sand and muddy sand all over the estuary. Where the ground became very muddy it disappeared.

NEPHTHYS CIRROSA, *Ehlers*, was found in considerable numbers on grounds where the soil was fine clean sand, but did not occur in any other localities. It appears to be only able to flourish in ground of this nature, and is therefore much more restricted in distribution than *Nephthys Hombergii*. *Nephthys cirrosa* was common on Polesands, on the sand of Bullhill Bank (sta. 9), and on the sand above Starcross (sta. 5); and one specimen is recorded from Cocklesand (sta. 13).

GLYCERA CONVOLUTA, *Keferstein*, was occasionally found on Bullhill Bank (sta. 9) and on the gravel between Powderham and Starcross (sta. 4).

PHYLLODOCE (*? maculata, Linn.*). A Phyllodoce, which appears to be referable to this species as described by Johnston (*British Museum Catalogue*, 1865), was taken on the sandy ground between Starcross and Cockwood (sta. 8).

PHYLLODOCE TERES, *Malmgren*. Found in fine clean sand on two grounds in the upper part of the estuary, viz. the sand bank above Starcross (sta. 5) and the sand west of Salthouse Lake (sta. 10). It is also recorded from the gravel between Powderham and Starcross (sta. 4), though the exact nature of the ground where the two specimens were taken was not noted. I found this species also at Teignmouth in clean sand, which appears to be its normal habitat (cf. Malmgren, *Nordiska Hafs. Annulater*, 1865, p. 97).

ETEONE PUSILLA, *Oersted* (nec *Malmgren*), was found several times

No other species of *Ayentoia* was found.

CLYMENIDS, probably belonging to two species of the genus *Praxilla*, were found in the sand west of Salthouse Lake (sta. 10). One small one was taken in the sand between Starcross and Cockwood (sta. 8).

OPHELIA BICORNIS, *Savigny* (*vide* de St.-Joseph, *Ann. Sci. Nat.*, v., 1898, p. 380). The sand on the north-eastern side of the Polesands, that is, the side nearest to the main channel of the estuary, is somewhat coarse and loose. The only animal found living in it was *Ophelia bicornis*, but this worm was present in great numbers. It was only necessary to dig into the sand with the hand, when one or two specimens would be exposed. It was also found in moderate numbers in sand of a somewhat similar nature on the highest part of Bullhill Bank, that is, the portion first uncovered on the fall of the tide. Single specimens of the species were met with on the north side of the Warren (sta. 12), in the sand below Lympstone mussel beds (sta. 6), and in the Cocklesand (sta. 13).

POLYMNIA NEBULOSA, *Montagu*. A few specimens from the dock, and from dredging material from the sponge ground below the pier (sta. 14B).

LANICE CONCHILEGA (*Pallas*) was very common on the banks in the estuary, where there was a large proportion of gravel mixed with clean sand. It was particularly abundant on the north side of the Warren (sta. 12), between Cockwood and Starcross (sta. 8), between Starcross and Powderham (sta. 4), on all which grounds the soil was of the

at Exmouth in clean fine sand, generally in the same kind of soil as *Phyllodoce teres* (stations 5, 8, and 10). I also found it at Teignmouth under similar circumstances. The specimens agree with Oersted's original description (*Ann. Dan. Conspec.*, 1843, p. 30), "papillis caudalibus subglobosis," and not with Malmgren's figure and description (*Nord. Hafs. Ann.*, 1865, p. 102 and Tab. XV. Fig. 37), "cirri anales lineare-fusiformes elongati." The head also resembles Oersted's figure rather than that figured by Malmgren.

EULALIA VIRIDIS, *Müller*. Two specimens, from Orcombe Rocks, at the mouth of the estuary.

AUDOUINIA TENTACULATA, *Montagu*. One specimen only, from Orcombe Rocks. The entire absence of this species from the estuary itself is noteworthy.

HETEROMASTUS FILIFORMIS, *Claparède*. A few specimens of this species were taken in the sand west of Salthouse Lake (sta. 10).

PYGOSPIO SETICORNIS (*Oersted*) and PYGOSPIO ELEGANS, *Claparède*. (*Vide* Mesnil, "Études de Morphologie externe chez les Annélides," *Bull. Sci. France et Belge*, XXX., 1897, p. 85.)

The distinction between these two species depends almost entirely upon the presence or absence of a pair of branchiæ on the second setigerous segment, these branchiæ being present in *P. seticornis* and absent in *P. elegans*. As, however, these branchiæ seem often to be lost in preserved specimens, the distinction between the two species cannot be satisfactorily made with such material. Unfortunately I was unacquainted with Mesnil's paper on the subject at the time when the specimens were obtained, and as in the preserved collections specimens from the same locality sometimes showed and sometimes did not show the branchiæ in question, I have in the lists included all under the name *P. seticornis*, though I have some reason to think that both species are represented in the estuary.

The tubes of *Pygospio* were abundant in the clean hard sand of the estuary (stations 5, 8, 9, 10, and 13), but were not seen in the hard sand at Polesands, where the conditions are marine.

NERINE CONIOCEPHALA, *Johnston*. This species is closely allied to, if not identical with, *N. foliosa*, Aud. et Edw. The Exmouth specimens agree with Johnston's description in having the front of the head bluntly conical and pointed, not rounded as described by Cunningham and Ramage (*Trans. Roy. Soc. Edinb.*, 1888) for *N. coniocephala*, and by de St.-Joseph and Mesnil for *N. foliosa*. The anus is not surrounded by cirri.

Several specimens were obtained in the sand west of Salthouse Lake (sta. 10) and in the hard clayey mud to the north of it (sta. 11).

NERINE CIRRATULUS (*Delle Chiaje*). Specimens were found on Bullhill Bank and Cocklesand.

SCOLOPLOS ARMIGER, *O. F. Müller*, was not uncommon in sand on all the banks in the upper part of the estuary, but was not found on the Polesands.

ARICIA LATREILLII, *Audouin et Edwards*, was moderately plentiful in the hard sand on the south of the Polesands. The specimens were here very large. One small specimen, probably belonging to the same species, was found in the sand between Starcross and Cockwood (sta. 8).

ARENICOLA MARINA, *Linn.*, was very abundant in all the sand and gravel in the estuary itself, but only one specimen is recorded from the Polesands. One only was obtained from the mud at Greenlands (sta. 1). The species was most abundant in the fine clean sand, becoming less plentiful in coarse ground. It was noticed that in ground where *Arenicola* became less plentiful the Terebellid *Lanice conchilega* became more abundant, and *vice versâ*.

No other species of *Arenicola* was found.

CLYMENIDS, probably belonging to two species of the genus *Praxilla*, were found in the sand west of Salthouse Lake (sta. 10). One small one was taken in the sand between Starcross and Cockwood (sta. 8).

OPHELIA BICORNIS, *Savigny* (*vide* de St.-Joseph, *Ann. Sci. Nat.*, v., 1898, p. 380). The sand on the north-eastern side of the Polesands, that is, the side nearest to the main channel of the estuary, is somewhat coarse and loose. The only animal found living in it was *Ophelia bicornis*, but this worm was present in great numbers. It was only necessary to dig into the sand with the hand, when one or two specimens would be exposed. It was also found in moderate numbers in sand of a somewhat similar nature on the highest part of Bullhill Bank, that is, the portion first uncovered on the fall of the tide. Single specimens of the species were met with on the north side of the Warren (sta. 12), in the sand below Lympstone mussel beds (sta. 6), and in the Cocklesand (sta. 13).

POLYMNIA NEBULOSA, *Montagu*. A few specimens from the dock, and from dredging material from the sponge ground below the pier (sta. 14B).

LANICE CONCHILEGA (*Pallas*) was very common on the banks in the estuary, where there was a large proportion of gravel mixed with clean sand. It was particularly abundant on the north side of the Warren (sta. 12), between Cockwood and Starcross (sta. 8), between Starcross and Powderham (sta. 4), on all which grounds the soil was of the nature described. It was met with in smaller quantity on the banks

where the soil was fine sand, *e.g.* Bullhill Bank (sta. 9), Cocklesand (sta. 13), and between Cockwood and Salthouse (sta. 10). It was not seen on the Polesands. This distribution is interesting when compared with the distribution at Salcombe, where the species occurred in great quantity on the fine clean sands near the mouth of the harbour.

As already pointed out under *Arenicola marina*, the latter species was very abundant on the fine clean sand banks where *Lanice* was not plentiful, whilst as the ground became coarser *Lanice* became abundant and *Arenicola* scarcer.

SABELLARIA ALVEOLATA, *Linn.* This worm was very common at Orcombe Rocks at the mouth of the estuary, forming the usual reef-like masses.

MELINNA ADRIATICA, *von Marenzeller.* One or two specimens only were found at each of the following localities: the Gravel between Powderham and Starcross (sta. 4), between Starcross and Cockwood (sta. 8), and on the sand west of the mouth of the Salthouse Lake (sta. 10).

The scarcity of this species in the estuary is noteworthy, as in the upper parts of the Salcombe estuary it occurred in enormous profusion in the mud-flats, especially in the very fine and soft mud. On the mud-flat at Greenlands, the highest part of the Exe estuary examined, and where the mud was in places very soft, not a single specimen was taken.

POMATOCEROS TRIQUETER (*Linn.*). Found only at Orcombe Rocks, at the mouth of the estuary.

CRUSTACEA.*

DECAPODA.

[Nomenclature: BELL, *Stalk-eyed Crustacea.*]

STENORHYNCHUS PHALANGIUM (*Pennant*). Three from Bullhill Deep Pit, one between Cocklesand and Bullhill Bank (sta. 13), one from Mere Bay (sta. 15), and four outside Polesands, all with mosquito net trawl.

CANCER PAGURUS, *Linnæus.* Small ones not uncommon among Orcombe Rocks; one small one dredged on the sponge ground off the Clock Tower (sta. 14B), and a few small ones in the dock.

CARCINUS MÆNAS (*Pennant*). Taken in almost every haul with the mosquito net trawl. Collected on Polesands and on most of the grounds above the Warren and in the dock.

PORTUMNUS VARIEGATUS, *Leach.* About half a dozen were found on the smooth sand on the west side of Polesands, buried an inch or two

* By R. A. TODD.

below the surface. After the flood-tide has started they seem to burrow a foot or so, generally in a direction towards the incoming tide, keeping just below the surface of the sand, and leaving a line of zigzag indentations on the surface, with a larger indentation at the end from which they started. One female was found in berry, July 3rd, 1901. One living specimen had a fairly large tuft of a green filamentous alga growing on the rostrum. Large numbers of cast shells were found on Polesands on July 17th, 1901.

PORTUNUS PUBER (*Linnæus*). Not uncommon in the dock and at Orcombe Rocks.

PORTUNUS DEPURATOR, *Leach*. One taken in mosquito net trawl outside Polesands.

PORTUNUS HOLSATUS, *Fabricius*. Two or three living specimens were found buried in the sand on Polesands.

CORYSTES CASSIVELAUNUS (*Pennant*). A female with ova found buried in sand on Polesands, July 17th, 1901.

PAGURUS (EUPAGURUS) BERNHARDUS (*Linnæus*). A few small ones on Bullhill Bank (gravel), one or two between Bullhill Bank and Cocklesand, one from Polesands, one in the dock, the latter with *Hydractinia:* small ones fairly common on Orcombe Rocks.

PORCELLANA PLATYCHELES (*Pennant*). Common under stones and in crevices at Orcombe Rocks, and one dredged on the sponge ground off Clock Tower (sta. 14B).

HOMARUS VULGARIS, *M.-Edwards*. Not uncommon in holes in the dock walls. They are caught by being enticed out with bait and speared.

CRANGON VULGARIS, *Fabricius*. Small and medium-sized shrimps were more or less abundant on all the sand- and mud-flats; large ones were only taken outside Polesands, on the Bar, and at Straight Point.

HIPPOLYTE (VIRBIUS) VARIANS, *Leach*. A few small ones were taken with the mosquito net trawl in Bullhill Deep Pit, two between Bullhill Bank and Cocklesand, and one on the Bar, all of a bright green colour.

PALÆMON SERRATUS (*Pennant*). One or two only from Bullhill Deep Pit, the channel between Bullhill Bank and Cocklesand, Mere Bay, and Kingslake. Common in the dock and at Straight Point, the latter being the locality where they, as well as shrimps, are taken for sale.

GASTROSACCUS SPINIFER (*Goës*). Nine were taken with the mosquito net trawl on the gravel on the west side of Bullhill Bank.

LEPTOMYSIS MEDITERRANEA, *G. O. Sars*. Two taken off the Polesands in 2–3 fathoms.

LEPTOMYSIS LINGURA, *G. O. Sars*. One taken off the Polesands in 2–3 fathoms.

MACROMYSIS FLEXUOSA, *Müller*. Taken everywhere in more or less abundance when using the mosquito net trawl. Common in the dock.

SCHISTOMYSIS PARKERI, *A. M. Norman*. One taken between Pole and Monster Sands.

SCHISTOMYSIS HELLERI, *G. O. Sars*. More or less common everywhere inside the estuary with *M. flexuosa*. One taken in the dock.

We are indebted to Mr. W. I. Beaumont for the following note on this species:—

"The specimens of *Schistomysis Helleri* from Exmouth, while agreeing generally with the descriptions of Sars and Norman, and with the figures of the first-named author, apparently fail to conform to the type in certain particulars, as did those found at Salcombe last summer. In the half-dozen adult specimens examined (males and females, from 9 to 13 mm. in length, inclusive of antennal scales and uropods), the number of spines on the margin of the inner uropods varied from twelve to sixteen, while an immature example of 8 mm. had already nine and ten spines respectively on those appendages; and in all the difference in length between inner and outer uropods is less marked than in the type. A further want of agreement with the published descriptions concerns the last pair of pereiopods, which in Exmouth examples cannot be strictly described as 'rudimentary,' or as being 'about half the length of preceding pairs.' In point of fact they are very much shorter than some of the anterior pairs, but the decrease in size is exhibited gradually in successive pairs; and, moreover, a nail is present, though small."

NEOMYSIS VULGARIS (*J. V. Thompson*). A few taken on the sand bank east of Powderham mussel beds (sta. 2).

ISOPODA.

[Nomenclature: G. O. SARS, *Crustacea of Norway*, vol. ii.]

GNATHIA MAXILLARIS (*Montagu*). A few taken in crevices at Orcombe Rocks.

IDOTHEA BALTHICA (*Pallas*). A few were taken at each of the following localities: South of Polesands, sand bank off Starcross, Bullhill Bank, the Bar, Cocklesand, and Orcombe Rocks.

IDOTHEA LINEARIS. One or two were taken on the Bar, south of Polesands, and on Bullhill Bank.

LIGIA OCEANICA (*Linnæus*). Common on the dock walls, above water-level.

SPHÆROMA SERRATUM. Fairly common on gravel on Bullhill Bank.

BOPYRUS SQUILLARUM. Two on *Palæmon serratus* from the dock.

AMPHIPODA.

[Nomenclature: G. O. Sars, *Crustacea of Norway*, vol. i.]

Talitrus locusta (*Pallas*). Very common under weed at high-water mark south of Cocklesand and on the north side of the Warren (sta. 12). Not uncommon burrowing in the sand at Cocklesand.

Bathyporeia pelagica, *Sp. Bate*. Twenty in mosquito net trawl on sand bank off Starcross, one on Bullhill Bank, three between Cockwood and Bullhill Bank.

Haustorius arenarius (*Slabber*). Not uncommon in the smooth sand west of Polesands. One in Shaggles Sand (sta. 5) and one in clean sand on north side of Warren (sta. 12).

Synchelidium sp. One taken on Bullhill Bank.

Paratylus Swammerdami (*M.-Edwards*). A few were taken at each of the following localities: Between Pole and Monster Sands, south of Polesands, between Bullhill Bank and Cocklesand, and on the Bar.

Dexamine spinosa (*Montagu*). A few were taken among weeds on a boat in the dock, and on the sponge ground off the Clock Tower (sta. 14B).

Gammarus locusta, *Linnæus*. More or less common in nearly all hauls with the mosquito net trawl.

Melita palmata (*Montagu*). One was taken with the mosquito net trawl on Bullhill Bank gravel.

Amphithoe rubricata (*Montagu*). One dredged on sponge ground off the Clock Tower (sta. 14B).

Aora gracilis, *Sp. Bate*. Two from sponge ground off the Clock Tower (sta. 14B).

Corophium grossipes, *Linnæus*. Common burrowing in the muddy sand north of Salthouse Lake (sta. 11).

CIRRIPEDIA.

Sacculina carcini (*J. V. Thompson*). Two on *Carcinus* from the Bar.

COPEPODA.

Notopterophorus (Doropygus) gibber (*Thorell*). Common in the pharyngeal cavity of *Ciona intestinalis* in the dock. The specimens were identified by Mr. R. Gurney.

INSECTA.

COLEOPTERA.

HETEROCERUS FEMORALIS (*Kies*). Very common burrowing in fine loose sand on Cocklesand. Fowler (*Coleoptera of the British Isles*, vol. iii. p. 385) gives its habitat as "Banks of ponds and ditches; not common; Sheerness, Gravesend, Deal, Hastings, Brighton, Weymouth, Exmouth, Wales, Hunstanton, Cleethorps, Manchester, Prestonmarsh (Lancs.), Lancaster; Scotland, local, Solway and Forth districts; Baldoyle (Ireland). Species said to be chiefly maritime." The specimens were identified by Dr. Sharp.

MOLLUSCA.*

[Nomenclature: JEFFREYS, *British Conchology*.]

ANOMIA EPHIPPIUM, *Linnæus*. Three small ones were taken on the Polesands, adhering to a shell of *Trochus magus*, and one on the dock wall underneath the stage.

OSTRÆA EDULIS, *Linnæus*. Three were found on the gravel south-west of Starcross Pier (sta. 7) and a few shells on Polesands. There is no oyster fishery in the Exe.

PECTEN OPERCULARIS (*Linnæus*). On Polesands, shells only.

PECTEN MAXIMUS (*Linnæus*). On Polesands, shells only.

MYTILUS EDULIS, *Linnæus*. Stray mussels were to be found everywhere in the estuary, the centre of distribution being a mussel bank which extends from Checkstone Ledge along the channel nearly to the mouth of the harbour. This bed is composed chiefly of mussels, mussel shells, and pebbles held together by the threads of the byssus of the mussel, thus forming a compact mass. The mussel fishermen, of whom there are about fifty belonging to Lympstone, Powderham, and Starcross, collect the mussels at low water, when they are only covered by two or three fathoms. The instrument used is a rake fixed to a pole 20–25 feet long, and having a wire-net bag attached behind it. The boat is moored by a kedge, and the mussels simply raked up from the bottom. When a sufficient number are caught they are taken up the river and laid on the mussel beds, which are on sand banks off Lympstone, Powderham, and Starcross, the Lympstone bed being much the largest. The mussels remain on these beds two to three years, by which time they are of a marketable size. They are then collected, washed, and sold either as bait or for food. The mussel beds are sometimes troubled by a large growth of weed, chiefly *Ulva* and *Enteromorpha*, which is kept down by winkles (*Littorina*

* By R. A. TODD.

littorea) and by hand picking. If this weed be allowed to grow, large numbers of mussels die from suffocation, as the weed causes the sand to silt up over them. This year (1901) the beds have suffered considerably from this cause, probably on account of the large amount of sunshine during the summer. The young mussels, about 1 mm. long, were extremely abundant on the *Enteromorpha* on Bullhill Bank (July 4th, 1901), on weed from the sponge ground off the Clock Tower (July 9th, 1901), and at Orcombe Rocks (August 17th, 1901). A single filament of *Enteromorpha* formed a resting-place for a hundred or more young mussels.

KELLIA SUBORBICULARIS (*Montagu*). One was taken in a crevice at Orcombe Rocks.

DIPLODONTA ROTUNDATA (*Montagu*). One or two shells were taken on Polesands, probably washed up from outside. It seems probable that this species burrows very deeply in the sand, as we have never yet taken it alive, although shells are not uncommon in places.

CARDIUM ACULEATUM, *Linnæus*. One valve of this species was found on Polesands.

CARDIUM ECHINATUM, *Linnæus*. Three small living specimens and many shells were taken on Polesands, the living ones being found just below the surface.

CARDIUM EDULE, *Linnæus*. Occurs in profusion on Cocklesand, Bullhill Bank, and all along the west side of the estuary, from the Warren upwards, wherever the ground is suitable. It is found either on the surface or buried just below, and its collection for sale gives employment to a fair number of men and women, who are generally to be seen at low tide armed with a "cock-rake," which is very like an ordinary garden hoe, and a basket. The ground is simply raked over, so that about half an inch to one inch of the surface is removed, and the cockles which are uncovered are then picked up.

CARDIUM NORVEGICUM, *Spengler*. Two living ones were obtained on the Polesands, lying on the surface of the sand. They were probably washed up from deeper water, the normal habitat of *C. norvegicum*.

VENUS CHIONE, *Linnæus*. Valves only of this species were found on the Polesands.

VENUS STRIATULA, *Linnæus*. One living one on the Polesands buried just below the surface.

TAPES VIRGINEA (*Linnæus*). One very small one dredged on the sponge ground off the Clock Tower (sta. 14B).

TAPES PULLASTRA (*Montagu*). A few shells only, on gravel between Cockwood and Starcross (sta. 17).

TAPES DECUSSATA (*Linnæus*). Living specimens were moderately common lying on the surface of the gravel on the north side of the Warren and east of the stream draining Greenland Lake (sta. 12). A few on gravel on Bullhill Bank and on coarse ground on Cocklesand.

TELLINA BALTHICA, *Linnæus*. Common on the mud-flats between Cocklesand and the L. and S. W. Station; a few on mud south of Lympstone mussel bed, and one or two on the west bank of the estuary between the Warren and Powderham. Nearly all the specimens obtained were lying on the surface of the mud, only one having been obtained by digging. They appear to be very shy animals, as we never saw one expanded, although they were kept alive for two or three days before preserving.

TELLINA TENUIS, *Da Costa*. This bivalve was very common on the west side of Polesands at low-water mark; moderately common on the fine sand between Cocklesand and Lympstone mussel beds, and a few were also taken on Bullhill Bank, the Warren, and Shaggles Sand. They were generally found buried two or three inches below the surface of the sand. On Polesands, where they were most common, three or four would be turned up in one spadeful of sand.

Tellina tenuis was always found on sand and *T. balthica* on mud.

DONAX VITTATUS (*Da Costa*). This mollusc was very common on the smooth banks of fine sand running off the west side of Polesands. Almost every specimen had a tuft of fine green weed or *Enteromorpha* (occasional) attached to the posterior (short) end of the shell. The animal being buried only just below the surface with the posterior end uppermost, the tuft of weed was always visible either waving in the water or lying on the sand, thus marking the position of the shell. A few of the living shells had hydroids growing on them, in addition to the weed, the hydroid being in three cases *Perigonimus repens*.

MACTRA SOLIDA, *Linnæus*. Not uncommon on Polesands in the same situation as *Donax vittatus*. When first uncovered by the tide they were generally found buried just below the surface, but after a time they emerged from the sand and lay uncovered until the tide rose again.

MACTRA STULTORUM, *Linnæus*. A few shells only of this bivalve were found on Polesands.

LUTRARIA ELLIPTICA, *Lamarck*. Shells only on Polesands.

SCROBICULARIA PIPERATA (*Linnæus*). One of the commonest bivalves of the Exe estuary; it was almost always present where the ground was composed of fine stiff mud. It occurred in profusion on Greenlands (sta. 1), on the mud inside Cocklesand (sta. 13), near Salthouse Lake (sta. 11), and all along the west bank, where the ground was suitable. It was generally found buried three to six inches below

the surface, with which its burrow was connected by two, occasionally three narrow passages, which allowed the protrusion of the siphons. The siphons are in large specimens as much as six or seven inches in length.

SOLEN ENSIS, *Linnæus*. Not uncommon in the smooth sand on the west side of Polesands. This and the succeeding species (*S. siliqua*) when uncovered by the tide very often emerge from the sand and lie on the surface until the tide covers them again.

SOLEN SILIQUA, *Linnæus*. This fine Solen was not uncommon on Polesands in the same situation as *S. ensis*.

SOLEN VAGINA, *Linnæus*. Moderately common on a patch of firm, muddy sand on the west side of the mouth of Salthouse Lake (sta. 10). One from sand on Bullhill Bank (sta. 9).

SAXICAVA RUGOSA, *Linnæus*. Common boring in Orcombe Rocks.

PHOLAS DACTYLUS, *Linnæus*. Borings common in Orcombe Rocks. Only one specimen was obtained.

PHOLAS PARVA, *Pennant*. Borings common in Orcombe Rocks. One specimen was taken.

PATELLA VULGATA, *Linnæus*. Very common on Orcombe Rocks; not uncommon on stones between Cockwood and Starcross (sta. 8).

TROCHUS MAGUS, *Linnæus*. Shell only, inhabited by hermit-crab, from Polesands.

TROCHUS CINERARIUS, *Linnæus*. A few living ones from rough ground on north side of Warren (sta. 12); shells from Orcombe Rocks.

TROCHUS UMBILICATUS (*Montagu*). One living one from Polesands.

LITTORINA LITTOREA (*Linnæus*). Found in profusion on Cocklesand, Bullhill Bank, and Greenlands; not uncommon on the west bank. They are collected by boys, who sell them to the mussel-bed proprietors for the purpose of keeping the beds clear from weed.

RISSOA PARVA (*Da Costa*). One from Orcombe Rocks and one dredged off the Clock Tower on the sponge ground (sta. 14B).

HYDROBIA ULVÆ (*Pennant*). Occurred practically on all the sandy and muddy grounds where there was *Ulva*, *Enteromorpha*, or *Zostera*, notably on Greenlands (sta. 1) and the muddy ground with weed inside Cocklesand (sta. 13). When left on a bare patch of sand by the receding tide they burrow to a depth of one-eighth of an inch, probably in order to protect themselves from the sun.

TURRITELLA TEREBRA, *Linnæus*. A shell only, from Polesands.

NATICA CATENA (*Da Costa*). A dozen or so were found on the smooth sand of Polesands, burrowing just below the surface.

PURPURA LAPILLUS (*Linnæus*). Very common at Orcombe Rocks; a few shells and one alive from Polesands.

BUCCINUM UNDATUM, *Linnæus*. Shells only, Orcombe Rocks and Polesands. One small living one on mussel bank (sta. 14C), and three dredged off the pier (sta. 14A).

CYPRÆA EUROPÆA, *Montagu*. A few alive from Orcombe Rocks; shells from Polesands.

APLYSIA PUNCTATA, *Cuvier*. Spawn only of this species was taken in the mosquito net trawl, between Bullhill Bank and Cocklesand.

ELYSIA VIRIDIS, *Montagu*. Three from Bullhill Deep Pit (sta. 9), and one or two from Engineering Company's stage in the dock.

DORIS TUBERCULATA (*Cuvier*). One specimen is recorded from Bullhill Bank by Mr. Holt, in May, 1897.

ANTIOPA CRISTATA, *Delle Chiaje*. Several on the walls and piles of the dock, and one from the bottom of the *Dawn*.

SEPIOLA ATLANTICA, *D'Orbigny*. One taken in shrimp trawl on Shaggles Sand (sta. 5).

POLYZOA.

[Nomenclature: HINCKS, *British Marine Polyzoa*.]

SCRUPOCELLARIA SCRUPOSA (*Linnæus*). A few colonies dredged on the sponge ground off the Clock Tower (sta. 14B).

BUGULA TURBINATA, *Alder*. Common in the dock on the piles, old boats, etc., and at Orcombe Rocks.

MEMBRANIPORA MEMBRANACEA (*Linnæus*). Common on Laminaria at Orcombe Rocks.

LOXOSOMA PHASCOLOSOMATUM, *Vogt*. Not uncommon on the posterior end of *Phascolosoma vulgare*, from the north side of the Warren (sta. 12).

TUNICATA.

[Nomenclature: HERDMAN, *A Revised Classification of the Tunicata*, Jour. Linn. Soc. Zool., xxiii.]

ASCIDIELLA ASPERSA (*O. F. Müller*). Common, growing on piles, boats, etc., in the dock. They seem to grow very rapidly, as specimens an inch long were found on the bottom of the ss. *Oithona* nine weeks after she had been scraped and painted, and of about the same size on the bottom of the *Dawn* after two months in Exmouth Dock.

CIONA INTESTINALIS (*Linnæus*). This Ascidian was found in great profusion in Exmouth Dock on the piles and wall under the Engineering Company's stage, and also on the wall just inside the dock gates, some of the specimens being eight or nine inches in length. Smaller ones were common on the bottom of boats which had been lying in

the dock for some time. One on the *Dawn*, after she had been lying there two months, was four or five inches long. Whether the dock is a regular habitat of *Ciona* we cannot say, not having any previous records, but at Plymouth this year the same species is extremely abundant in Millbay Docks, some of the specimens being as much as a foot long, whereas formerly we have never found more than a few small ones each year. Many of the Exmouth specimens were infested with a large species of Copepod, *Notopterophorus gibber*.

PISCES.*

[Nomenclature: DAY, *British Fishes.*]

LABRAX LUPUS (*Lacépède*). Caught in the estuary by hook and line and by seine. Between the Warren and Cockwood, seine, April 7th, 1897, one, 13 cm.; May 29th, 1897, one 8 cm., one 12 cm. [E. W. L. HOLT.]

COTTUS BUBALIS, *Euphrasen*. Four were taken between Bullhill Bank and Cocklesand, measuring respectively 4, 4·6, 10·2, and 11·7 cm. Off Bullhill Bank, off the Warren (north side), and Mere Bay, April and May, 1897. [E. W. L. H.]

TRIGLA HIRUNDO, *Linnæus*. Five, 14–23 cm., caught with seine off Bullhill Bank, May, 1897. [E. W. L. H.]

AGONUS CATAPHRACTUS (*Linnæus*). One taken between Pole and Monster Sands and one on sand bank off Starcross; 4·8 cm. and 4·4 cm. respectively. Off the north side of the Warren and Bullhill Bank, April and May, 1897. [E. W. L. H.]

TRACHINUS VIPERA, *Cuv. and Val.* A "sting-fish," probably this species, was taken by professional seiners off Polesands. The specimen was not examined. Two off Bullhill Bank, May, 1897. [E. W. L. H.]

GOBIUS RUTHENSPARRI, *Euphrasen*. Fairly common among the piles in Exmouth Dock, especially under the stage. One taken in a hand net measured 5·3 cm.

GOBIUS PAGANELLUS, *Gmel.* Several taken in the dock in a prawn-pot, 5·8 to 10·1 cm. in length.

GOBIUS MINUTUS, *Gmel.* This is by far the commonest Goby of the estuary; it was present in almost every haul of the mosquito net trawl taken above the Warren, varying in length from 1·2 to 5·7 cm. A batch of eggs found in a shell on Bullhill Bank, July 4th, 1901, hatched out the same day, the newly hatched young being about 2·4 mm. in length.

CALLIONYMUS LYRA, *Linnæus*. One off the north side of the Warren and one off Bullhill Bank with seine, May, 1897. [E. W. L. H.]

* By R. A. TODD.

BLENNIUS PHOLIS, *Linnæus.* Most common at Orcombe Rocks and among the piles and in crevices in the walls of the dock. Two were also taken in Mere Bay and one on Bullhill Bank.

ATHERINA PRESBYTER, *Jenyns.* A large shoal of very young Atherines was seen in the dock on August 16th, 1901. Those which were caught were ·7 to 1·1 cm. in length. No large ones were seen. The specimens were identified by Dr. Kyle.

MUGIL CHELO, *Cuvier.* Shoals of large grey mullet were almost always to be seen in the dock, generally under the boats which had been in the dock some time, and were therefore covered with weed, etc. A shoal of young ones was seen in the dock on August 16th, 1901, and about twenty were caught, measuring from 2·5 to 2·7 cm. Common in the dock, May, 1897 [E. W. L. H.] Grey mullet are also caught in the estuary, generally in seines.

GASTEROSTEUS ACULEATUS, *Linnæus.* One "three-spined stickleback" was caught in the dock, with the young grey mullet mentioned above, 2·5 cm. in length.

GASTEROSTEUS SPINACHIA, *Linnæus.* Single specimens were taken with the mosquito net trawl at each of the following localities: Bullhill Bank, Mere Bay, and between Pole and Monster Sands. Two off north side of Warren, in the seine, April, 1897. [E. W. L. H.]

LABRUS MACULATUS, *Blainville.* Between Bullhill Bank and Cocklesand, two of 2·0 and 2·5 cm.; Mere Bay, one of 2·2 cm., and Bullhill Deep Pit, five, 1·4 to 3·0 cm. in length; Exmouth Dock, one of 15 cm.

CRENILABRUS MELOPS (*Linnæus*). Small ones from 1 to 3 cm. long were moderately common in Bullhill Deep Pit, channel between Bullhill Bank and Cocklesand, and Mere Bay. Larger ones of about 7 cm. and upwards were not uncommon in the dock, being frequently caught in a prawnpot.

GADUS POLLACHIUS, *Linnæus.* One, 4·0 cm. in length, was caught in the dock on July 9th, 1901.

AMMODYTES TOBIANUS, *Linnæus.* One of the commonest fish in the lower part of the Exe estuary. It was often to be seen going about in shoals containing several thousand fish of about the same size. In a shoal seen in the dock entrance on July 11th, 1901, five were caught from 4·5 to 5·5 cm. in length. I am indebted to Dr. Kyle for the identification of this species.

RHOMBUS MAXIMUS (*Linnæus*). One seined off north side of Warren, April 7th, 1897, 14 cm. long. [E. W. L. H.]

RHOMBUS LÆVIS, *Road.* Young brill were caught in the mosquito net trawl, etc., at the following localities: On the Polesands, one with

fine-meshed seine; off Cockwood, on sand, one of 2·3 cm. (July 8th, 1901); in Salthouse Lake, July 18th, 1901, one of 3 cm., August 5th, 1901, two of 2·9 and 2·8 cm. respectively; Mere Bay, April, 1897, two of 18 cm. [E. W. L. H.]; off north side of Warren, April, 1897, one of 14 cm.; and two in May, 1897, of 17 and 21·5 cm. respectively. [E. W. L. H.]

PLEURONECTES PLATESSA, *Linnæus.* Young plaice were found to be very common in Salthouse Lake and along the shore above the mouth of the lake at low water, and were taken in some numbers in a shrimp net (shove net). Mr. Holt records a number of plaice obtained at Exmouth in 1897 with a seine net as used by the fishermen at Exmouth, and with a tuck net of the Saltash pattern belonging to the Laboratory.

The numbers and sizes (in inches) of fish obtained are recorded in the following tables:—

Plaice taken in Mere Bay by Mr. Holt with Professional Seine in April, 1897.

Size in inches.	Number.	Size.	Number.	Size.	Number.
2¾	1	5¼	8	9	1
3	2	5½	3	9½	1
3¼	3	5¾	3	11	1
3½	3	6	3	11½	1
3¾	4	6¼	1	11¾	1
4	8	6½	3	13	1
4¼	4	7	2	13½	1
4½	3	7¼	2	13¾	1
4¾	3	8	1	14	1
5	5	8¼	1	20	1

Plaice taken in the Bight north of the Warren by Mr. Holt with Professional Seine in April, 1897.

Size in inches.	Number.	Size.	Number.	Size.	Number.
2¼	1	4½	10	6¾	2
2½	10	4¾	4	7	2
2¾	31	5	2	7¼	1
3	38	5¼	6	7½	1
3¼	23	5½	12	8	1
3½	18	5¾	3	8½	1
3¾	15	6	3	9	1
4	19	6¼	5	10¾	1
4¼	14	6½	4	—	—

Plaice taken in the Bight north of the Warren by Mr. Holt with the Laboratory Tuck Net in May, 1897.

Size in inches.	Number.	Size.	Number.	Size.	Number.
1¼	3	4¼	21	6¾	2
1½	1	4½	14	7	2
1¾	2	4¾	7	7¼	4
2	3	5	10	7¾	2
2¼	2	5¼	8	8¼	1
3	3	5½	8	8½	1
3¼	14	5¾	6	8¾	1
3½	25	6	8	10¾	1
3¾	31	6¼	5	11	1
4	18	6½	3	11½	1

Plaice taken at Exmouth during July and August, 1901, almost wholly in Salthouse Lake, with Shove Net.

Size in inches.	Number.	Size.	Number.	Size.	Number.
1½	20	2¾	12	5½	4
1¾	40	3	2	5¾	1
2	29	3¼	1	6¼	1
2¼	17	3¾	1	—	—
2½	12	4½	2	—	—

PLEURONECTES LIMANDA, *Linnæus.* Off north side of the Warren, April and May, 1897, nine, 9–11·5 cm. Bullhill Bank, May, 1897, eleven, 9·5–12·5 cm. [E. W. L. H.]

PLEURONECTES FLESUS, *Linnæus.* Off the north side of the Warren, May, 1897, one of 13 cm. and one of 30·5 cm.; Bullhill Bank, April and May, 1897, five, 9·5–17 cm. [E. W. L. H.]

SALMO SALAR, *Linnæus.* There is a regular salmon fishery in the Exe estuary during the season, which gives employment to several large rowing boats, each of which is manned by four to six men and works one seine. The seine is about one hundred fathoms long and three to four fathoms deep in the middle, where there is a bag, and narrows to a fathom at each end, with a mesh of 4¼ inches. The net is shot across the stream, then towed down with the tide for two or three hundred yards and hauled. Each boat generally manages two and sometimes three hauls at low water.

BELONE VULGARIS (*Linnæus*). One was caught when seining for sand-eels (*Ammodytes*) off Polesands.

CLUPEA HARENGUS, *Linnæus.* Bullhill Bank, seine, April, 1897, two, 26 and 29 cm.; and north side of Warren, seine, April, 1897, six, 23·5–32·5 cm. [E W. L. H.]

CLUPEA SPRATTUS, *Linnæus.* Bullhill Bank, seine, May, 1897, six of 5 cm.; and off north side of Warren, April, 1897, six, 5·5–7 cm. [E. W. L. H.]

ANGUILLA VULGARIS, *Turt.* Two small ones, about 20 cm. in length, were caught in the dock.

CONGER VULGARIS, *Cuvier.* One of about 4 lbs. weight was seen among the piles in the dock.

SYNGNATHUS ACUS, *Linnæus.* Two were taken in the mosquito net trawl on the sand bank off Starcross, and several in the shove net in Salthouse Lake. Two were taken off the north side of the Warren in the seine, April, 1897. [E. W. L. H.]

SYNGNATHUS ROSTELLATUS, *Nilss.* This species is easily distinguishable from *S. acus* of the same size by the number of pre-anal rings, which in *S. rostellatus* varies, in the specimens obtained at Exmouth, from 13 to 15; in *S. acus* they number 19–20 (see Duncker, *M.B.A. Journal*, N.S. vol. v. p. 175). Seven were taken in the mosquito net trawl on the Bar, from 5·8–11·5 cm.; seven, a quarter-mile south of Polesands, 5·9–14·9 cm.; two between Pole and Monster Sands, 7·4 and 13·8 cm.; a few in the dock and on Shaggles Sand; and four on the sand bank east of Powderham mussel beds, 12·3 to 15·7 cm. in length. The one measuring 15·7 was a male carrying embryos which hatched out on the same day (July 25th, 1901), the young fish measuring 14 mm. when hatched. The finrays and rings in the specimens from a quarter-mile south of Polesands (the only ones examined) were found to vary as follows: Pre-anal rings, 13–15; total number of rings, 52–56; dorsal finrays, 34–40; pectoral, 10–11, mostly 11; caudal rays, 10.

The Foraminifera of the Exe Estuary.

By

R. H. Worth.

SAMPLES of sand were taken, either from the shore immediately above low water of spring tides, or from the bottom in a few inches of water.

With one exception no samples were dredged. The localities were few: Polesands; the north or estuarine shore of the Warren west of Salthouse Lake; the banks of the Salthouse Lake; a low-water stream on the Warren; near Lympstone; and (the dredged sample) within Exmouth Docks.

To appreciate the results it is necessary to consider shortly the physical conditions at the mouth of the Exe estuary.

The low-water channel of the Exe, which would naturally enter the sea in a southerly direction, is diverted by a spit of land known as the Warren and a sand bank known as the Polesands, turned through a right angle to the eastward, and only after passing some little distance parallel to the coast discharges into the sea.

That portion of the Polesands which uncovers at low water is chiefly, if not entirely, pure sand; the surface is in no way compacted, but is unstable and ridges, furrows, and travels with every tide.

The Warren consists of sands, gravels, and shingles, with patches of fair-sized pebbles, and to the westward compact clays.

From the presence of these clays it may be surmised that the western end of the Warren is a genuine spit of land; the eastern end and the Polesands are alike due to littoral drift.

The mouth of the Exe is more exposed to southerly than to easterly gales, and breakers from the southward drift the beach across the estuary, and drift it in greater quantity than the tidal current of the ebb, setting out from the estuary, can remove in the intervals between successive gales.

Easterly gales, which are rare, and are to some extent fended off by the coast-line, have been unable to drive the sand and shingle back to their original postion westward and southward of the harbour mouth.

In course of time the limit has been reached at which the tidal scour of the ebb, and the breakers from the eastward, suffice to check the further easterly advance of the bar.

The channel between the Polesands and the land has adjusted itself

to that width and depth through which the waters of the ebb will flow with sufficient velocity to maintain a fairly constant cross-section.

The surface of the Polesands, turned over by wave and current action even in calm weather, contains little or no organic matter, and any Foraminifera attempting to establish themselves thereon are liable on each tide to be buried at a considerable depth below the surface.

The average least diameter of the largest sand grains on the seaward slopes of the Polesands is 0·7 mm., the average least diameter of the largest sand grains on the estuarine slope of those sands is 0·4 mm.; in each case the average greatest diameter would be about 50 per cent. more. The figures were obtained by ranging a number of grains between parallel plates. The average least diameter of the largest sand grains at low-water mark on the north shore of the Warren is 0·25 mm.

To move a grain of quartz sand of 1 mm. diameter requires a current of velocity 0·5 feet per second, or, say, one-third of a knot; while to move a grain of 0·25 mm. requires a velocity of 0·25 feet per second, or, say, one-sixth of a knot.

If the sand is once allowed to compact thoroughly with a reasonable admixture of silt, a much higher velocity is required to move it, say, up to ten times the figures above given.

To anyone familiar with the actual tidal currents at Exmouth the unstable nature of the surface of many of the sand banks, especially below half-tide level, will be at once apparent.

According to King's *Channel Pilot*:—

"When the banks at the entrance (of the estuary) are covered, both flood and ebb streams set fairly over them, about 2½ knots; but when uncovered, these streams run strong through the channel, and their strength increases at Ferry Point to 5 knots."

The channel followed by the ebb across the Polesands at the end of the Warren, until these sands are uncovered, can be clearly seen on the chart of the harbour.

It is to be noted that the grains on the inner side of the Polesands are much better polished and rounded than those on the outer. The former travel some little distance to and fro with each ebb and flood, the latter are chiefly subject to wave-action.

The Warren sand is richer in organic matter as it rises in level from low-water toward high-water level, but it is not to be understood that the increase in organic matter is directly proportioned to level.

Near Lympstone a very fine sand occurs, the average least diameter of the largest grains being only 0·12 mm.

The conditions being so unfavourable, it is not surprising that Foraminifera are scarce.

On the Polesands, above and immediately below low water, there are practically no living Foraminifera.

Stranded on the outer or seaward slopes of these sands the following dead shells were found; no attempt has been made to estimate the relative numbers.

Miliolina seminulum.
Truncatulina lobatula.
Rotalia beccarii.
Nonionina depressula.
Polystomella crispa.
Polystomella striato-punctata.

On the northern or estuarine slope of these sands even dead shells are absent.

The method of investigation adopted consisted in spreading 13 c.gms. of each sand on a glass slip and counting and identifying the Foraminifera.

This process is not exhaustive, as small specimens and species may be overlooked, no matter how carefully the sand may be spread. Also the less common species cannot be expected to be represented in each 13 c.gms. Accordingly fifty times this quantity (6·5 gms.) is taken, and the Foraminifera floated from same as far as may be. Invariably additional species are thus found. The drawback to this proceeding lies in the fact that the numerical results are no longer absolute. No doubt the direct count gives results in themselves too low, but at least fairly comparable as between the species identified. In floating, however, only a small proportion of the Foraminifera of any species are obtained, and the relative numbers of the different forms depend largely on the weight per unit displacement of the individual species. Thus *Rotalia beccarii* floats extremely ill, and *Polystomella striato-punctata* fairly well. The effect from actual averages is as follows: Assume a case in which 1,000 of each of the following species are counted in a sample, then on floating we should obtain the following numbers only :—*

	For each 1,000 found by actual count.
Polystomella striato-punctata . .	170 or 17 per cent.
Biloculina ringens . . .	167 ,, 16·7 ,,
Planorbulina mediterranensis . .	73 ,, 7·3 ,,
Nonionina depressula . . .	36 ,, 3·6 ,,
Bulimina pupoides . . .	30 ,, 3 ,,
Miliolina seminulum . . .	13 ,, 1·3 ,,

* It should be noted that the figures given are the average of a large number of observations; but when, as at Exmouth, a great proportion of each species is represented by small individuals, the actual percentages which float will be much greater than given in the table, the relative percentages remaining constant.

	For each 1,000 found by actual count.
Discorbina rosacea	12 or 1·2 per cent.
Truncatulina lobatula	10 „ 1 „
Textularia gramen	6 „ 0·6 „
Rotalia beccarii	1½ „ 0·15 „

It would therefore appear as though *Polystomella striato-punctata* were 113 times more numerous than *Rotalia beccarii*, although both would really be present in equal numbers.

Undoubtedly some of the *Lagena*, *Nodeosaria*, and *Bolivina* float better than *Polystomella*, but exact figures have not been ascertained; the above table is itself somewhat tentative. Meanwhile, numerical results from floating are still of value as giving the relative abundance of any one species in different samples.

SAMPLE taken just above low-water mark, on the north shore of the Warren, about 150 yards west of Salthouse Lake stream.

FORAMINIFERA COUNTED IN 13 C.GMS.	No.	Per cent.
Nonionina depressula	4	50
Polystomella striato-punctata	2	25
Miliolina seminulum	1	12½
Rotalia beccarii	1	12½
	8	100

FORAMINIFERA FLOATED FROM 6·5 GMS.	No.
Nonionina depressula	90
Polystomella striato-punctata	52
Lagena orbignyana	6
Miliolina seminulum	5
Rotalia beccarii	5
Polymorphina (?) *	3
Trochammina inflata	3
Polystomella arctica	3
Polystomella crispa	2
Nonionina stelligera	2
Bulimina pupoides	1
Bolivina	1
Spirillina (?)	1
Undetermined	2
	176

A SAMPLE taken at the same place but under low-water mark contained but few Foraminifera, and the results would only be possibly misleading.

* Provisionally attributed to *Polymorphina*. This species will form the subject of further inquiry.

ANOTHER SAMPLE taken from inside an old kettle resting on sand at same point below low water yielded the following:—

FORAMINIFERA COUNTED IN 13 C.GMS.	No.	Per cent.
Nonionina depressula	5	45½
Polystomella striato-punctata	4	36½
Polystomella arctica	1	9
Rotalia beccarii	1	9
	11	100

The comparative shelter of the kettle probably accounts for the presence of these as against the practical absence of all Foraminifera from the sand on which the kettle rested.

A SAMPLE taken immediately above low water on the bank of the Salthouse Lake stream, about 100 yards from the low-water channel of the Exe.

FORAMINIFERA COUNTED IN 13 C.GMS.

This method was not applied in the present instance.

FORAMINIFERA FLOATED FROM 6·5 GMS.	No.
Polystomella striato-punctata	91
Nonionina (chiefly) depressula	49
Rotalia beccarii	3
Polymorphina (?) *	2
Miliolina seminulum	2
Trochammina inflata	1
Haplophragmium canariense	1
Lagena hexagona	1
Lagena orbignyana	1
Bulimina pupoides	1
Bolivina dilatata	1
Biloculina ringens (?)	1
	154

SAMPLE received labelled—"Lympstone mussel-bed, sand between weeds." This is a singularly fine sand and very free from silt.

FORAMINIFERA COUNTED IN 13 C.GMS.	No.	Per cent.
Rotalia beccarii	6	60
Nonionina depressula	3	30
Polystomella striato-punctata	1	10
	10	100

* See previous footnote.

Foraminifera floated from 6·5 gms.	No.
Nonionina depressula	30
Polystomella striato-punctata	27
Lagena orbignyana	18
Rotalia beccarii	9
Miliolina seminulum	8
Polystomella arctica	2
Verneuilina polystropha	2
Undetermined	4
	100

Sample dredged from bottom of Exmouth Docks: consists of a fine sand mixed with much silt and organic matter; general appearance a somewhat sticky mud. In this case there is an entire absence of tidal scour or wind wash, and a constant depth of water. On the other hand, the water of the dock is by no means so clear or pure as in the channel outside the gates.

Foraminifera counted in 13 c.gms.

It was impossible to take a satisfactory census in this manner.

Foraminifera floated from 6·5 gms.	No.
Nonionina depressula	178
Polystomella striato-punctata	33
Rotalia beccarii	31
Lagena orbignyana	11
Miliolina seminulum	10
Bulimina pupoides	5
Verneuilina polystropha	2
Polymorphina compressa	2
Bolivina textilaroides	1
Bolivina dilatata	1
Cornuspira foliacea (?)	1
Undetermined	11
	286

From the relative floating capacity of the species it is obvious that *Rotalia beccarii* greatly predominates, and is followed by *Nonionina depressula*.

LIST OF SPECIES TAKEN.

[Nomenclature: BRADY, *Challenger Report*, ix.]

BILOCULINA RINGENS (*Lamarck*). One individual somewhat doubtfully identified, from Salthouse Lake.

MILIOLINA SEMINULUM (*Linn.*). Dead shells from the southern slope of the Polesands. One of the four or five commoner species from the Warren, Salthouse Lake, and Lympstone; and decidedly one of the more prominent on the bed of Exmouth Docks. Nowhere really plentiful, and no large, well-grown specimens obtained except from the south slope of the Polesands.

HAPLOPHRAGMIUM CANARIENSE (*d'Orbigny*). A single individual from Salthouse Lake.

TROCHAMMINA INFLATA (*Montagu*). At low-water mark on Warren and from Salthouse Lake. Well-grown specimens.

VERNEUILINA POLYSTROPHA (*Reuss*). Found at Lympstone and in Exmouth Docks. Appears in this estuary to replace the *Textularia*, no specimen of either *Textularia gramen*, *agglutinans*, or *saggitula* having been found.

BULIMINA PUPOIDES, *d'Orbigny*. Single individuals from Warren and Salthouse Lake; five times as plentiful in Exmouth Docks, which is not a typical ground for this species. Probably, however, *Bulimina*, in common with all the more elongate Foraminifera, suffers more than the lenticular forms from the tidal scour. The actual number present in the sample from the docks does not compare with the representation of this species on grounds where it is really at home.

BOLIVINA DILATATA, *Reuss*. Found at Warren, Salthouse Lake, and Exmouth Docks; in neither case more than barely represented. From some results not numerically stated above, is probably more plentiful in the docks than elsewhere.

BOLIVINA TEXTILAROIDES, *Reuss*. Exmouth Docks.

LAGENA HEXAGONA (*Williamson*). Salthouse Lake only, but may occur elsewhere; distinctly rare however.

LAGENA ORBIGNYANA (*Seguenza*). Six floated from 6·5 gms., Warren; one from 6·5 gms., Salthouse Lake; eighteen from similar quantity, Lympstone; and eleven from Exmouth Docks. A light shell of small size which succeeds here in establishing itself in comparatively quiet situations. Compared with its occasional numbers, it is poorly represented at all the stations mentioned above.

POLYMORPHINA COMPRESSA, *d'Orbigny*. Infrequent.

SPIRILLINA. One of doubtful species, from Warren.

CORNUSPIRA FOLIACEA (*Philippi*). A single individual somewhat doubtfully identified, from Exmouth Docks.

TRUNCATULINA LOBATULA (*Walker and Jacob*). Dead shells from south slope of Polesands; absent elsewhere. An adherent species; its absence is probably largely if not entirely due to the want of suitable hosts.

It may be noted that *Planorbulina mediterranensis*, another adherent species, is also absent.

ROTALIA BECCARII (*Linn.*). In all samples. Where the numbers are so small percentages are apt to be misleading. At the Warren and Salthouse Lake this species is third in point of number, *Nonionina* and *Polystomella* being distinctly more numerous.

In the sample from Lympstone *Rotalia beccarii* is distinctly the dominant species, as also in the dredging from Exmouth Docks.

NONIONINA DEPRESSULA (*Walker and Jacob*). All samples. The dominant species at Warren and the second at Lympstone, probably the second in Exmouth Docks. Distinctly an estuarine species, but is still fairly prominent in some localities at twenty fathoms off this coast.

NONIONINA STELLIGERA, *d'Orbigny*. Probably occurs in all samples; in much less number, however, than *depressula*.

POLYSTOMELLA CRISPA (*Linn.*) and

POLYSTOMELLA STRIATO-PUNCTATA (*Fichtel and Moll.*). These forms have been treated as separate species to this extent, that the individuals have been assigned to one or the other denomination according to a purely arbitrary judgment that the specimen more nearly approached the recognised type of *crispa* or *striato-punctata*.

Var. *striato-punctata* is distinctly the more prominent, and is second in order at the Warren, probably third in order at Salthouse Lake, third at Lympstone, and third in Exmouth Docks.

Well-charactered forms of var. *crispa* are rare, and extreme types absent.

POLYSTOMELLA ARCTICA, *Parker and Jones*. This seems another ill-defined species, which may apparently be regarded as of merely varietal significance.

The above list of species gives all the commoner forms, and some at least which are present in but small numbers; it cannot, however, be regarded as actually exhaustive.

Generally speaking, it indicates that the conditions are very distinctly more estuarine than at Salcombe.

A few dredgings from the low-water channels would have given a greater value to the results.

The Plankton of the Faröe Channel and Shetlands. Preliminary Notes on some Radiolaria and Copepoda.

By

R. Norris Wolfenden, M.D., Cantab., F.Z.S.

(With Plates I.–IV. and a Chart.)

In the year 1899 I commenced a series of tow-nettings round the coast of Shetland, and established four stations—one south of Sumburgh Head (III.), one west of Papa Stour (IV.), one of the northernmost points of Shetland (V.), and one due east of Bressay (VI.). During 1899 my yacht (the *Walwin*), a cutter of forty tons, made the round of these stations once a month during October, November, and December; and in 1900 during January, February, March, April, May, and June. During July, 1900, a passage was made across to Thorshaven (and back to Scalloway, Shetland), where stations were established, numbered respectively A1, A2, A3, A4, A5, A6, A7, A8, A9. (See Chart.) During August, 1900, only a short trip to the first two stations in the Faröe Channel was possible. In October, 1900, January, 1901, April, 1901, the stations round Shetland were visited again, and during May, 1901, a further passage was made to Thorshaven and back to Scalloway, visiting the stations previously fixed in the Faröe Channel. This passage was repeated in June, 1901, and again in July, 1901.

At each station round Shetland a surface haul was made with a fine silk net, followed by a vertical haul with an open net; and in February, 1901, I used for the first time a closing net supplied to me by the Plymouth Biological Station, and designed by my friend Mr. W. Garstang. This has subsequently been used on every occasion, both at the Shetland stations and on each trip to the Faröe Islands.

Thermometers were attached to the net, a reversing thermometer of Negretti and Zambra's pattern, supplied with Knudsen's bulb, and a Miller-Casella minimum thermometer; and the temperatures of each haul have been carefully recorded. In addition to these hauls a mid-water net of Professor McIntosh's pattern, supplied to me from St. Andrews, was used on every occasion where it was practicable. The procedure adopted has been as follows: At the Shetland stations

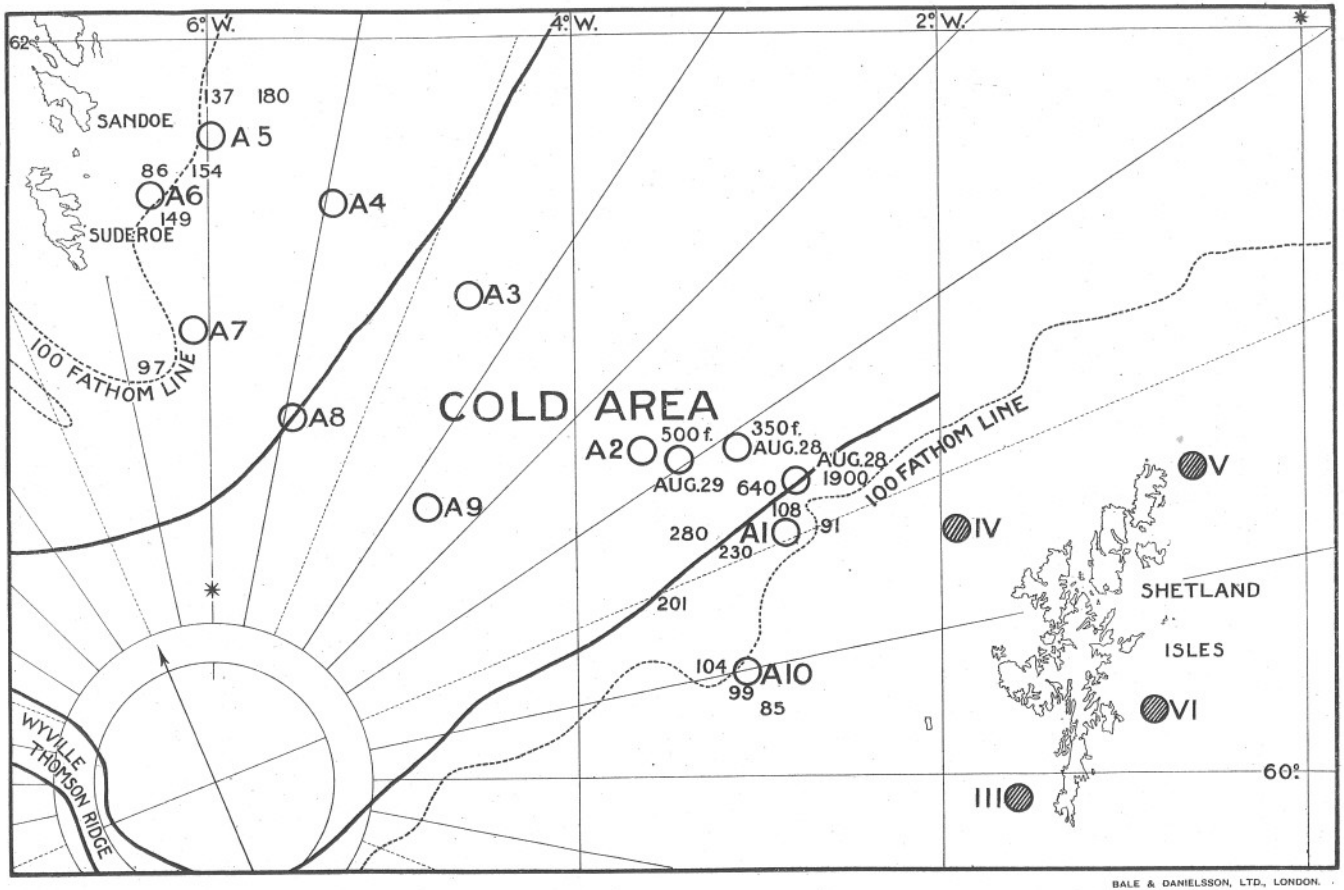

CHART SHOWING STATIONS AT WHICH TOW-NETTINGS WERE TAKEN IN THE FARÖE CHANNEL AND ROUND THE SHETLAND COAST BY DR. WOLFENDEN.

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a sounding was first taken, then a surface haul, then a vertical haul with open net, and finally a haul from the deepest area with a closing net (Garstang's). Temperature records and water samples * of the area fished were taken, and the mid-water net was towed out behind the vessel while these observations were being made—sometimes (when in deep water) for as much as five hours at a station where much work had to be done. Once over the 100-fathom line, *i.e.* in the Faröe Channel, these procedures were repeated at each 100-fathoms depth down to 500 fathoms, with the omission of the vertical haul with open net, this being considered unnecessary. I have found Garstang's net perform very satisfactorily, and with a fine wire stand quite vertically in the sea. I am aware that objections are urged against a light net of this character in deep water, and Dr. Fowler used in the Faröe Channel a net and wire which, when weighted, exceeded some four times the weight of Garstang's net. I do not intend here to discuss the matter, but will merely remark that my own hauls in deep water agree very closely with those of Dr. Fowler, which were executed with every possible care to ensure accuracy. It is with satisfaction that I note this, and I cannot but think that some of the objections to a light net of Garstang's pattern are more theoretical than practical. Dr. Fowler has very kindly undertaken for me the superintendence of a heavy net of his pattern, which I propose to use in the Faröe Channel; and until I have compared the results of this net with those of the lighter net I defer any remarks as to the vertical distribution of the plankton of this area. An examination of his Copepods taken in his "Research" work (which he has very generously placed at my disposal) shows, however, how closely our results agree.

With the mass of material accumulated during three years' work it has been impossible for me to devote attention to more than two groups, viz. the Radiolaria and the Copepods. My attention was early attracted to the former group on account of the great number and considerable variety which occurred constantly round the Shetland coasts, and because there appears to have been but little work done with respect to this group in British waters. The few notes which Mr. Allen has kindly given me the opportunity of publishing in the Journal of the Marine Biological Association will, I hope, be amplified in a separate publication. The Copepods, the study of which has revealed several new forms, and extension to northern waters of many interesting forms of more or less constant occurrence round the Shetland coasts, will also be more fully dealt with later in a special monograph.

* Mr. H. N. Dickson, of Oxford, has been kind enough to undertake the analysis of my water samples.

I am greatly indebted to Miss Marion Lees for the beautiful drawings which she has executed, and is still engaged upon, in illustration of my plankton preparations.

I. RADIOLARIA.

THE COLONY-BUILDING RADIOLARIA are well represented round the Shetland coasts and in the Faröe Channel. Haeckel, in the *Challenger Report*, described and figured (Plate III.) a Collozoum, to which he gave the name "*C. ellipsoides, n. sp.*" Fowler (*Proc. Zool. Soc.*, December 13th, 1898, p. 1024) speaks of a Collozoum, which he captured in 30 per cent. of epiplankton hauls in the Faröe Channel, of apparently two species, neither of which could be attributed to *Collozoum inerme* or to Haeckel's *Collozoum ellipsoides*.

COLLOZOUM.

A Collozoum which I have captured in several tow-nettings, and on many occasions round the coasts of Shetland, agreed in all particulars with the same organism which I also obtained in considerable quantity in surface tow-nettings in the Faröe Channel. It bears considerable resemblance to *Collozoum pelagicum* (Brandt), but does not fully agree in important particulars with any of the Collozoums described by Brandt or Haeckel.

The colonies are yellowish in colour, and sufficiently so when in quantity to colour the whole capture a yellowish green. The jelly is often delicate and easily torn. The colonies are for the most part elongated, rarely spherical. Except in what are probably very young colonies, the jelly is of moderately firm consistence. The individuals are at once distinguished by the presence of one or more bright yellow oil drops in the centre of the central capsule. The nests are not closely packed, and the spaces between them are fairly regular.

The zooids are for the most part spherical, and only in cases where division is in progress or about to take place is this form departed from. Then they are lengthened out in the axis, and are frequently "fiddle-shaped." Division appears to be in progress in most of the colonies captured by me in the autumn of 1900.

The central capsules have a diameter, in the spherical condition, of ·09–·10 mm., and are packed with small round cells. In many colonies the individuals contain only one oil drop, but most have two, and some even three or four, occupying the exact centre of the capsule, and in all cases of a deep yellow colour. Where zooids are undergoing division these oil drops are often small and numerous. A fine membrane appears to surround the central capsule, and round most nests there is a thick

layer of granular protoplasm, from which arise numerous pseudopodia which ramify through the calymma, and are connected with the extracapsular bodies and spaces. The yellow cells (xanthellae) are numerous —12 to 20 or 30 in an individual—and where the central capsule is dividing many of these appear to be undergoing the same process. They have an average size of ·02 mm. Extracapsular bodies are numerous, and contain granular protoplasm, and often what look like small fat drops, but osmic acid fails to stain them.

The description of this Collozoum may be briefly put as follows:— Colonies, long and thin, more or less elongated, not segmented. Individuals, ·09–·10 mm. in diameter, round, with thick pseudopodia, central capsule very fine, "assimilation plasma" (Brandt) absent (?); two to four oil drops of bright yellow colour occupying the centre or major portion of the capsule; yellow cells (xanthellae) numerous, 12–30, situated in the "pseudopodia mother-bed" round the capsule.

Distribution: In surface waters round the whole coast of Shetland, and in the Faröe Channel.

The species under discussion—a more detailed description of which is reserved for a future occasion—while possessing some of the characters of *C. fulvum*, much resembles *C. pelagicum* in the possession of yellow oil drops, but differs from the latter in the great number of xanthellae, which in *C. pelagicum* are only 2–6 per individual. The size of the individual agrees more with *C. fulvum*. We must bear in mind the caution given by Brandt in his painstaking monograph on the colony-building Radiolaria, that it is very difficult to recognise the various Collozoums in their young stages. Besides *C. inerme, pelagicum, fulvum, hertwigii,* Brandt describes eight examples of skeletonless sphærozoida which do not conform with any of the above, some resembling *pelagicum*, others *inerme*, others having apparently distinct peculiarities. It may be remarked that Haeckel's description of *Coll. pelagicum* differs remarkably from that of Brandt,* and the latter, whose careful and minute descriptions, as I have found from experience, appear to be extremely accurate, remarks that under *Coll. inerme* both Haeckel and Hertwig have confused many different kinds. This northern species of Collozoum, which is certainly not *C. inerme*, appears to more nearly resemble *C. pelagicum* than any other kind.

Quite recently (September, 1901) I have found in Scapa Flow, in Orkney, day after day for a fortnight, quantities of a Collozoum which differs greatly from the organism just described. A detailed study

* Haeckel (*Challenger Report*) describes *C. pelagicum* as having small, irregularly shaped central capsules, transparent and without oil globules, often many extracapsular vesicles in the jelly body. Membrane very thin and delicate. Diameter of central capsules, ·02–·08 mm.

upon living specimens has been possible, since I have captured it in the several stages of development, including the spore-formation stage. The colonies are for the most part globular, never segmented like *Coll. inerme*, the calymma is delicate and packed with zooids of ·12–·15 mm. diameter (smallest) to ·24 mm. (the largest), many in the same colony being quite round, others ovoid or elliptical, but varying as much in shape as size, long, fiddle-shaped (dividing) zooids measuring as much as ·34 mm. in length.

Similar variation existed in the number and size of the oil drops, the occurrence of one oil globule being quite exceptional, most colonies, except those in the spore stage, containing zooids with a central rosette of eight or nine colourless oil drops, while in long, fiddle-shaped zooids they were more numerous still. The xanthellae were very numerous—in many of the young reproductive colonies from 20–30, in individuals of other colonies, which are apparently the same species, being as many as 80-100 per individual. Staining with osmic acid failed to reveal any "assimilation plasma" (Brandt), and the pseudopodia were very fine and the pseudopodium bed surrounding the capsules of moderate thickness. While a detailed description is reserved for a further occasion, it is evident that the organism is not *Coll. inerme* or *Coll. pelagicum*, and I have little doubt that it is a new species. What is a further peculiarity is that the calymma is filled with diatoms exactly similar to those described by Brandt (and figured in Plate 2, Fig. 9, of his monograph),*† long bodies (·085 mm.) tapering to a fine point at each extremity, thicker in the middle, containing yellow pigment granules and four or five lightly refracting dots which stain darkly with osmic acid. They possess a certain degree of movement in a longitudinal direction, and I have watched them making to-and-fro movements of considerable length through the jelly. Some colonies have a yellowish appearance, to the naked eye, and this appears to depend mostly, if not entirely, upon the number of diatoms present, for the number of green cells does not appear to make any difference, and the oil drops are in all cases quite colourless.

Brandt has already described the occurrence of these diatoms in four colonies of a young kind of Collozoum, which he found in the Mediterranean and which did "not appear to be identical with any known species." The zooids in his Collozoum had a diameter of only ·07–·09 mm. and contained one colourless oil drop of ·023–·03 mm. diameter with a small pseudopodia layer and no assimilation plasma. This is practically all the description which he was enabled to give of this Collozoum, for which he was unable to assign a specific place.

* Die Koloniebildenden Radiolarien.

† This does not appear to be an accidental occurrence, but a constant association.

I think it is possible that the *Collozoum ellipsoides* (*n. sp.*) described briefly by Haeckel.* ("central capsules regularly ellipsoidal, very large; length 0·3–0·4, breadth 0·2; in every capsule 50–80 oil globules") may be a stage of the same organism. This Collozoum has been watched by me in the spore-forming stages, and I have studied both the anisospore and isospore conditions. A study of these Collozoums has convinced me how little reliable can be a differential classification of these organisms based on the shape of the zooids, as indicated by Haeckel (p. 24 of the same monograph).

These swarms of Collozoum were observed in Scapa Flow to come to the surface on an exceedingly hot day with a burning sun and quite calm sea. As soon as any ripple of the surface occurred, with a breeze of wind, they disappeared below the surface, and were found 10–12 fathoms deep. It is probable that temperature affects them but little, as I experimentally submitted the living colonies to a temperature of 33° F. and found that after two hours' treatment they still floated at the surface, and at the other extreme a temperature of 80°F. did not affect their vitality. *Chœnicosphœra murrayana* has been captured by me, living, in the sea at a temperature of 29° F. Wind, tidal and other currents have probably more to do with distribution in these cases than temperature.

In assigning any Collozoum to its specific place, no system can be reliable which does not take into full account the various stages in the life-history of the organism. I therefore quote from Brandt's monograph the following data arranged in tabular form and with which I have incorporated the new species (to which I have given the name *C. brandtii*). These serve for the discrimination of the known European species, or as type forms round which others may be grouped.

* *Challenger Report*, "Radiolaria," p. 26.

	Colony.	Zooids.	Central Capsule Membrane.	Assimilation Plasma.	Nuclei.	Xanthellae.	Behaviour under chromic acid.
1. Coll. inerme .	Sausage-shaped, with large vacuoles	0·1–0·13 mm.; often irregular	Absent	Occurs	2 layers	Numerous; nearly all round central capsule	Jelly dissolved; zooids fall out
2. Coll. fulvum .	Round; one large central vacuole	0·09–0·14 mm.; generally round	Fine	Occurs	2 layers	Very numerous	Colony loses its form
3. Coll. pelagicum .	Thin, sausage-shaped; often exceedingly long; never segmented	0·8 mm.; mostly round; oil drops brown-yellow; thick pseudopodia	Fine	Absent	1 layer	Few; 2–6 pro individual; all round the central capsule	Jelly dissolved; individuals fall out
4. Coll. hertwigii .	Round	0·12–0·22 mm.; mostly round; often ellipsoid or kidney-shaped	Thick	Absent	?	Numerous; all round the central capsule	Colony retains its form
5. Coll. brandtii . (nov. sp.)	Round or slightly elongated; never segmented; numerous vacuoles.	·13–·24 mm.; ovoid, ellipsoid, or round; oil drops 5–10, colourless	Absent in young condition; extremely fine in isospore stage	Absent	1 layer	Very numerous; usually 30, often over 100; round the zooid	Jelly partially dissolved; zooids held more or less together by slimy threads of plasma

	Young Reproductive Stage, with Intracapsular Bodies.		Old Reproductive Stage.	
			Isospore Stage.	Anisospore Stage.
1. Coll. inerme. .	Fat colourless, in large drops	Yellow cells fall out in swarm stage	Crystals ·008–·01 mm. long inside nucleus; isospores 0·012 mm.	Small crystals; fat not distorted
2. Coll. fulvum .	Fat colourless, very small quantity		Crystals form outside, small; isospores ·009–·010 mm.	Small crystals; fat distorted
3. Coll. pelagicum .	Fat yellow, in large drops	Yellow cells remain in swarm stage	Crystals outside, small	?
4. Coll. hertwigii .	?			Fat distorted; lumps smaller than in Coll. fulvum
5. Coll. brandtii . (nov. sp.)	Fat colourless, in small drops	Yellow cells retained	Crystals small and on outer side of nucleus	Fat breaks up into small drops; very small crystals.

Note.—It is necessary to comprehend the term "Assimilation Plasma" as used by Brandt. By this is meant a peculiar form of plasma which is in some species contained in the pseudopodia bed round the zooids, and occasionally in the pseudopodia, and which by its behaviour to reagents appears to be chemically different from ordinary plasma. It is chiefly distinguished by its reaction to osmic acid, with which it stains brown or black, while the remaining plasma remains unaffected. It probably has some metabolic function, and appears to be entirely absent in some species.

SPHÆROZOUM (OVODIMARE (?) *Haeckel*). Plate I., Fig. 5.

On one occasion only during two years' work have I captured in the tow-net a Sphærozoum. This was at a position almost due west of Papa Stour, in Shetland, and first on the 100-fathom line.

The colony possessed a clear white and firm calymma, with thin strands of finely granular protoplasm. Individuals were of comparatively large size, the largest averaging ·12 mm. diameter, circular, greenish yellow in colour, containing numerous small cells, and in the centre one large oil drop. The individuals were surrounded by a fine membrane, and there were numerous xanthellæ from 12–20 round each individual. It bore a striking resemblance to Collozoum except for the presence in the calymma of numerous needles lying between, but not upon, the individuals. They consisted invariably of a straight central rod, and generally of three processes or shanks, arising at an oblique angle from each end of the rod. Some rods possessed four shanks at one end, but the general rule was three. They varied much in size, the largest needles being: rods, ·002 mm. long; shanks, ·003 mm. long. The latter were invariably longer than the rods. Many were quite plain, but others had short, minute processes or thorns on their edges, never, however, so marked as those figured in Haeckel's monograph as characteristic of *Sph. punctatum*. In this species also, according to Haeckel, the rod is longer than the shanks.

The presence of scattered needles in the calymma suffices to diagnose this Radiolarian as a Sphærozoum. Four species are described by Haeckel as Atlantic or common forms: (1) *Sp. hexactinium* (captured in the Faröe Channel), having six or seven curved shanks; (2) *Sp. ovodimare* (Mediterranean and Atlantic); (3) *Sp. punctatum* (cosmopolitan in warmer seas); (4) *Sp. quadrigeminum* (North Atlantic), four shanks at each end of the rod.

All colonies with tangential "punctatum" needles are placed by Brandt under the designation of *Sp. punctatum*, but he remarks that there may be many kinds. While this particular Sphærozoum is obviously not the one described as *Sp. hexactinium* from the Faröe Channel by Haeckel, it agrees in the fact that the shanks are longer than the needles, and more or less in the size of the central capsule with his *Sp. ovodimare*, and may be provisionally placed with that.

COLLOSPHÆRIDA.

CHŒNICOSPHÆRA MURRAYANA.

This is the commonest form of colony-building Radiolarian occurring on the coasts of Shetland, and I have found it in most tow-net captures from September to March. It was originally briefly described by

Haeckel as found in the Faröe Channel and named by him after Sir John Murray.

The colony is a hollow sphere of rather tough jelly of from 3·6 to 4 mm. diameter, and the zooids are dotted over it in little white spots, making it quite easy to identify with the naked eye. The cell nests average ·18 mm. diameter. The central capsule, of pale yellow-green colour, occupies the greater part of every shell, and averages ·11 mm. diameter. In the centre is one oil globule of ·05 mm. diameter. Between the central capsule and shell is a thick layer of granulated protoplasm, and outside the shell is another similar layer, from which issue pseudopodia in all directions. Each shell individual appears to lie often in an alveole with a distinct finely granulated boundary. The shells have an average diameter of ·18 mm.

In the thick "pseudopodia mother-bed" lie the xanthellae, which also occupy the pores of the shells. They are very numerous. Strands of granular protoplasm radiate from the circumferential layer, throughout the jelly mass. For the most part they are not thick, and extra-capsular bodies are few and small.

The shells have a general resemblance to the figure in Haeckel's *Challenger Report*, and many of them answer to his description:—

"*Chœnicosphœra n. gen.*—Collosphærida with simple shells, armed on the outside with radial spines, forming elegant coronals around the larger pores.

"Sub-genus 1. *Chœnicosphœrula.*—A coronal of spines around every pore of the shell" (*Challenger Report*, vol. xviii. p. 102).

The examination of a large number of specimens shows that the number of spines forming the corona is very variable, frequently six or seven, but often less. In the same shell in which some of the pores may have the typical corona others are found with few spines or none at all.

The pores are of unequal size, some large, others small, distributed irregularly, but ten to twelve in the half-meridian.

The coronal spines are very short and there are no spines between the pores.

It is probable that there is more than one variety of *Ch. murrayana*. All the kinds captured by me in the Faröe Channel and Shetland waters can only be referred to the sub-genus "Chœnicosphœrula" (Haeckel), though it may be remarked that the classification founded on the character of the shell only and the coronals of the pores is necessarily a very artificial one.

The form and disposition of the zooids in the calymma appear to vary with the age of the colony. In some instances individuals are met with having an oval shape side by side with spherical individuals.

On other occasions what are probably very young individuals appear to be without shell, and bear much resemblance to a Collozoum. The number of the coronal spines round the pores of the shell varies considerably, and it is probable that the *Trypanosphæra brachysiphon n sp.* briefly described by Cleve is really a Chœnicosphæra.

Of the other Collosphærida I have found only shells of *Acrosphæra spinosa*, never a colony. These have been brought up in the tow net vertical hauls, on the west coast of Shetland, on three occasions. Its appearance in this locality can be little more than accidental. The shell is a perfect sphere with many short conical spines, rather broad at the base, and tapering to a point and slightly curved. All the spines are similar. They arise at the base from an upward process of shell at the side of the pore, causing the base to appear as if perforated. The pores are irregular in size, large and small being irregularly distributed. The bars between the pores are three or four times the diameter of the smaller of the latter.

Diameter of the sphere, ·21; length of spines, ·002 mm.; width of largest pore, about ·0012; widest bars, ·001 mm.

The shell has much resemblance to *Ac. echinoides* (Haeckel), but does not fully resemble either that or *Ac. spinosa.*

THALASSICOLLIDA.

1. Thalassicolla nucleata.

This is taken with great frequency in the surface tow net in the coastal waters of Shetland and in the Faröe Channel, and I have found it in quantities in the mid-water net at a depth of 40 to 50 fathoms.

The organisms are, to the naked eye, little spherical balls of clear jelly with a darkly pigmented centre, often densely black, less often cinnamon-brown or yellow. The colour of the pigment is variable.

The thick jelly calymma is characterised, as Hertwig remarked, by (1) the richness in black pigment, (2) the numerous vacuoles. The latter are small near the central capsule, larger towards the periphery. The pigment is contained in a thick layer of the extracapsular sarcode surrounding the central capsule, and is a dense layer of very small round, black, or brown cells. From this layer it radiates in small quantity through the protoplasmic strands which pass in all directions between the vacuoles. Slight pressure of the cover glass is sufficient to shell out the central capsule from the surrounding pigment layer. It is surrounded by a firm membrane,* which on its inner side is

* The dissection of this membrane from the central capsule is very easily accomplished without previous treatment of the specimen.

lined with a continuous layer of polygonal areas, and perforated by numerous pores. In the centre of the capsule is a rounded nucleus, which, as Hertwig remarks, is easily shelled out of the capsule by pressure, owing to its thick wall.

The contents of the central capsule are rounded bodies of various constitution, some containing oil drops, some granular protoplasm, others pale and clear, and oil drops of varying size, some few of which are large and of cinnamon colour. Numerous vacuoles occur, large and small.

The nucleus has an investing membrane sufficiently dense to allow of its being readily shelled out of the central capsule on pressure. It is closely packed with small round cell-like bodies, amongst which are some large oval, or ellipsoidal, nucleated bodies. The colour of the nucleus is yellow. Diameter of the calymma, 3–4 mm.; of the central capsule, 1·1 mm.; of the nucleus, ·05 mm.

2. THALASSICOLLA PELAGICA (Haeckel, *Die Radiolarien*, 1862).

This species is distinguished by the small size of the central capsule in comparison with the calymma, the pellucid appearance of the latter, the small amount of pigment, and pale white or yellowish white colour of the central capsule. The jelly of the calymma is much less firm and consistent than that of *Th. nucleata*, and the pigment is much less distributed in strands through the calymma than in the latter, and is nearly entirely grouped round the central capsule. The membrane surrounding the central capsule is thin, and though marked with very close dots (pores), does not possess the polygonal cell area markings of *Th. nucleata*.

The contents of the central capsule are small, round bodies, packed densely between which are many small oil globules, but the latter are grouped into larger drops chiefly round the outer rim of the central capsule and within the central capsular membrane. Between the intracapsular bodies are many small vacuoles, often containing small oil drops.

The nucleus has a fine and porous investing membrane, and is papillated with irregular-shaped protuberances about as long as the radius, and there are a few long, tube-like or vermiform bodies. The rest of the contents of the nucleus appears to be made up of small rounded bodies, between which are spaces resembling vacuoles. Diameter of the calymma, about 3–4 mm.; of the central capsule, 0·4–0·6 mm.; of the nucleus, ·02 mm.

The third kind of Thalassicolla possesses a remarkable central capsule, and it has been suggested to me that it should be referred to a new genus, for which the term Thalassiosolen is proposed.

3. THALASSIOSOLEN ATLANTICUS (*nov. genus et nov. sp.*).

In general appearance the animal resembles *Th. nucleata*, in the possession of a vacuolated calymma and a central capsule surrounded by black or dark brown pigment. This latter is very thick, and extends between the extracapsular vacuoles in thick strands. The calymma and vacuoles are otherwise like *Th. nucleata*. The central capsule shells out quite easily, and its investing membrane (which is readily dissected off with needles) is much thinner than that of *Th. nucleata*, but, like the latter, is perforated by multitudinous fine pores, apparently more numerous than in *Th. nucleata*, but showing on its inner surface the same polygonal area markings as *Th. nucleata*.

A narrow space is observed all round the capsular contents and just within the capsular membrane, in which I have been unable to trace anything but oil globules. The whole of the centre of the capsule is occupied by layers of radially disposed, rounded tubes, closely packed in two (or three ?) layers converging towards the centre, where their ends lie over and around the nucleus, without, however, any intimate connection with the latter, and towards the periphery branching into two, or sometimes three, club-shaped, closed ends. Throughout the rest of their course they are usually quite straight, and are rarely branched at their proximal ends. These tubes are yellowish in colour, and appear to contain granules and irregularly shaped bodies, which stain deeply with osmic acid. As they dissolve completely in mineral acids they are not of siliceous nature. They leave behind nothing but oil drops. With prolonged treatment by caustic potash the contour of the tubes is not altered. Stained with picrocarmine, the tubes are seen to be filled with granules deeply stained and with clear spaces between them. Treated with ether, and subsequently stained with picrocarmine, the tube contents are unaltered, except that the granules stain deeper than the rest. Osmic acid stains them dark brown or black. They are not fat, and bear a remarkable resemblance to the "assimilation plasma" of the Collozoums. It is difficult to rupture the tubes, and they always break transversely. The granules are arranged down the sides of the tubes, apparently firmly adherent to the walls, and the lumen of the tubes contains a clear space (? filled with fluid *intra vitam*).

There do not appear to be any vacuoles in the central capsule, as in other Thalassicollidæ, but oil drops of irregular though often considerable size occur between the tubes.

The nucleus is round, and the investing membrane rather dense, and it does not rupture easily. It is packed with small round bodies, with a few of larger size, but contains no vacuoles. A few

large cinnamon-coloured oil drops are irregularly distributed in its contents.

Diameter of calymma, 2·6 mm.; of central capsule, 1·4 mm.; of the nucleus, ·18 mm.

CŒLODENDRIDA.

CŒLODENDRUM RAMOSISSIMUM is not unfrequently found in Shetland waters, and I have captured it on the east as well as on the north and west sides.

The skeletal tubes branch dichotomously, each sub-branch doing the same, and becoming progressively smaller and thinner towards the periphery. These tubes are hollow, and the branches are given off nearly at right angles. The smallest and terminal twigs are each surmounted by eight small recurved teeth and end in a knob. The main branches arising from the galea are closed. At each pole three branches arise from the galea, two being together and one a single one. The central capsule is enclosed in a two-valved shell, with numerous large pores of irregular size, a peculiar hard ridge on the surface, and a curved process at the side. The shell is perforated at the base and sides by small, round, irregular pores.

The phæodium is large. Diameter of the entire animal, ·8 mm.; length of principal branches, ·07 mm.; diameter of shell valves, ·06 mm.

AULOCANTHIDA.

AULACANTHA SCOLYMANTHA (*Haeckel*). Plate I., Fig. 3.

This is a common Radiolarian round all the coasts of Shetland, where I have taken it in greater abundance than in the open waters of the Faröe Channel. As the spines are almost invariably toothed, whereas in Haeckel's *A. lævissima* (the only known habitat of which is the Faröe Channel) the spines are smooth, my species cannot be referred to the latter. At the same time it must be remarked that they do not quite agree with *A. scolymantha* as received (in the preserved condition *) from Naples, nor quite with Haeckel's pictures (Monograph, 1862), the differences being in the almost invariably excentric position of the central capsule, the smaller quantity of phæodium, and the character of the radial tubes. These taper at each end, and are thickest in the middle. The proxinal end tapers to a rounded extremity, and the distal to a blunt point. Many tubes are slightly

* In my experience no method of preservation retains the form of the animal in such a normal condition as the well-known 5 per cent. formalin. Specimens may be observed in detail on shore when opportunities fail—as they usually do—at sea, within a few weeks with practical certainty that the organisms have retained their normal condition. Spirit or other preservative certainly distorts to a considerable extent.

curved distally. They bear from 5–15 minute teeth subalternately placed along the edges of the spines, but only in their distal fifth.

The measurements (from average-sized specimens) are: Diameter of the calymma, ·73 mm.; of the central capsule, ·16 mm.; length of the radial tubes, ·75 mm.; greatest thickness, ·01 mm. The radial tubes number from 28–30, never more; the tangential network which surrounds the jelly consists of fine needles, which form a mesh without branching. Like the radial tubes, they are not dissolved by mineral acids. The central capsule is covered with a tough investing membrane, has an operculum (striated), and a nucleus occupying its centre and about half its size. The phæodium is copious.

AULOGRAPHIS FURCELLATA, *n. sp.* Plate I., Fig. 1.

This species was captured at 250 fathoms. The animal, in shape more or less spherical, had a diameter of 1·5 mm. The calymma contains a tangential needle system, the needles being thicker than those of Aulacantha, but while crossing and recrossing one another, nowhere branched or anastomosing. The central capsule lies in an extensive phæodella, of which many of the green cells are of very large size. Radiating through the calymma are about 40 tubes, many of which are slightly curved distally. They are broad towards the proximal end, and taper as a rule but slightly towards the distal end; all appear as if grooved in the outer portion, and while some are very broad, others are of much slighter build. At the extremity of each radial tube are two very short simple branches, bearing neither teeth nor spathillæ. Each is curved and more or less crescent-shaped.

Length of tubes, ·3 mm.; breadth, ·09 mm. (in middle).

I am unable to refer this to any of Haeckel's Aulographantha, though it bears all the characters of the genus Aulographis. It certainly does not correspond to either of the three forms, *A. pistillum, penicillata, pandora,* the habitat of which is the North Atlantic.

AULOGRAPHIS TETRANCISTA (*Haeckel*), *variety.*
Plate I., Figs. 2 and 2a.

In this animal there is a tangential needle system in the calymma of rather thick single rods, resembling the last-mentioned species. The diameter of the whole animal is about 2·3 mm., and there is an extensive phæodella. The tubes are frequently slightly curved, a few considerably bent at the distal end. Thick and broad in the middle, they taper towards each end, but more at the proximal extremity, where they terminate in a rounded end. Towards the distal extremity they appear grooved. Each radial tube carries a

verticil of four (rarely five) thin and rather long divergent branches, slightly curved. Each terminal branch ends in a cushion carrying four or sometimes five very small teeth.

Length of the tubes, ·88 mm.; breadth in the middle, ·08 mm. The length of the terminal branches varies; some are thick and stout, others longer and thinner, five to ten times as long as broad.

This Radiolarian bears considerable resemblance to Haeckel's *Aul. tetrancista* and *hexancista*, both of which are Pacific deep-water forms.

My specimen was taken at 400 fathoms in the Faröe Channel, and is probably to be regarded as a North Atlantic variety of *Aulographis tetrancista*, from which it differs slightly.

AULODENDRON BOREALE, *n. sp.* Plate I., Figs. 4, 4a, 4b.

A Phæodarian was captured at 400 fathoms, which, though very much broken and injured, showed some characters distinct enough to enable it to be placed in Haeckel's genus Aulodendron ("Aulocanthida with a veil of tangential needles, and inter-radial tubes which bear numerous irregularly scattered lateral and terminal branches."—*Chall. Rep.*, p. 1588).

The calymma measured 2·5 mm. across; was covered with a veil of stiff, straight, tangential needles unbranched and not anastomosing, but of considerable thickness, the needles measuring in width ·01 mm.

The radial tubes, which were irregularly scattered, were very numerous, straight, of fairly equal thickness throughout their length, tapering only slightly or not at all at the proximal end (Fig. 4a), but at the distal end having a constriction below the verticil, which formed a rounded knob bearing in some four, in a few others six slightly curved branches, widely divergent, about ·055–·060 mm. long, and thin (Fig. 4).

In the outer half of the radial tubes branches were given off at irregular intervals, generally alternate, but often two on one side close together. These branches are short and carry a forked or slightly denticulate knob at the extremity (Fig. 4b), and of about the same length as the branches of the verticil. Generally there were twelve lateral branches, all of about the same length. Often they are again branched, the terminal twigs being very small. The length of the radial tubes was very variable, averaging about ·12 mm., and the width was similarly variable, some not being more than half the width of others, but averaging ·02 mm. The proximal ends of the tubes lie centrally over the phæodella, which is very copious.

The animal, while being undoubtedly an Aulodendron, is difficult

to place specifically owing to its mutilated condition, but it does not appear to agree with any of the five species described by Haeckel (p. 1589, *Chall. Rep.*), none of which are North Atlantic forms. It is therefore interesting to note the occurrence of the species in the North Atlantic. The characteristics of the radial tubes are quite peculiar.

CHALLENGERIDA (*J. Murray*, 1876).

These singular organisms are not uncommon* round the Shetland waters and in the cold area of the Faröe Channel, and I have taken them both in surface and deep tow-nettings. One species, captured by me off the north coast of Shetland in a surface tow-netting, appears to be new.

CHALLENGERON WALWINI, *n. sp.* Plate II., Figs. 1, 1a.

The shell, which is longer than broad, presents the usual "diatomaceous" structure. Its margin has twenty-five spines, of which that at the aboral pole is the largest; on each side of this spine is a very short spine. The other spines round the lower edge are long, though not so long as the apical spine, and progressively and regularly diminish in size towards the peristome. The latter presents two lateral slightly curved and divergent teeth and a dorsal bifid tooth. All are beset with short and sharp spines. There is no pharynx.

Dimensions.—Length of the shell, ·18 mm.; of the body, ·11 mm.; of the peristome, ·07 mm.; of the lateral teeth of the peristome, ·03 mm.; of the principal aboral spine, ·03 mm.; breadth of the shell, ·09 mm.

This animal would appear to belong to Haeckel's subgenus "Challengerosium" ("margin of the shell dentated or serrated with a continuous series of numerous short radial spines"), all of which, with the exception of one (as to which the depth is not stated), *C. johannis* (taken in the Faröe Channel, Gulf Stream), are deep-water species, and tropical or Pacific.

It was captured at Station V., February 9th, 1900, at the surface.

It is closely related to *C. willemœsii* (Haeckel), but differs in having a smaller number of marginal spines (in *C. willemœsii* these are fifty to sixty), and the spinulation of the peristome also differentiates it from this.

* In some hauls, *e.g.* Station A1, in August, 1900, they were captured in great quantity in the Mesoplankton, chiefly at 350 fathoms.

CHALLENGERON BALFOURI (*? var.*), *J. Murray.*
Plate II., Figs. 2 and 2a.

Shell rather broader than long towards the base, compressed laterally, of the usual diatomaceous structure. At the aboral margin are two short conical teeth—one on the ventral, the other on the dorsal aspect. The peristome is deeply cleft ventrally, and strongly keel-shaped dorsally. It is bifid at the apex, with one tooth rather shorter than the other. The peristome is marked with transverse ridges (not the diatomaceous shell structure), especially in the cleft of the ventral side and along the external surface of the peristome and edge of the teeth. The mouth is wide, and has no pharynx.

Length of the shell, ·2 mm.; breadth, ·212 mm.; length of the peristome, ·093 mm.; length of the aboral spines, ·03 mm.; width of the mouth, ·05 mm.

CHALLENGERON BALFOURI, *variety.* Plate II., Figs. 3 and 3a.

This species resembles the preceding, except in the characters of the peristome, which is stouter and posteriorly produced into a rather prominent elbow, above which the peristome ends in two pointed divergent teeth. The peristome is strongly marked with ridge markings, but not on the elbow, and on the ventral aspect in the groove. It is essentially the same, except in the characters of the peristome, as the last species. It was taken at 350 fathoms along with the last species.

Neither of these two species exactly corresponds with Haeckel's description of *C. balfouri* (*Challenger Report*, "Radiolaria," p. 1655), which was a surface species. Both the examples described are probably deep-water varieties of *C. balfouri.*

CHALLENGERIA TRITONIS (*Haeckel*). Plate II., Fig. 4.

The shell is longer than broad, ovate seen from the dorso-ventral aspect, marked apparently diatomaceously; but this is not of the usual aspect, but consists of simple rounded pits, many of large size, and the usual hexagonal framework between the pits is absent in this case.

The mouth is comparatively small, and forms a rounded opening, situated rather on the ventral aspect of the shell. There is a long peristome tapering to a blunt point, directed vertically, and having fine markings on the dorsal and ventral sides, unbranched and possessing no teeth.

Length of the body of the shell, ·2 mm.; of the peristome, ·1 mm.; width of the body of the shell, ·17 mm.; width of the mouth, ·04 mm.

CHALLENGERIA ZETLANDICA (*n. sp.*), Plate II., Fig. 5.

Shell subspherical and strongly compressed (oval seen sideways) with the usual diatomaceous markings. The peristome is long, and at the base nearly as long as the shell, and ovate, and terminates in one bifid tooth. The whole peristome is strongly directed towards the ventral side. The shell is much longer than Haeckel's *Ch. sloggettii*, and the aboral line is rounded, not straight, as in *Ch. sloggettii*. It differs from both *Ch. sloggettii* and *harstoni* in the possession of a single bifid tooth, instead of two parallel teeth.

The shell is also much smaller than any of the Challengerida with which I am acquainted, being only ·053 mm. long and the peristome ·03 mm. long. The width of the shell (dorsally) is ·03 mm.

II. COPEPODA.*

The Copepoda of the Faröe Channel have been briefly reported on by I. C. Thompson for Fowler (Research Expn. P.Z.S., 1897). In the same paper a list is given of these, with the areas of their vertical distribution. For the present I withhold any comment on these results, my own work in the Faröe Channel not yet being completed, and will only remark that my own captures with Garstang's closing net in the deeper waters of the Faröe Channel have produced results agreeing in the main with those of Fowler. With work which has accumulated during three years it will be readily understood that it must take a considerable time before a complete survey can be given. I append a first list of Copepoda taken during these expeditions:—

IN THE SHETLAND WATERS.	IN THE FARÖE CHANNEL.
Calanus finmarchicus.	*Calanus finmarchicus.*
Calanus parvus.	*Calanus parvus.*
Calanus hyperboreus.	*Calanus hyperboreus.*
Pseudocalanus elongatus.	*Pseudocalanus elongatus.*
Rhincalanus nasutus.	*Rhincalanus nasutus.*
	,, *cornutus.*
Eucalanus elongatus.	*Eucalanus elongatus.*
	E. attenuatus.
	E. crassus.
Euchæta norvegica.	*Euchæta norvegica.*
	E. barbata.
	E. marina.
	Euchirella carinata (*nov. sp.*).
	E. rostrata (?).

* The Copepoda of the Faröe Channel will form the subject of a subsequent monograph.

IN THE SHETLAND WATERS.	IN THE FARÖE CHANNEL.
Oithona spinifrons.	*Oithona spinifrons.*
Acartia clausii.	*Acartia clausii.*
,, *discaudata.*	
Oncœa mediterranea.	*Oncœa mediterranea.*
,, *subtilis.*	,, *subtilis.*
Metridia lucens.	*Metridia lucens.*
,, *longa.*	,, *longa.*
Temora longicornis.	*Temora longicornis.*
Anomalocera pattersoni.	*Anomalocera pattersoni.*
Centropages typicus.	*Centropages typicus.*
Candace pectinata.	*Candace pectinata.*
Pleuromma abdominale.	*Pleuromma abdominale.*
	,, *robustum.*
	,, *abyssale.*
	Heterochœta clausii.
	,, *spinifrons.* [*longicornis*)
	,, *zetesios* (*nov. sp.*), (*non-*
	Tetragoniceps —— (*nov. sp.*).
	Scolecithrix —— (*nov. sp.*).
	Ægisthus atlanticus (*nov. sp.*).
	Leuckartia flavicornis.
	Augaptilus zetesios (*nov. sp.*).
Ætidius armatus.	*Ætidius armatus.*
Ectinosoma atlanticum.	*Ectinosoma atlanticum.*
Thaumaleus longispinosus.	*Gaidius boreale* (*nov. sp.*).
Pseudocyclopia giesbrechtii (*nov. sp.*).	
Cyclopina gracilis.	
Sapphirina (*nov. sp.*).	

I have intentionally not included in this list the Harpacticidæ. It will be noted that several of these Copepods are new species, and I may add that they will form the subject of description subsequently, when the drawings are completed.

There are several additions to the list given in Fowler's paper (*loc. cit.*), notably *Pleuromma robustum, Heterochœta clausii, H. zetesios, Augaptilus, Oncœa, Eucalanus elongatus* and *crassus, Tetragoniceps, Scolecithrix, Rhincalanus nasutus,* and *Ægisthus.*

The limits of distribution of the following "warm-water species" are extended by these observations:—

Euchirella; Eucalanus attenuatus, E. crassus; Euchœta barbata; Heterochœta clausii, H. spinifrons; Leuckartia flavicornis; Scolecithrix; Oncœa mediterranea* and *subtilis; Pleuromma abdominale; Rhincalanus*

* *Eucalanus crassus, Pleuromma robusta, Ægisthus, Augaptilus* I found in Fowler's collection, the two first also occurring in my own tow-nettings.

cornutus and *nasutus; Thaumaleus; Ætidius armatus; Augaptilus; Ægisthus; Gaidius.*

Perhaps the most remarkable in this list is *Ægisthus*, of which only four examples are recorded by Giesbrecht, the limits of the species being 3° S. and 3° N., 99° W.

The common *Eucalanus* of the Faröe Channel is *E. elongatus*. *E. attenuatus* is very uncommon. *Eucalanus elongatus* is frequently found round the Shetland coast, and on one occasion I took a quantity in Scalloway Deeps.

Rhincalanus nasutus, common in the Faröe Channel, is also often captured off the Shetland coasts. *Pleuromma abdominale* I have only once captured off the north coast of Shetland, and *Pleuromma robustum* is quite as common in the Faröe Channel as *P. abdominale*.

Oncæa is common in deep water and up to surface hauls in this region. *Euchæta norvegica* I have never taken at the surface, though not unfrequently at forty to fifty fathoms' depth, but this being in an open "mid-water net," it may very well have been caught on the way up.

Scolecithrix is not uncommon in the Faröe Channel, but I am unable to refer my specimens to any described species. Curiously I have never succeeded in finding (though I have sought diligently) the *Metridia normani* which Giesbrecht records from the Faröe Channel. In few tow-nettings is *M. lucens* (and in deep water *M. longa*) absent, and of very common occurrence is a ♂ *Metridia* with the clasping antenna on the left side, but this species is certainly not *M. normani*. It very greatly resembles *M. lucens*, except for the peculiar position of its clasping antenna (left side).

Leuckartia flavicornis and *Thaumaleus* have each been captured only once. The occurrence of such forms as *Ægisthus*, *Augaptilus*, and *Gaidius* in these northern waters is very singular. *Calanus hyperboreus*, which occurs occasionally around the Shetland coast and frequently in the Faröe Channel, is described by Giesbrecht as a distinct species. Thompson, in his report on Fowler's Copepods (*loc. cit.*), is inclined to regard it as merely a larger variety of *C. finmarch.*; but I see no reason to doubt the correctness of Giesbrecht's view, that it has specific differences from the latter.

Augaptilus, *Euchirella*, *Gaidius*, and *Heterochæta* appear to be deep-water Copepods, and not to approach the coasts. *Anomalocera* is apparently one of the very few Copepods (not Harpacticidæ) which never descend into deep water, probably never below fifty fathoms.

ÆGISTHUS ATLANTICUS, *nov. sp.* (One specimen only, which I found in Dr. Fowler's Research Collection.)

Size 1·45 mm. Tail setæ 5½ times the length of the whole body, and coalescent throughout their course until just at the end. One is a little shorter than the other, and each ends in a peculiar spine, which articulates with the seta, and probably serves to fix the animal in the mud. This animal, unlike any other Copepod, possesses a sixth pair of feet, each a simple process with two hairs. The fifth feet are characteristic, long, and consist of only one segment. The inner terminal fan differs from Giesbrecht's species *mucronatus* and *aculeatus*, arising more proximately than in either of these, and not reaching the end of the terminal fan. The other feet have three-jointed outer and inner branches, and the second basipodite is joined to the first in quite characteristic manner (see Giesbrecht's figures, Fauna und Flora Neapel, Pl. 49).

The anterior antennæ consist of six joints; on the upper margin of the second joint is a strong spine proximally bent, and a long peculiar process (sensory ?) on the third joint, and a similar one on the end joint. The maxilla and post. foot jaw agree closely with *Æg. mucronatus* (Giesbrecht). Of the mandibles only the biting end remains.

The body of the animal is more or less torpedo-shaped, and the head narrows in front, and is produced into a long stout spine, curved downwards and forwards. The animal bears some resemblance to *Æg. mucronatus*, but is little more than half the size, differs in the length and terminations of the tail setæ, the presence of a long sensory process on the last joint of the anterior antenna, the possession of a three-jointed internal and external branch of the second feet (two-jointed in *mucronatus*), the disposition of the fan bristles of the fifth feet, the length of the bristles on the sixth feet (longer than *mucronatus*), the absence of teeth on the posterior edges of Th. 2, 3, and 4.

ÆTIDIUS ARMATUS.

The examples captured by me in the Faröe Channel and round the Shetlands fall into two groups, and further study will probably warrant the differentiation of more than one species.

A large number of apparently adult specimens attain a size only of 1·65–1·7 mm., and in these the rostrum is large and strongly chitinised, the anterior antennæ reach quite to, or a little beyond, the end of the furca, and the tenth, eleventh, and twelfth segments are proportionately a little larger than in the second species, and more

or less coalesced. The pointed angles of the last thoracic segment are also dorsally more prominent and the spurs are shorter than in the other group (in which they reach beyond the end of Ab. 2).

In the second group the animals are much larger, 2·0–2·3 mm. long, the rostrum is smaller, the angular point of the last thoracic segment longer, and the antennæ are shorter, reaching only to the end of the first abdominal segment, and the joints 10, 11, 12 are more clearly segmented.

The specimens examined agree more closely with Giesbrecht's description than Brady's (*Challenger Report*), whose drawings and descriptions contain many inaccuracies. Brady gives the size of *Ætidius armatus* at 2·1 mm., Giesbrecht 1·55–1·9 mm., and the latter speaks of the variability in length of the points of Th. 5. These differences may be accounted for by the occurrence of two closely allied species, further discussion of which I defer for another occasion.

Gaidius boreale, *nov. sp.*

Half a dozen specimens captured at 300 fathoms at station A 2 exhibited the following characters as described by Giesbrecht (*Bull. Mus. Comp. Zool. Harvard*, 1895): Short, one-pointed rostrum; the last thoracic segment produced into a long and sharp point. The inner branch of the posterior antenna : outer half :: 5 : 8. The bristles of the inner branch are 8+6. The head rounded, and without crest. Abdomen of four segments, the genital segment strongly swollen, but quite symmetrical. Of the swimming feet, the first has a two-jointed exopodite and one-jointed endopodite; the second, third, and fourth have three-jointed exopodites, but while the third and fourth feet have three-jointed endopodites, the second foot has an endopodite with only one joint like the first foot. There is an indistinct trace of segmentation into two joints.

The maxilla and mandible resembles Gaetanus. In the posterior foot jaw the second basal, which is longer than the first, is about three times as long as the five-jointed endopodite. The fourth feet have the stiff, broad bristles on the inner margin of the second basal, which slightly resembles the lamellæ of the same foot of *Euchirella rostrata*, and of which Giesbrecht remarks, "Die Fiedern am proximalen Theile des Innenrandes des 1 Basalgliedes sind am 4 Fusse breiter, und, wie es scheint, steifer als an den vorhergehenden Füssen, worin man einen Uebergang zu den Lamellen und Stacheln finden wird, welche sich bei *Euchirella* an der gleichen Stelle finden" (*loc. cit.*).

The size of my animals is 3·55 mm. (♀), while that of Giesbrecht's is 3·2 mm. The limits of distribution of Giesbrecht's species were

35° N. to 125° W. My species differs a little from Giesbrecht's, and may be, from the locality of its occurrence, designated *boreale*. Only a brief description of *Gaidius pungens* is available (*loc. cit.*), the only described species.*

EUCHIRELLA CARINATA ♂ *nov. sp.*

A male taken at A2, 300 fathoms, measured 3·71 mm. long, the fore-body six times as long as the abdomen. The last thoracic segments are rounded. The head is produced into a curious rostrum rather like *E. galatea* ♀, and dorsally there is a strong crest. There is red pigment about the mouth organs and the mandible chewing end is strongly coloured deep orange-red, the foot jaws having their bristles similarly but slightly coloured. The anterior antennæ reach just to the hind end of the thorax and consist of twenty-three joints. The feet have three-jointed exopodites except the second, in which they consist of only two joints, the endopodites of the first feet have one, those of the second feet two, and of the third and fourth feet three segments. There is a pair of rudimentary fifth feet, consisting each of an exopodite and endopodite. The right foot is a little the largest, its external branch of only one segment, in which are indistinct traces of three joints; the terminal joint ending in a blunt rounded process. The internal branch is of one stumpy rounded segment only. The left foot has a one-segmented outer branch, with blunt rounded end, and a short (not half the size of the opposite foot) rounded segment, like a small stump. Neither foot has any trace of spines or hairs.

The anal segment is very short and tucked into the fourth abdominal segment as in other Euchirellas.

The external branch of the posterior antenna is over three times as long as the inner branch, which carries 6 + 5 bristles at the end.

There are no spines or bristles on the first basal of the fourth foot.

The twentieth and twenty-first joints of the anterior antennæ are not coalesced, but the antennæ strongly resemble those of Euchirella. 8 and 9 and 24 and 25 are joined.

This Copepod agrees with Euchirella in the possession of twenty-three jointed anterior antennæ, the shape and number of segments of the abdomen, the segments of the branches of the feet, and the posterior antennæ. The maxillæ and foot jaws are well developed, the former very similar to the maxilla of the ♀ *E. messinensis*, the second basal joint of the posterior foot jaw is not quite twice as long as the well-

* The nearest related genus is Gaetanus (Giesbrecht), but this Copepod is removed from it by the absence of any median spine on the head. The indistinct traces of segmentation of the first and second feet cause it to approach the genus Gaetanus, while the lamellæ of the fourth feet (basal joint) again differentiate it. On the whole, it approaches more nearly to Gaidius than Gaetanus.

developed five-jointed endopodite; in the anterior foot jaw the lobes are large, compressed, and the endopodite articulates behind, as in Ætidius. The hooked bristle on the fourth lobe is very strong and longer than that in the fifth lobe. This organ greatly resembles *E. rostrata*. The animal resembles no known ♂ Euchirella (*E. amœna*, *E. messinensis*, *E. pulchra*), but though comparatively large, it may be an undeveloped ♂. It will be figured and described subsequently.

EUCHIRELLA ? ROSTRATA *(? var.)* ♀.

Size 3·8 mm. There is no crest, but a one-pointed rostrum. The abdomen and genital segment are quite symmetrical. The anterior antennæ have twenty-three joints. The internal branch of the posterior antennæ is as 5 : 8, and the end of the endopodite carries 6 + 5 bristles. The fourth feet have peculiar spines on the inner margin of the first basal joint, four in number, one of which is large (the proximal), the others progressively smaller and further proximally from the stout inner hair than in *E. rostrata*, which it most resembles. The maxilla is very similar to *E. rostrata*, and the mandible is similarly like, except that the inner tooth of the chewing end is much longer and sharper. The absence of a crest and the symmetrical genital segment and spines of the basal joint of the fourth feet differentiate it from *E. pulchra* ♀.

The larger size and number of bristles on the endopodite of the posterior antennæ and smaller number of spines (or triangular lamellæ) on the fourth basal differentiate it from *E. rostrata*, of which, however, it may be a variety. It will be described and figured subsequently.

Two perfect specimens were captured at 300 fathoms.

HETEROCHÆTA ZETESIOS, *n. sp.* ♂

Length 3·5 mm. This Copepod, found in Fowler's Research Collection, was in very good state of preservation, except that the end segments of the anterior antennæ and tail setæ were damaged. The portion of the anterior antennæ left (nineteen joints) reached a length of 4 mm., so that it was much longer than the whole length of the animal. The geniculation occurs between the eighteenth and nineteenth joints. The basal joint of the posterior foot jaw has bristles, but no long spine, and the last two lobes of the anterior foot jaw carry plain hooks not beset with comb teeth. The fifth lobe is very much longer than any of the others, and its hooked bristle is stouter than that of lobe 4, and is quite without teeth or hairs, while that of lobe 4 is beset with fine short bristles. The mandibles, unlike *H. longicornis* (of which it might possibly be the ♂, but

the ♂ of this species is unknown), are not alike, the chewing end of one carrying two trifid, one single pointed, and one long, stout, pointed outer tooth (four in all), whereas the chewing end of the opposite mandible carries only two slenderer, long, pointed teeth. The exopodite of the mandible carries four extraordinarily long and densely feathered bristles, the endopodite is well developed. The last joint of the outer branch of the fourth feet is of similar form to that of the third foot. The fifth feet are unlike those of any known Heterochæta, the second basal of the right foot being produced into a long comb-like process with stiff, short bristles on the inner margin, the first segment of the exopodite is small, the second very large and very broad with the internal margin armed with two protuberances, one having a series of short teeth, the other and distal one armed with a few stiff bristles. The second basal of the left foot has a rounded and projecting distal inner margin armed with stiff bristles. The bristles of the posterior antenna are of great length and densely feathered.

In size, length of anterior antennæ, characters of the basal joint of the posterior foot jaw, and of the anterior foot jaw, and normal shape of the third segment of the exopodite of the fourth foot this Copepod resembles *H. longicornis* (Giesb.). The ♂ of this species is, however, unknown, and the example under notice may possibly be this, or a new species. Provisionally I name it *zetesios.*

Pleuromma robustum, *Dahl.*

Many examples of this Copepod have been captured in my Faröe tow-nettings, and I found several examples of it in Fowler's Research Collection. The ♀ averages 4 mm. length, the ♂ 3·5–3·7 mm. The pigment spot is always on the right side of the body, and the clasping antenna on the left. The teeth of the anterior antennæ are small, and both the second feet have excavations and teeth on the first segment of the internal branch. The abdomen is quite symmetrical. Dahl remarks of this species that though found in tropical areas of the ocean singly and in deep water, it has a wide distribution, and in northern regions comes nearer to the surface, having been once taken in the vertical net from 100 metres to the surface. I have taken it several times in the closing net at 100 and 150 fathoms.

Thaumaleus longispinosus ♂.

Only the ♂ of *Th. longispinosus* and *Th. thompsonii* are known, and the furca of the former has four bristles, while that of the latter species has only three. If the tail bristles are to be regarded as of constant diagnostic value, this specimen approaches more nearly to *Th. longi-*

spinosus in the possession of four furcal bristles. The whole length of my specimen is 1·19 mm., and the relative length of abdomen to cephalothorax is as 1 to 4, somewhat different from Giesbrecht's measurements, making the body in the Shetland specimen larger in proportion. *Thaumaleus longispinosus* was taken by Bourne at Plymouth in 1890, and *Th. claparedii* by Scott in 1889 in the Firth of Forth, and by Thompson in 1889 in Liverpool Bay; but so far as I am aware no Thaumaleus has been captured so far north as Shetland before.

AUGAPTILUS ZETESIOS, *n. sp.* Plate III.

Total length 4·71 mm., of moderate transparency. Head separate from thorax, with weak rostrum situated on a papilla. Abdomen three segments, the genital longer than both the others together. Furcal segment four times as long as broad. Anterior antennæ of twenty-five segments, and reaching considerably beyond the end of the furca. The outer branch of the posterior antennæ is a little the longest. The hairs of the outer branch are very long and feathered; those of the other branch shorter and naked. Mandibles have a long and thin chewing end with two large and one very small teeth. Maxillæ have all the outer and inner lobes except the first (of each) suppressed. The bristles are of very great length. The bristles of the second basal and endopodite of the anterior foot jaws carry two series of the peculiar "hutpiltzformigen Anhange" characteristic of Augaptilus (see Fig. 12). In the posterior foot jaws the bristles of the endopodite are similarly armed. The swimming feet have each three segmented inner and outer branches. The outer spine on the first segment of the exopodite of the first foot is very long and closely haired, and the distal segment carries two long tapering naked bristles. In the second and third pairs the long bristle on the second basal (which is present in the fourth feet) is absent. The third segments of the exopodites of the second, third, fourth, and fifth feet have a very convex outer margin, and the spines are very rudimentary. The bristles at the end (especially in the third and fourth feet) are stiff and curved inwards, with long hairs on the inner aspect, and short stiff hairs on the outer. The fifth feet have a rather longer (proportionally) endopodite, and the last joint of the exopodite is shorter than in the second to fourth pairs, while the distal segment of the inner branch is comparatively longer than in the other feet. The second segment of the outer branch carries a long, stout (at the base), and tapering spine nearly as long as the joint and armed on the inner side with stout teeth from the base to the distal end, and many short teeth on the surface and a few stout teeth on the outer proximal margin. This Copepod bears some resemblance to *Aug. longi-*

caudatus, Giesb., but is considerably larger. The genital segment is longer than both succeeding segments; the anal segment is half as long again as the middle segment of the abdomen. The bristles of the mandible and anterior foot jaws, and the proportions of the joints of the posterior foot jaws, also differ. The fifth foot differs in relative proportions, and the spine on the second joint of the exopodite is quite peculiar. It differs from *Aug. megalurus*, especially in the large spine of the fifth foot and the size of the middle segment of the abdomen.

Two specimens were found in Dr. Fowler's collection, one from a bottle marked 19 d.e. Epiplankton, and one from Mesoplankton 20 (stations referred to in his paper in the *Proc. Zool. Soc., loc. cit.*).

PSEUDOCYCLOPIA GIESBRECHTII, *nov. sp.* Plate IV.

Length of the whole animal, ·72 mm. (cephalothorax, ·575 mm.). Body robust, with a short pointed rostrum, and of four segments. Abdomen slender, of four segments, the first equal in length to the third and fourth. Furcal segment about as long as broad—of the four tail setæ, the two middle of each side are stout, not jointed, and cross-ringed in their whole length, and feathered throughout; the four shorter hairs are cross-ringed only to the joint. The *anterior antennæ* do not reach to the end of the cephalothorax, and contain seventeen joints, the first joint about equal in length to the succeeding thirteen joints. The *posterior antennæ* have only one branch (internal) composed of four joints. The *mandibles* are large, with broad chewing end and two-branched palp. The *maxillæ* and *anterior foot jaws* present nothing unusual, except that the exopodite of the former is suppressed. The *posterior foot jaws* consist of two basal joints and a five-jointed endopodite. The two basal joints are about equal in length. The endopodite is shorter than the second basal joint.

The Swimming Feet.—The first pair is short, and has three jointed exopodites and one jointed endopodites; the second pair has three jointed exopodites and two jointed endopodites; the third pair has three jointed outer and inner branches. The internal branch of the right foot is longer than that of the left side, the second segment being longer than that of the other internal branch. The distal joint of the outer branch of the left foot is much longer and broader than that of the foot of the other side, has two stout spines on the outer margin, and a long apical spine twice the length of that of the opposite foot, the terminal joint in which carries only one outer marginal spine and a very short apical spine. The long, stout, naked spine arising from the inner distal margin of the first basal joint is in each foot as long as the internal branch. This foot is very remarkable, and may be an ab-

normality. The fifth feet are very peculiar, consisting each of one branch only, each of the two basal joints and a terminal joint forming three finger-like projections. The second and in greater degree the third and fourth feet have their segments ornamented on the surface with rows of fine spines, and the joints of the endopodites of the third pair are fringed with spines.

The absence of a secondary branch of the posterior antennæ in this species is remarkable. In other particulars, size and spinulation of the feet segments, number of antennæ, joints, etc., it differs from any known species of *Pseudocyclopia*. I have named it after Dr. Giesbrecht, to whom I showed these drawings when recently I visited Naples. It was captured in the surface tow-net off the island of Bressay, Shetland, in March, 1900.

EXPLANATION OF PLATES I.–IV.,

ILLUSTRATING DR. R. N. WOLFENDEN'S PAPER ON "THE PLANKTON OF THE FARÖE CHANNEL AND SHETLANDS."

PLATE I.

1. *Aulographis furcellata* (*nov. sp.*), a needle.

2 and 2*a*. *Aulographis tetrancista* (?) (variety).

2. A short-branched verticil.

2*a*. A verticil with long branches.

3. A needle of *Aulacantha scolymantha*.

4, 4*a*, 4*b*. *Aulodendron boreale* (*nov. sp.*).

5. Needles of *Sphærozoum* (*ovodimare?*).

PLATE II.

CHALLENGERIDA.

1. *Challengeron walwini* (*nov. sp.*).

1*a*. The peristome in different aspect.

2. *Challengeron balfouri* (?) (variety).

2*a*. The peristome (enlarged).

3. *Challengeron balfouri* (?) (variety).

3*a*. The peristome seen dorsally.

4. *Challengeria tritonis*.

5. *Challengeria zetlandica* (*nov. sp.*).

5*a*. Viewed ventrally.

Plate III.

Augaptilus zetesios (*nov. sp.*).

1. Whole animal, dorsal (2 inch obj. × 5 oc.).
2. Fifth feet (½ inch obj. × 5 oc.).
3. Spine on second segment of exopodite of fifth feet (¼ inch obj. × 5 oc.).
4. Fourth foot (½ inch obj. × 5 oc.).
5. First foot (½ inch obj. × 5 oc.).
6. Second and third segments of exopodite of first foot (¼ inch obj. × 5 oc.).
7. Mandible (½ inch obj. × 5 oc.).
8. Maxilla (½ inch obj. × 5 oc.).
9. Posterior antenna (1 inch obj. × 5 oc.).
10. Anterior foot jaw (½ inch obj. × 5 oc.).
11. Posterior foot jaw (½ inch obj. × 5 oc.).
12. Processes on bristles of posterior foot jaw (⅛ inch obj. × 5 oc.).
13. Anterior antenna (1 inch obj. × 5 oc.).

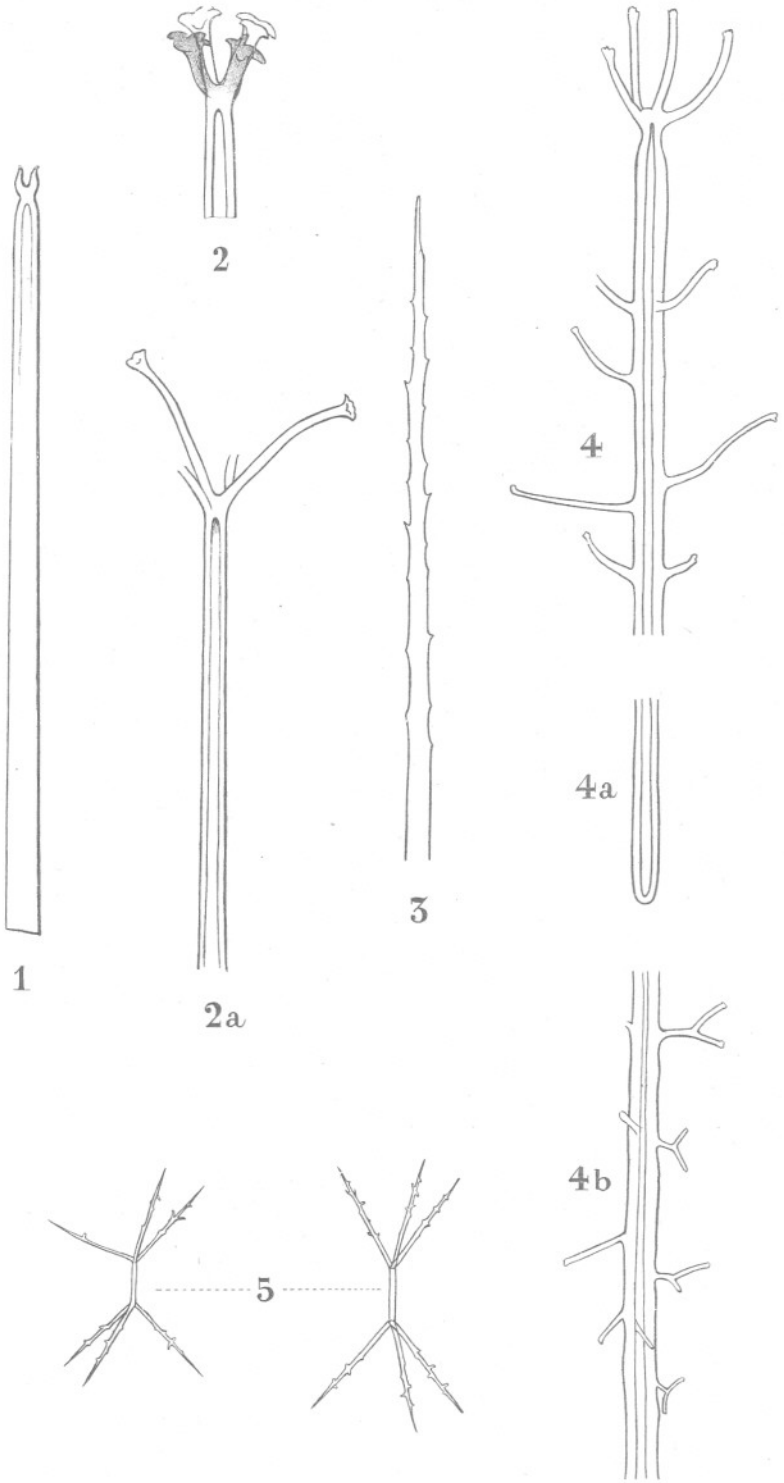
Plate IV.

Pseudocyclopia Giesbrechtii (*nov. sp.*).

1. Whole animal in profile (½ inch obj. × 3 oc.).
2. Abdomen, dorsal view (¼ inch obj. × 5 oc.).
3. First foot, dorsal view (¼ inch × 5 oc.).
4. Third feet, ventral view (¼ inch × 5 oc.).
5. Fourth foot (¼ inch × 5 oc.)
6. Second foot, dorsal view (¼ inch × 5 oc.).
7. Fifth feet, dorsal (¼ inch × 5 oc.).
8. Anterior antenna.
9. Posterior antenna.
10. Mandible.
11. Maxilla.
12. Anterior foot jaw.
13. Posterior foot jaw.

(All ¼ inch obj. × 5 oc.).

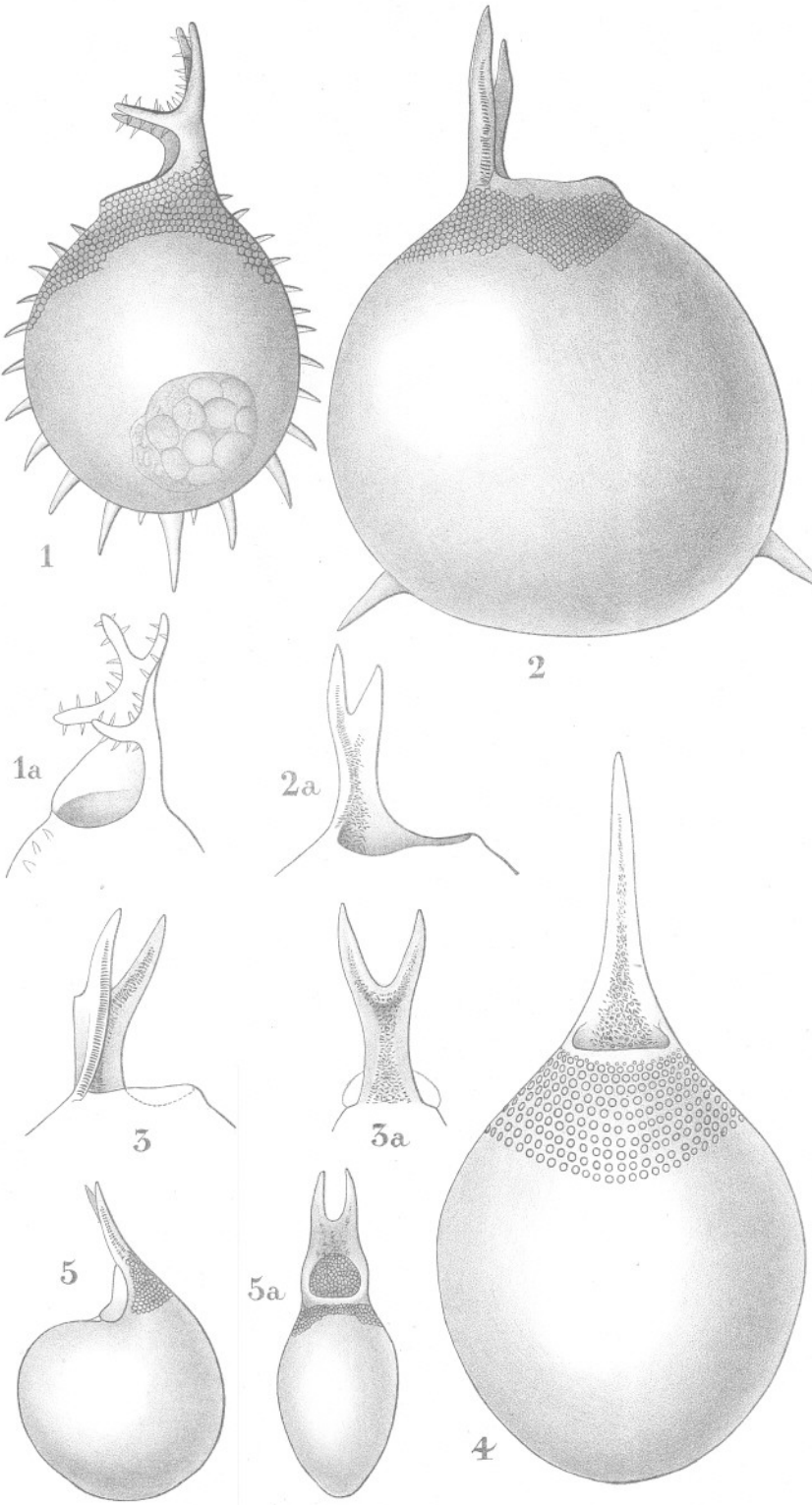
Plate I.



Drawn by Marion Lees.

Bale & Danielsson Ltd. lith.

Plate II.



Drawn by Marion Lees.

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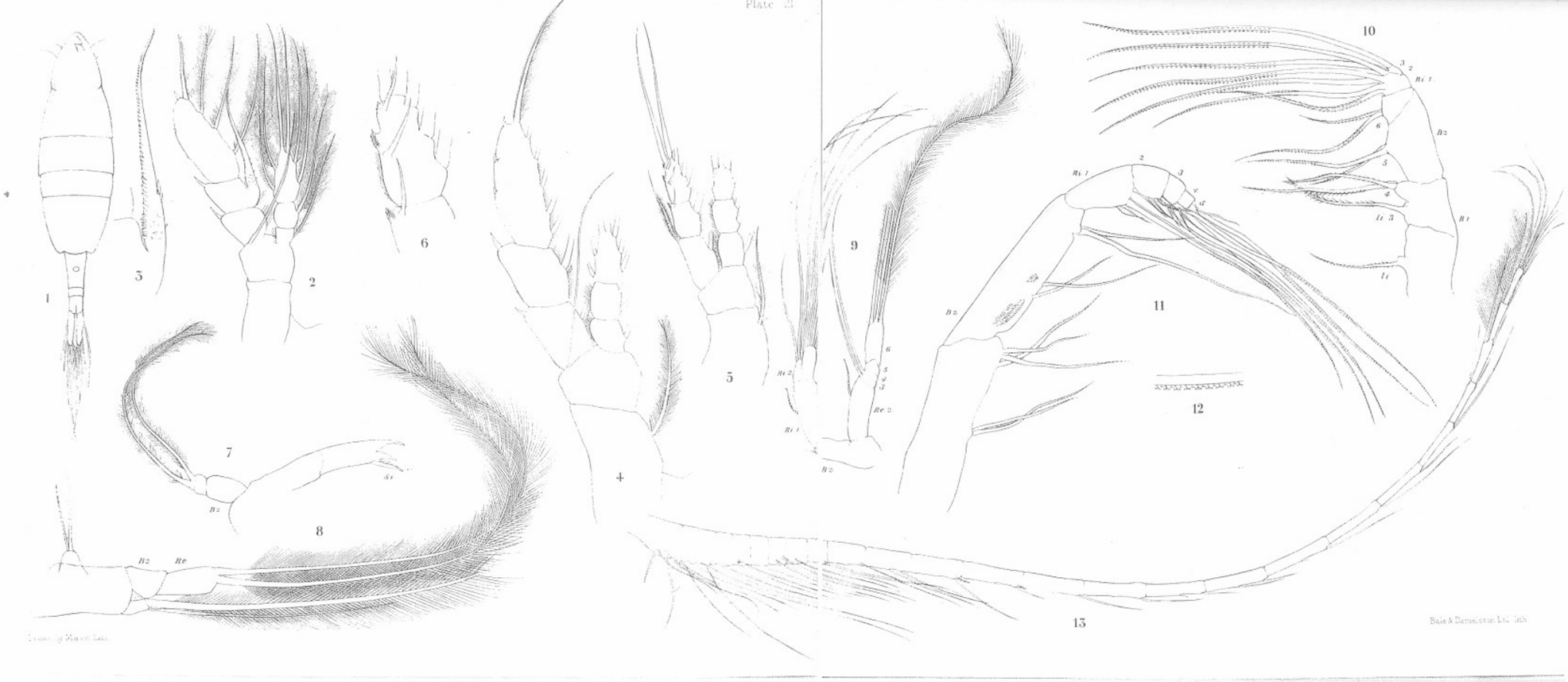
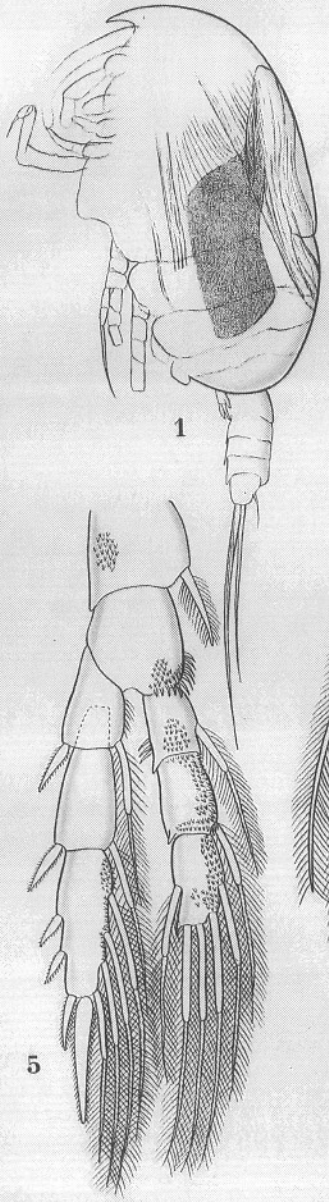
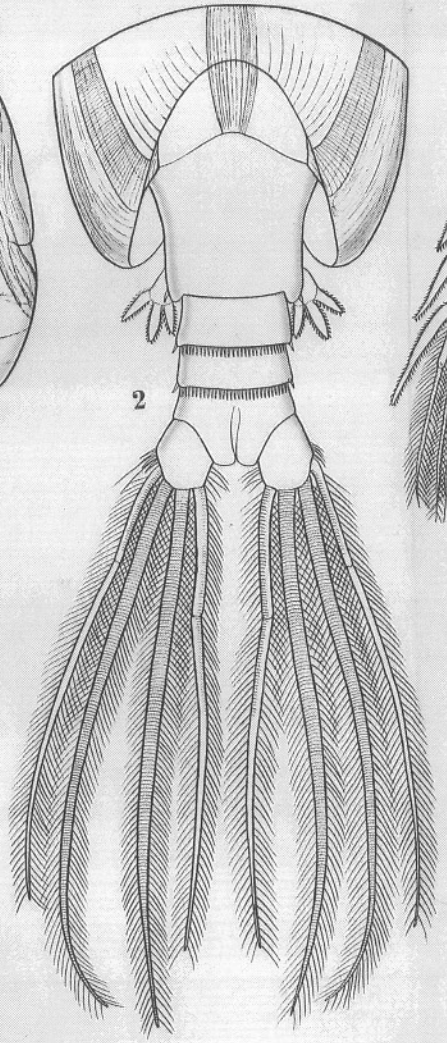
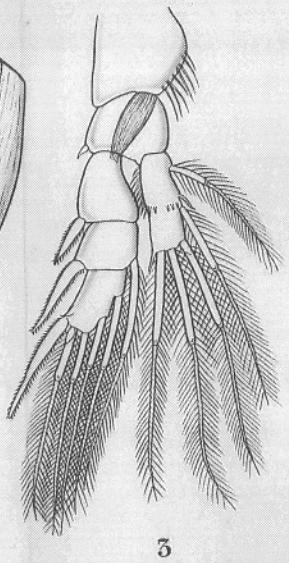


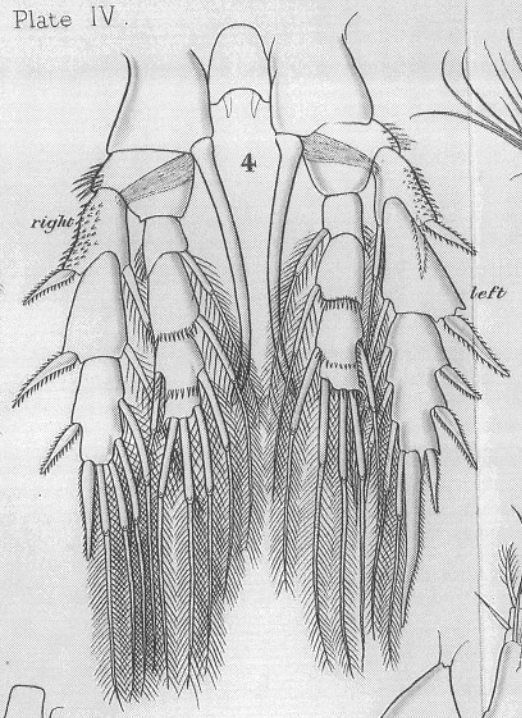
Bale & Danielsson Ltd. lith.

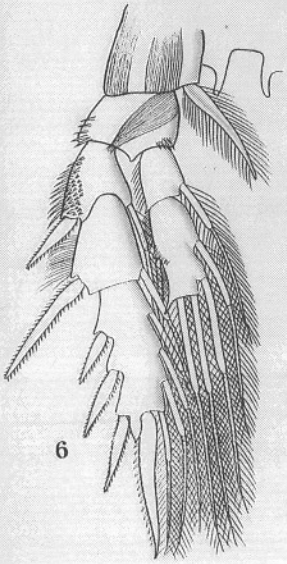
Plate IV.

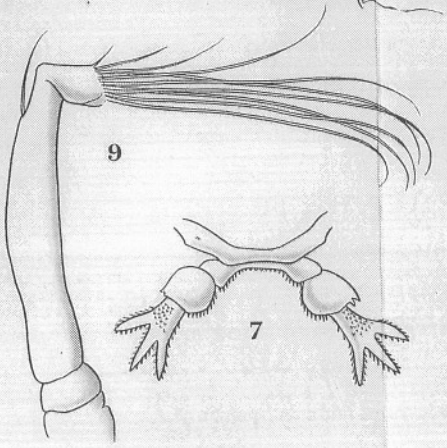


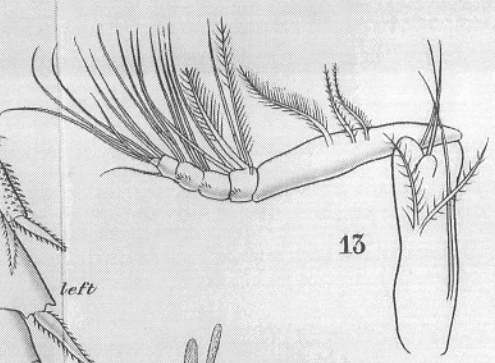


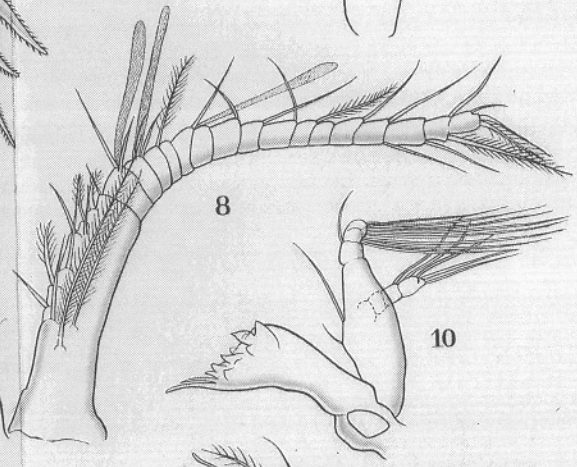


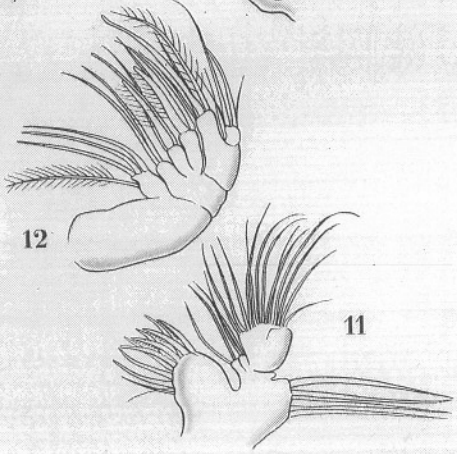












Drawn by Marion Lees.

Bale & Danielsson Ltd. lith.

The Periodic Growth of Scales in Gadidæ and Pleuronectidæ as an Index of Age.

By

J. Stuart Thomson,

Lecturer on Biology, Municipal Technical Schools, Plymouth.

(With Plate V.)

THE first part of a lengthened and detailed statistical paper on the structure and seasonal growth of Gadoid and Pleuronectoid scales will shortly be issued from the Marine Laboratory.

The forthcoming paper will show by means of tabulated statistics that scale growth is accelerated during the warmer season of the year; but diminished during the colder season in such a methodic manner as to cause the formation of annual rings. The formation of these annual rings results from the fact that the lines of growth on the scale surface are comparatively widely separated from one another in that portion of the scale formed during the warmer season of the year; but much less widely separated in that part built up during the colder season. Thus by following the arrangement of the lines of growth on scales, it is a simple matter to observe the starting place of any year's growth by the comparatively wide separation of the growth-lines at that portion of the scale, and in this way the surfaces of scales appear mapped out by annual rings. These annual rings supply us with an index as to the age of the fish, and may be roughly compared to the rings in many trees. The annual rings in the stems of trees are due to seasonal nutritive conditions, and the rings on the scales of fishes are probably the result of seasonal environmental conditions such as food, temperature, etc. In more detail, the alternate occurrence of comparatively rapid and slow areas of growth in scales is probably the result of the variations in food, temperature, etc., which are associated with the alternation of summer and winter. For example, the abundant supply of food (plankton, etc.) during the warmer season of the year probably has much connection with the comparatively rapid growth of the scale at that time as compared with the slow increase during the colder season, when there is a decrease in the supply of food.

These facts appear to possess both scientific and economic importance,

since they permit the extension to marine fishes of a new system of age determination by means of these annual rings on scales, a system which has recently been shown and demonstrated by Dr. Hoffbauer for the carp.*

I hope to illustrate clearly the mode of formation of annual rings in Gadoid scales by the aid of the figure on the accompanying plate.

The figure (Plate V., Fig. 1) represents the scale of a pollack, 28·5 centimetres (11½ inches) in length, captured towards the end of October. A minute translucent area (see Fig. 1, C) devoid of any lines is situated towards the narrower and more internal end of the scale; and around this area, which is the first portion of the scale to be formed, are grouped numerous excentric lines of growth similarly disposed to the excentric layers in the starch grains of the potato.

The excentric lines of growth on this scale, however, are arranged in such a manner (see figure) as to map out its surface into two main regions, namely, an internal area, which is the entire growth of the first year, and an external part, the summer growth of the second year. One understands how these two areas appear so distinctly if one follows the lines of growth outwards from the translucent area to the broader and more external part of the scale. One may firstly observe that there are nineteen lines comparatively widely separated from one another, which indicate the growth of the first summer, and secondly, ten lines less widely separated, indicating growth of the first winter. External to these, there follows an area showing much more widely separated lines of growth, which indicate the scale growth of the second summer.

The difference between the lines of growth formed during the second summer and those of the preceding winter is so apparent as to clearly define the termination of the first year's growth. The widely separated lines of the second summer number nineteen, and as the pollack from which this scale was taken was captured in October, it appears that in this scale the number of lines formed during the second summer exactly agrees with the number formed during the first summer.

In most cases, however, the growth of the scale in the pollack's second year appears to be greater than that of preceding and succeeding years. As the statistics of the forthcoming paper are too detailed for the purposes of this note, I select a few tabulated figures relating to *Gadus pollachius* and *Gadus minutus*, which will in some measure show the general bearing and object of this work. The following tables commence with fish about an inch in length, the scales of which show a small translucent area without any lines of growth (excentric lines),

* "Die Altersbestimmung des Karpfen an seiner Schuppe," von Dr. HOFFBAUER; *Jahresbericht des Schlesischen Fischerei-Vereins für das Jahr 1899.*

PLATE V.

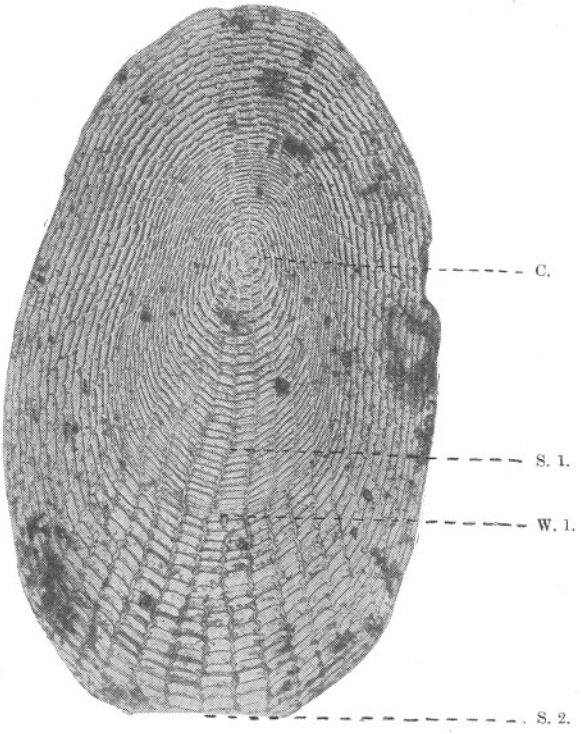


FIG. 1. Microphotograph of pollack scale at end of second summer.
(Magnified 45 diameters.)

C. = Centre of growth.
C.—W. 1. = Growth of first year.
C—S. 1. = Growth of first summer.
S. 1.—W. 1. = Growth of first winter.
W. 1.—S. 2. = Growth of second summer.

and terminate with a pollack apparently at the commencement of the ninth summer. By means of these tables a comparison may be made as to the number of lines of growth (excentric lines) formed during successive years.

GADUS POLLACHIUS.

No. of fish.	Length of fish.	Date (month of capture).	No. of annual rings.	No. of lines of growth (excentric lines) in years. I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.
2	2·3 cm.	May	0	0	—	—	—	—	—	—	—	—
4	4–6 ,,	July	,,	2–4	—	—	—	—	—	—	—	—
3	6–7 ,,	,,	,,	3–5	—	—	—	—	—	—	—	—
6	9–10 ,,	Oct. to Dec.	1st forming	13–16	—	—	—	—	—	—	—	—
9	10–11 ,,	,,	,,	15–19	—	—	—	—	—	—	—	—
2	11–12 ,,	December	,,	15–19	—	—	—	—	—	—	—	—
2	35–39 ,,	April to June,	2 complete	23–24	30–31	7	—	—	—	—	—	—
1	45 ,,	April	3 ,,	21	29	18	2	—	—	—	—	—
1	60 ,,	,,	4 ,,	24	24	18	22	3	—	—	—	—
1	84 ,,*	June	8 —	26	25	12	12	11	9	11	10	3

* In this case the majority of the scales showed much disintegration.

GADUS MINUTUS.

No. of fish.	Length of fish.	Date (month of capture).	No. of annual rings.	No. of lines of growth (excentric lines). Year I.	Year II.	Year III.
1	3·3 cm.	June	0	0	—	—
8	3·4–5 ,,	,,	,,	2–7	—	—
17	5–6 ,,	,,	,,	3–9	—	—
8	6–7 ,,	,,	,,	6–10	—	—
3	11–12 ,,	July	1 complete	27–33	6–10	—
6	12–15 ,,	,,	1 ,,	23–32	9–12	—
2	19–20 ,,	Not known	2 ,,	19–25	20–25	10–15

From the preceding tables the age-indices of these varied sizes of *Gadus pollachius*† and *Gadus minutus* may be tabulated as follows:—

GADUS POLLACHIUS.

Length of fish.	Age of fish.
2–7 cm.	First summer
9–12 ,,	First winter
35–39 ,,	Third summer
45 ,,	Fourth spring
60 ,,	Fifth spring
84 ,,	Ninth spring (?)

GADUS MINUTUS.

Length of fish.	Age of fish.
3·3–7 cm.	First summer
11–15 ,,	Second summer.
19–20 ,,	Third summer

In conclusion, I would express my indebtedness to the officials of the Marine Biological Association, more especially to Mr. Walter Garstang, Naturalist in Charge of the Fishery Investigations.

† Compare CUNNINGHAM, *Marketable Marine Fishes*, 1896, p. 295.

Notes on Plymouth Sponges.

By

George Bidder.

(1) Sycon compressum:

On a Specific Character.

Sycon compressum is one of the long-recognised sponges, that stand refreshingly conspicuous in a group made difficult with doubtful definitions. The unique dermal spicules, and the striking outward form, divide it from other species in a way quite different from that in which *Sycon raphanus* is divided from *S. villosum* or *Reniera cinerea* from *Reniera permollis.*

From the doctrine of evolution it would appear the logical deduction that the constant and striking differences which *S. compressum* shows from its next allies are important to its existence, while the varying differences shown among other so-called species are nearly, or quite, uninfluential. It therefore seems worth while to examine whether we can find circumstances in the life of the sponge which can lift this statement from the deductive to the empirical standpoint, by showing that there are exceptional facts in the environment, to which the unusually marked specific characters exceptionally fit the animal.

Walking on the low-tide rocks immediately under the Laboratory at Plymouth, it will be found that there occur in abundance *S. compressum, S. ciliatum, Leucosolenia botryoides, Guancha coriacea, Halichondria panicea,* and *Hymeniacidon sanguineum.*

In the tide-pools all four calcareous sponges occur in quantity, and under heavy masses of weed both the Sycons are equally abundant. But on the tops of all the naked rocks we find able to support existence only the green tufts of *Halichondria*, the red smears of *Hymeniacidon*, and the crisp little white leaves of *S. compressum.*

Both the siliceous species are comparatively massive incrusting sponges, and therefore exist under completely different conditions to the delicate, bag-like, Calcarea. Leaving them, therefore, for the present, we find, with respect to two closely allied sponges, that *S. compressum* and *S. ciliatum* live side by side in every sheltered cranny, but on the working tops of the rocks *S. compressum* is alone—

often with little even of seaweed hardy enough to bear company—exposed for hours every day to sun, rain, or wind.

I made some tentative experiments as to the endurance of *S. compressum*, a brief summary of which, with figures of the metamorphosed collar-cells, appeared in "The Collar-cells of Heterocœla," *Q. J. M. S.*, vol. 38. Though they would have been better if comparative with studies on other species, the results by themselves are fairly striking.

(1) Several sponges were gathered at 1 p.m. on February 6th at low neap tide. They were taken from positions on the tops of rocks, free from all water or seaweed, and placed, without more water than they contained, in a small empty corked bottle. On February 7th, at 1 p.m., a section from a large specimen was examined under the microscope; though twenty-six hours out of the water, flagella were moving everywhere (though not quite on all cells). The absence of collars and hemispherical outline of the cells has been described in the paper referred to. The remainder of the sponge was placed in the aquarium circulation, and on February 8th, at 6 p.m., was found in the most healthy life, most of the cells being collared and perfectly normal in shape, while the flagella were in active motion.

(2) Some of the same collection were taken from the bottle at 8.30 p.m. on February 7th and placed in sea-water, having endured some thirty-four hours' sojourn in air. Another experiment being designed, the sea-water was saturated with indigo-carmine, was out of the circulation, and through a disconnection of the tubes was most of the time entirely without aeration. Notwithstanding that these circumstances were most unfavourable to recuperation, one of the sponges examined at 4 p.m. on February 8th showed a fair proportion of collars, had very active flagella all over, and looked exceedingly healthy; another examined on February 10th, though having no collars, showed healthy flagellate action everywhere. Of the four other specimens treated in the same way and examined on these two days, only one (on February 10th) was found to be completely dead.

(3) Some sponges were collected from the upper and exposed surfaces of rocks, where rain had been falling on them for three hours. They were placed in a dry bottle and, after a further three hours, examined with the following results:—

(*a*) Possibly dead; no changes recognisable; all the cells amœboid in form.

(*b*) Flagellar action observed and (?) the regeneration of a collar.

(*c*) *Violent* flagellar action. This sponge was only just dipped in the sea-water before cutting, (*a*) and (*b*) had lain in sea-water some minutes.

(*d*) Held under a stream of fresh water some minutes, tissues all destroyed.

(*e*) One minute lying in fresh water, of which for thirty seconds it was entirely submerged; a few flagella were found moving, in most parts they were not visible, in most places the cells had thrown out strings of protoplasm, and were in other ways altered.

Though improbable, it was logically conceivable that the comparative immunity to rain and other fresh water was due to modification of the naked protoplasm itself. While (*e*) was in full action, therefore, a drop of fresh water was introduced under the cover-slip. For a moment the flagella quickened, almost instantly stopped, and within a few seconds the cells successively became transparent, then ovoid, then disappeared.

It appears to be fairly certain, therefore, that this apparently fragile member of a singularly delicate group of animals must have some exceptional provisions, (1) to resist evaporation, (2) to withstand injury from such evaporation as still takes place, (3) to resist the entrance of noxious fluids, *videlicet* pure water.

To meet (1) and (3) I propose at once the spicules. Dendy, in his masterly review of the Heterocœla,* pointed out the anomalous position of *S. compressum*, in having a highly developed cortex and yet retaining what may be called the "conal acerates," that is, the centrifugal bunch of unbranched spicules which surmounts the end of each radial tube. The first, as he shows, is a Grantiad character; but the second is typically Syconid.

Now I suggest that the thick, continuous, cortex, set with its dense mass of club-shaped radial spicules, enables the sponge to pursue its daring existence; clothing it with a deep armour of calcareous mosaic through which, when the skin is contracted on its pores, a minimum amount of permeation or evaporation can take place. The shillelagh-like outer ends of the spicules serve, like the heads of iron nails set in a pile at sea, to cover and protect the surface of the substance in which their points are embedded.

As to (2). The danger to a sponge from evaporation of the contained water comes at a stage short of desiccation. If we suppose a rigid, cylindrical, Sycon to be exposed to the sun and wind for two or three hours between tides, the returning water would find it—though perhaps damp, and still in cellular life—with its gastral cavity empty; evaporation having replaced the liquid reservoir by a bubble. Such a sponge is doomed. It has occurred to me again and again, when measuring the oscular currents, to be surprised at the sudden quietude

* *Q. J. M. S.*, vol. 35.

of a *Leucandra* or other sponge employed, after being transferred from one basin to another; a quietude at once replaced by the accustomed stream when the obstructing bubble was removed. This was accomplished in very wide-mouthed sponges by merely raising the osculum, but in most of those dealt with, the bubble could not escape without the aid of pressure.

Hence the flat form of *S. compressum*. In its cloaca a bubble is never formed. The tide leaves it with rounded outline, so that in a sponge a centimetre wide, its shorter axis may be nearly half as much. As there occurs evaporation, even from its protected surface, into the air round it, and the fine capillaries of its walls suck in fresh supplies of water from the central drop, the sides gradually come nearer, like the capsule surfaces of an aneroid barometer, until the cloacal cavity may attain itself such capillary dimensions that only very dry air can further extract the moisture.*

As a matter of observation, above the rising tide it is easy to observe on every side flat, yellowish, sponges, like oval pieces of whitey-brown paper, which swell out at once in water to their natural rounded form; and if a sponge in the rounded form be taken from the water and laid on blotting paper, it becomes flat. On the other hand, in tide-pools which never dry I have found several specimens of *S. compressum* with the oscular part of the cloaca cylindrical, and this observation only corroborates one noted long ago by Grant.

The cylindrical form is never met with on exposed sites. One such specimen was found, not in a pool, but hanging under a large rock, down which, from weeds and growth of all sorts, a trickling of sea-water kept up through the whole period between tides. There was a constantly renewed drop falling from the open cylindrical mouth, and when this was dried away with a handkerchief the sponge could not flatten, like those accustomed to be dry in every ebb, but its stiff round tube remained open and empty.

Among all the Calcarea, the only sponge that I know described of absolutely comparable shape is *Sycortis lingua*, Haeckel (Newfoundland), which appears to me a near connection of *S. ciliatum*. Haeckel notes that only two sponges have dermal spicules at all comparable with *S. compressum* for size and arrangement; the one is *Leucandra lunulata* (Cape of Good Hope), which takes the form of "plattgedrückte langliche Schlaüche"; the other is *Ascandra falcata* (Adriatic), apparently cylindrical.

As to the siliceous companions of *S. compressum*, their complicated,

* In the drying of marine organisms the external deposit of salt, and internal concentration of brine, must considerably retard ultimate desiccation; though probably with injurious results to organisms whose protoplasm is not adapted to withstand such salinity.

and massively "spongy," structure opens up a totally different series of needs and adaptations, not comparable with the delicate simplicity of the Sycon. One point only may be noted; that for *Halichondria* with its few wide oscula, the difficulty with the contained bubble is slight, and when the oscula point upwards it will escape at once. I am somewhat of opinion that the hairy coat of *S. ciliatum* may assist it in another way to retain moisture, when, in its intermediate situation, hanging under sheltering masses of damp seaweed; it is worth noting that *S. lingua*, from Haeckel's description, has no cortex, but a very long fur.

It would involve far more space and detailed discussion than are here convenient to endeavour to assign the exact importance of the few facts above narrated, nor until associated with many parallel observations is it worth while. The subservience of a "marked species characteristic" to outward circumstances, shown in the partly cylindrical form of tide-pool specimens, may be due to the fact that only here such varieties can survive, may indicate a power of individual adaptation. Probably it means merely that mobility, never exercised, is lost; and that the spicules which are never called on to slide over one another become locked and plaited to the rigidity of other Sycons. I have before now endeavoured to show* that the definite series of changes in canal-system and outward form, with which homoplasy presents us again and again in every group of Porifera, bring definite increasing mechanical advantage. Here I have attempted to argue that the most definitely characterised common species of sponge has the most definite use for its species characters. I hope later to be able to show, in the case of *Reniera*, that the minute spicular changes which fill our classifications, and to which it appears impossible to ascribe utilitarian value, are not characteristic of species, but merely the direct consequence in the individual of some altered physical conditions of the nutrient medium.

(2) Halichondria panicea; Suberites domunculus: Variation and Metampy.

The specimen of *H. panicea* given me from Exmouth (*vide* p. 317) differs markedly from a Plymouth specimen, or from Bowerbank's figures, in having the interior skeleton far looser and more fibrous in character. The Exmouth specimen shows, even in the innermost mass, numerous well-marked bundles, three or four spicules in thickness, branching, but having a general tendency to parallelism. The Plymouth specimen shows the confused skeleton recognised as characteristic by all authors; and the far more numerous spicules form, in the interior of

* *Loc. cit.*, p. 18, and *Proc. R. S.*, vol. 64, p. 61.

the sponge, an irregular criss-cross, rarely showing well-marked fibres; looking like a felt of pine-needles, and well represented in Bowerbank's figure (Fig. 300, *Mon.*, vol. i.).

This difference is explained when we consider the difference in conditions of life: the Exmouth specimen living some fifteen feet below low-water mark, removed from the possibility of any shock or jar; the Plymouth specimen between tidemarks, exposed to what is often a very violent surf. Such a loose framework as is found in the Exmouth specimen, being very slightly bound together, will dislocate under shocks, and the (sharply pointed) needles drive over one another to form the smaller, and denser, skeleton which is best known to shore-collectors.

I have found a difference, closely comparable to that between the deep-water *Halichondria* of Exmouth and the surf *Halichondria* of Plymouth, in *Suberites domunculus*. In this species the individuals carried on the back of a hermit-crab have a dense skeleton, like the surf-beaten *Halichondria*, and justify their name with a consistency almost of cork; while the individuals found growing on rock in the deep waters of Millbay Channel (Plymouth Sound) are much larger, supported by a skeleton of precisely similar elements, but much looser, giving the sponge the soft consistency of a ripe plum.

If the above explanation be correct of the differences between the soft and hard specimens of *Suberites* and *Halichondria*, the soft *Suberites domunculus* is not a "variety" in the sense that an albino rabbit, or a six-toed cat, is a variety. I am not aware of any word applicable to describe a definite difference from the type, frequently encountered, but known to be due to post-natal influences. It appears useful, in instances where such a history can be proved, to have a word to distinguish the phenomena from those of congenital difference—to distinguish conditional from germinal variation. I suggest the unscholarly, but manageable word, "metamp," suggested by the Greek μεταμπέχομαι = "to put on a different dress." Thus we shall speak of "*Suberites domunculus* met. *mollis*"; and distinguish the inherited darkness of the Cinghalese from the metampic brown of the tropical Englishman. Holding, as I do, that the sizes and forms of sponge spicules are largely influenced by the temperature and constitution of the sea in which they grow, I believe that not only varieties, but many so-called species of sponges, are merely metamps of each other.

To speak of "abnormal forms" does not meet the case—neither the tidal nor the deep-water *Halichondria* can be considered abnormal. The determination of a normal form would, on the view here put forward, mean merely the determination of a normal depth, a normal salinity, or a normal temperature. In the case of littoral and sub-

littoral species such a determination would in many cases be quite meaningless.

The cylindrical *Sycon compressum*, referred to in the previous note, may be considered a metamp of the flat *Sycon compressum*. In this case the flat form may be considered normal, since according to present knowledge it is a thousand times more frequent. Vosmaer (*Mitt. aus d. Zool. Stat. z. Neapel*, vol. v. part 3) has put forward the view that *Leucandra aspera* is extraordinarily diverse according to its habitat, and my own work has caused me to take the same view of *Sycon raphanus* (cf. the papers cited in previous note); these are cases of mutual and probably continuous metampy, where a normal form is difficult to select.

The skin of *H. panicea*, with its net of spicules, is well represented in Bowerbank's figure (*Monograph*, vol. i. Fig. 505). It is coherent and easily detachable, and, as Ridley and Dendy remark (*Challenger Mon.*, p. 15), Schmidt's definition of his genus *Pellina* is completely fulfilled by this species. Topsent, however, has since (*Réforme dans la Classification des Halichondrina*) revived the genus *Pellina*, with a Renieran instead of a Halichondrian skeleton.

The skin is considerably thicker and more spicular in the Plymouth than in the Exmouth specimen, being conspicuous in spirit as a white veil over the sponge, showing as a hard white line when the sponge is cut. It is tempting to connect this denser spicule-sheathing of the tidal sponge with the restraint of evaporation and protection of soft tissues against brine and rain-water, as suggested in regard to the club-spicules of *S. compressum;* but it must be remembered also that far denser crusts are well known in other siliceous genera which are not tidal.

Bowerbank's Fig. 300 does little justice to the subdermal space. This is not a series of spherical lacunæ in the tangle of spicules; the spicules in the ectosome of *H. panicea* are as definitely arranged as in an *Axinella*. The skin is only connected with the body by spicule-fibres, which traverse the subdermal space like the columns in a Norman crypt, expanding above to support the tangential spicules of the skin, and below to root in the body.

Notes on the Young of *Blennius galerita*, L.

(Montagu's Blenny).

By

L. W. Byrne.

No description of the young of this species seems to exist, with the exception of that given by Emery (**1**) of some examples from Naples.

The specimens here described were captured at Newquay, on the north coast of Cornwall, in September, 1898, and have been preserved in formol. They were caught in sandy pools surrounding or surrounded by rocks in the shelter of which they seemed to be fond of lying. When disturbed they darted with considerable rapidity from place to place, and in doing so were seemingly assisted by the large pectoral fins which were carried nearly at right angles to the body by the fish when at rest.

They exhibit the large pectoral fins typical of the young of many British species of *Blennius*, but in other respects generally resemble the adult in form. Although these specimens exhibit a remarkable amount of individual variation and show a considerable lack of uniformity in growth and development, the presence of the interorbital "helmet," taken in conjunction with their comparatively small size and radial formula, seems to be diagnostic from a length of 15·5 mm. (including caudal fin) upwards.

A brief description of the Cornish specimens follows.

Length.	Length with middle caudal rays.	Depth of body.	Length of head.	Length of pectoral.	Pectoral compared with length of body.	Averages.
13	15·5	—	3	4·5	·35	
13	15·5	2·75	3	4·75	·37	
13·25	15·75	—	3	4·5	·34	·352
13·5	16	—	3	4·5	·33	
13·5	16	2·75	3	5	·37	
14·25	17	2·75	3·25	4·75	·33	
14·5	17·25	3	3	5	·34	
14·75	17·5	3	3·5	5	·34	·33
14·75	17·5	3	3·5	4·75	·31	
15·5	18·75	3·5	3·5	5	·32	·32
17·5	21	4	3·5	5	·29	·29

Fin-rays. D. xiii. 15–16; A. 18–20.

Pigmentation. At 13 to 13·5 mm. (15·5 to 16 mm. including the middle caudal rays) the caudal peduncle is still quite or almost devoid of pigment. The pectoral fin is more or less thickly covered with a variable number of black chromatophores, and there are a few others at the base of the caudal fin and in a roughly horizontal band on the anal fin.

There is a varying amount of diffuse brown pigment, more especially (*a*) on the upper part and front of the head, (*b*) in a band running from the eye to the upper jaw, (*c*) on the operculum and base of the pectorals, and (*d*) on the body. In the latter situation it is most noticeable (i.) in four more or less faint V-shaped markings on each side of the dorsum, the first below the origin of the dorsal fin and the third below its lowest point, and (ii.) in more or less indefinite patches below and alternating with these.

A considerable number of dark brown chromatophores (very probably black chromatophores seen through the diffuse brown pigment) are scattered along the dorsum on each side, along the base of the anal fin, and, less freely, on the trunk; in some cases similar chromatophores may be detected among the diffuse pigment (*a*), (*b*), and (*c*), already mentioned.

At 14·25 to 14·75 mm. (17 to 17·5 mm. with the middle caudal rays) the caudal peduncle is still almost devoid of pigment. A few of the black chromatophores at the base of the caudal fin remain, while those on the pectorals vary much in number, being in some cases many and closely set and in others few and scattered.

The diffuse brown pigment is more marked and more generally distributed, beginning to appear on the dorsal and anal fins and the lower part of the pectorals. There are six V or U-shaped dorsal markings, the last of which is still faint and is situated below the posterior end of the dorsal fin, and alternating with and below these are ∧ or ∥-shaped markings on the body. The dark brown chromatophores are much less noticeable and more restricted in distribution.

At 15·5 mm. (18·75 mm. with middle caudal rays) the large black chromatophores on the pectoral fin are no longer visible, the body is generally covered with diffuse brown pigment, which extends on to the dorsal, anal, and lower part of the pectoral fins, the dark chromatophores have almost disappeared, and the body markings are much as in the last stage, with the addition of traces of a seventh dorsal band on the caudal peduncle.

At 17·5 mm. (21 mm. with middle caudal rays) the pigmentation remains practically the same, but is more intense.

The *pectoral* fins grow comparatively shorter with age, though subject to considerable individual variation; both these points appear sufficiently in the table.

The *narial tentacles* are plainly visible in all examples from 13 mm. up.

The *interorbital "helmet"* increases with age, but may attain a very different growth in two individuals of the same size. It consists of a single leaf-like and broadish tentacle followed by several smaller ones; these latter seem to vary much in the period at which they appear—though present in one specimen of 15·5 mm. they have not yet appeared in another of 17·25 mm.

A comparison with the figures given by Emery (**1**) of young forms attributed to this species from Naples shows that (in addition to the individual variations above alluded to) there is a very great difference in the development of Atlantic and Mediterranean specimens; a Neapolitan example of 15 mm. (including caudal) shows no trace of the interorbital "helmet" and has far longer pectorals than any of the Cornish specimens, while a Neapolitan example of 23 mm. (including caudal) still retains most of the black pigment on the pectorals, which it is obvious must undergo their comparative reduction in size at a much later period of growth than in the case of the Cornish specimens. The differences in pigmentation and general form do not appear, when allowance has been made for the different methods of preservation, to be very great.

Apparently in *B. galerita*, as in *B. pholis* (**3** and **5**) and *B. ocellaris* (**2** and **3**), the size and dark pigmentation of the pectoral fins increase until a certain stage of growth is reached (possibly the stage at which the young fish first begins to assume the habits of the adult), when this increase is checked and the fins gradually assume the form and colouration found in the adult.

The true significance of the "long-finned" phase of *Blennius* is by no means certain. It has been suggested that it is of an ancestral nature, but if so it is curious that *Anarrhichas* does not appear to pass through such a phase. The groups of *Acanthopterygii* in which the pectorals are most markedly developed are the Trigloids and Scopænoids, forms which are closely allied to one another, but do not appear to be in any way related to the blennies.

If, on the other hand, the large size and dark pigmentation of the pectorals are regarded as a purely transitory and adaptive character, the "long-finned" blenny may be compared with the pelagic stages of certain gadoids (*e.g. Molva* and *Onos*), in which the ventral fins are enormously prolonged and deeply pigmented. It is not much use speculating upon the origin and utility of such a stage, but the observation on *Dactylopterus* mentioned by Holt (**4**) certainly suggests the possibility that

the possession of large and darkly pigmented accessory organs may easily divert the attacks of enemies from a defenceless but almost transparent larval fish during the pelagic stage of its existence, and this theory is to a certain extent borne out by the fact that the decrease in size and loss of pigment would appear in *Blennius* to coincide to some extent with the adoption of the habits and colours of the adult.

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2. Garstang.—*M. B. A. Journal*, vi. p. 70 (1900).
3. Holt.—*M. B. A. Journal*, v. p. 107 (1898), and *Ann. Mus. Marseille*, v. p. 5 (1899).
4. Holt.—*P. Z. S.*, 1898, p. 314.
5. McIntosh and Masterman.—*British Marine Food Fishes*, p. 206 (1897).

On the Occurrence of *Squilla desmaresti* in the North Sea.

By

F. Jeffrey Bell, M.A.

So far as I have been able to discover, there is no record of the presence of this or any other Squilla in the North Sea; to make sure I inquired of Dr. Hoek, whose experience is unrivalled, and he assures me that the only record is that of an *Erichtheus* stage, discovered on the Dogger Bank during the cruise of the *Pommerania* (1872). Early in May (1901) I received through the Director of the Natural History Museum a specimen of Squilla, as to the rarity of which in the Channel he called my attention. It was accompanied by letter A, the writer of which was Lieutenant and Commander G. S. Carr, R.N., C.M.G. I thought the circumstances warranted my writing as I did in letter B, the answer to which (C) is, if I may be allowed to say so, the very pattern of what an answer should be, and another example of the admirable training of our seamen.

I think it may quite safely be said that *Squilla desmaresti* has been dredged in the North Sea; in this, if not in previous centuries—*auspicium melioris ævi!*

(A) H.M.S. "Circe," Harwich, 30*th April*, 1901.

Dear Sir,—By this post I am sending you a specimen for classification. It was trawled up by *May Queen* (R. 32) on 29th about three miles east of the Kentish Knock. I am quite unable to identify it, and should be much obliged if you will give me its name, etc. During two years now in charge of the North Sea Fisheries it is the first specimen I have seen.

(B) Natural History Museum, 3*rd May*, 1901.

Sir,—The specimen sent by you is the Stomatopod Crustacean *Squilla*. I cannot find the Kentish Knock (if I have read it correctly) in our atlases, but if it is in the North Sea I should like to have your assurance that your

collector is trustworthy, for Squilla is very rare even off Cornwall, and its appearance in the cold sea of April off Harwich is, I believe, unrecorded, to say the least.

(C) H.M.S. "CIRCE," *4th May*, 1901.

SIR,—With reference to your letter of yesterday the Squilla was actually taken out of the trawl of the boat R. 32 on the date mentioned. One of my officers saw it when he was boarding her, and the skipper sent it to me, as he said that in all his experience of forty years' trawling he had never seen one like it. The Kentish Knock is a shoal off the Thames Estuary in lat. 51·39 N., long. 1·41 E. The water the Squilla was dredged up in was about twenty-four fathoms. The surface temperature was 52° Fahrenheit at the time.

The Second International Conference for the Exploration of the Sea, Christiania, 1901.

On the invitation of the Norwegian Government a second International Conference met at Christiania in May, 1901, to revise and complete the proposals formulated at the Stockholm Conference in 1899 for a combined hydrographical and biological exploration of the North Sea and adjoining waters in the interests of the sea-fisheries.

The delegates appointed by the various Governments to attend the Conference were as follows:—

Norway.—Prof. F. Nansen, Dr. J. Hjort.

Sweden.—Prof. O. Pettersson, Prof. P. T. Cleve, Mr. G. Ekman, Capt. E. G. D. Maechel, Dr. F. Trybom, Mr. A. Wijkander.

Russia.—Prof. O. von Grimm, Dr. N. Knipowitsch.

Finland.—Dr. O. Nordqvist.

Germany.—Dr. H. Herwig, Prof. K. Brandt, Prof. F. Heincke, Prof. H. Henking, Prof. O. Krümmel.

Denmark.—Capt. C. F. Drechsel, Dr. M. Knudsen, Dr. C. G. J. Petersen.

Holland.—Prof. P. P. C. Hoek.

Belgium.—Prof. G. Gilson, Mr. R. Andvord.

Great Britain.—Sir Colin Scott Moncrieff, Prof. D'Arcy W. Thompson, Mr. W. Garstang, Dr. H. R. Mill.

The Report of the Conference has recently been issued, and contains minutes of each day's proceedings and the Resolutions of the Conference. A translation of the former and the authorised English version of the Resolutions are given below.

The Programme of Researches is included under the Resolutions. It embodies a comprehensive scheme of investigations designed to throw light on the various problems to which the representatives of the differ-

ent nationalities attached importance. Prominence has been given to questions concerning the irregular fluctuations in the yield of the line and drift-net fisheries, to the alleged impoverishment of the trawling grounds, and to the destruction of immature (undersized) fish. The physical and biological investigations which the Conference has resolved upon in connection with these matters are minutely detailed in the programme, which is subdivided into sections according to the character of the work proposed. A characteristic feature of the biological programme is its division into obligatory and optional sections—an arrangement which provides the elasticity necessary for so large an undertaking, while adequately safeguarding the international character of the fundamental inquiries. The investigation of the distribution and destruction of immature (undersized) fish forms part of the obligatory programme.

The general idea of the international programme is as follows:—

I. To obtain an accurate knowledge of the seasonal and other periodic changes in the waters of the North and Northern Seas, both as regards the distribution of temperature, salinity, etc., and also as regards the course and distribution of the currents. (Recent scientific observations on a limited scale have rendered it probable that in some years Arctic water, and in others Atlantic water, predominates in the North Sea basin,—changes of such magnitude that obviously the distribution of food-fishes and of other animals throughout this area must be profoundly affected.)

II. To determine the amount of variation in the character and abundance of the food-supply of food-fishes, whether floating (*i.e.* plankton) or on the sea-bed.

III. To determine the variations in the abundance and distribution of food-fishes, both in the egg, young, and adult conditions.

IV. To determine the extent to which these variations are due, either (*a*) directly to natural physical causes; or (*b*) indirectly to the same causes through fluctuations in the food-supply; or (*c*) to the operations of fishing-vessels in modifying the natural conditions of reproduction and growth.

V. To provide other information necessary for the consideration of remedial measures; *e.g.* artificial propagation, effect of special fishing implements, new methods, places and seasons of fishing, size limits.

In order to carry out the international programme each of the participating countries needs its own local organisation and equipment, and a central international office and staff is required for co-ordinating the work in general under an International Council. Provision for the latter is made in the Resolutions of the Conference

(C, §§ 1–18), but the local arrangements are left to the respective Governments. In this matter the Conference merely draws the attention of each country concerned to the necessity of providing a specially constructed steamer for the scientific investigations (Resolution D). These steamers are to be employed in the regular investigation of predetermined areas adjoining the coasts of the respective countries. As will be seen from the programme (A, § 2), they are to make simultaneous quarterly cruises for the collection of the necessary physical observations, and are to be engaged in the intervals in the fishing and other experiments detailed in the biological programme.

It remains only to draw attention to the fact that the adhesion of the Continental Governments to the Scheme of International Explorations has already been signified, and that the work is announced to begin in May, 1902, at latest (cf. Resolution E).

The decision of the British Government has not yet been announced.

June 10th, 1901.

MEETINGS OF THE CONFERENCE.

ABSTRACT OF THE MINUTES.

(Translated and slightly abridged.)

MONDAY, MAY 6TH, 1901.

12 noon.—Opening of the Conference in the reception hall of the University of Christiania by His Excellency the Prime Minister of Norway, Mr. Steen.

On behalf of His Majesty the King of Norway, Mr. Steen extended a cordial welcome to the members of the Conference. He said that they were assembled, as all knew, to draw up their final proposals for an international investigation of the North and adjacent seas. Repeated attempts on an isolated footing had been made to solve the problems of the sea and of the manifold life beneath its surface, and only after ripe experience had the different nationalities come to recognise that co-operation in their labours was essential to success. The task before them was not only an intellectual enterprise of the highest order, but also an application of knowledge in the service of the industrial life of society. It might be difficult to help the fisherman to know where to shoot his nets with the same certainty of a harvest as that with which the farmer manipulated his land and crops. Nevertheless, that was their aim; and if it were only approximately realised, sea-fishing would become the object of intelligent management, relieved of the caprices of chance which at present characterised it. Norway long ago took up and had constantly extended the scope of her scientific investigations

upon the life and wanderings of food-fishes. The steamer which they had specially built and equipped for these inquiries had proved satisfactory in every way. As a consequence of their first investigations a new outlook had opened up for their fatherland, with its extensive seaboard and its rich fishing-banks: the prospect of obviating disappointments, the loss of time and labour, and the distress which followed in their train.

Repeating his wish that the labours of the Conference might lead to a satisfactory issue, Mr. Steen formally declared the opening of the proceedings of the Conference.

Dr. Herwig (Germany) thanked the Prime Minister for his good wishes, and spoke of the vast scientific and economic importance of the work which the Conference was to take in hand. As regards Germany, he was glad to say that she was contributing to the work not in name only but in deed, the National Assembly having voted both the money necessary for the construction of a special exploring vessel, and also a sum sufficient for the participation of the Empire in the scientific researches for a period of five years.

Prof. D'Arcy Thompson (Great Britain) and Dr. Knipowitsch (Russia) addressed His Excellency on behalf of the other countries represented, and associated themselves with Dr. Herwig's expression of thanks, recognising at the same time the active collaboration of the Norwegians in these scientific researches.

Upon the proposition of Dr. Herwig, Prof. Nansen was elected President of the Conference with acclamation.

Having taken the chair, Prof. Nansen thanked the Conference for the honour they had done him. He proposed to proceed without delay to the nomination of Vice-Presidents, one for each country represented, and for the sake of continuity proposed the re-election of those who had been Vice-Presidents at Stockholm; viz. Dr. Herwig (Germany), Capt. Drechsel (Denmark), Prof. Hoek (Holland), Prof. Pettersson (Sweden), and Dr. Knipowitsch, in the absence of Prof. von Grimm (Russia). As regards England, he proposed to await the arrival later in the day of Sir Colin Scott Moncrieff, Under-Secretary for Scotland. The Belgian delegates had not yet arrived.

These proposals were unanimously accepted.

The meeting adjourned at 1.15 p.m., to meet again at 2.30 p.m. in the reception room of the Grand Hotel, where the business of the Conference would be transacted.

2.30 p.m. Prof. Nansen (Norway) in the chair.

Present: All the delegates except those of Belgium and Prof. von Grimm, who was prevented by illness from attending. The British

delegates, Sir Colin Scott Moncrieff, Mr. Garstang, and Dr. Mill, arrived at 3 o'clock.

It was resolved, on Dr. Herwig's proposition, to follow the same order of business as at Stockholm. The President proposed that they should take the Stockholm programme as the basis of discussion, and thought that a division into two sections, for hydrography and biology, would be unnecessary on this occasion. The Conference agreed.

Dr. Herwig (Germany) proposed that they should discuss the biological questions first, as these had been less elaborated than those relating to hydrography, and would consequently demand more time.

Prof. D'Arcy Thompson (Great Britain) approved of this suggestion, and the Conference accepted it.

Upon the proposition of Prof. Pettersson (Sweden), Dr. Hjort (Norway) was elected General Secretary.

Dr. Herwig, on behalf of the German delegates, submitted a draft programme of biological researches for the consideration of the Conference.

The Conference rose at 3.30 p.m.

TUESDAY, MAY 7TH.

11 a.m. Dr. Herwig (Germany) in the chair.

Present: All the delegates except those of Belgium.

The Conference discussed the programme of biological investigations.

The Chairman submitted for consideration certain proposals of Drs. Hjort (Norway) and Petersen (Denmark), together with some suggestions of Dr. Knipowitsch (Russia).

After a preliminary discussion of various points before the general meeting it was resolved to entrust to a committee the task of drawing up a new biological programme, in which a distinction should be drawn between investigations obligatory upon all the states concerned (*i.e.* a minimum programme), and such investigations as were desirable, but not compulsory, for the participating states. In general, the proposals of Drs. Hjort and Petersen were to be taken as establishing the minimum programme. The questions of plankton and the bottom fauna were reserved for subsequent consideration.

Prof. Pettersson and Dr. Trybom (Sweden) drew attention to the fact that all the countries concerned would probably not be equally prepared for the collection of statistical data over their entire extent; and that for such countries the measurement of the fishes caught during the scientific expeditions should suffice.

Mr. Garstang (Great Britain) drew attention to a paragraph in the German proposals which dealt with investigations concerning the cap-

ture of undersized fish. These had a special interest for England, and the British Government attached much importance to them.

Some further discussion took place concerning the German proposals as to the subdivision of territory for biological exploration among the different states.

Mr. Garstang proposed that the English Channel be included within the area of investigation, as being a channel of great importance for the supply of Atlantic water into the North Sea.

Prof. Nansen (Norway) recalled that it was decided at the Stockholm Conference to allot this territory to France and Belgium, if these countries should desire to take part in the international researches. Now that it was settled that France was not to participate, it was naturally to be desired that England and Belgium together would undertake to carry out the investigations in the Channel.

The general question of the delimitation of areas was then referred to committee for more ample consideration.

The following were elected members of the Biological Committee:— Messrs. D'Arcy Thompson, Garstang, Heincke, Henking, Hjort, Hoek, Knipowitsch, Nordqvist, Pettersson, Trybom, with Dr. Gran as Secretary.

The Conference rose at 1.30 p.m.

WEDNESDAY, MAY 8TH.

11 a.m. Prof. Pettersson (Sweden) in the chair.

Prof. Krümmel (Germany) proposed that the hydrographical programme should be provisionally discussed in full congress. The resolution was accepted, and the successive paragraphs of the Stockholm programme passed under review.

A discussion arose as to the margin of time which might be allowed for the seasonal hydrographic cruises in order to satisfy the conditions as to simultaneity.

Messrs. Hjort (Norway), Knipowitsch (Russia), Drechsel (Denmark), and several others remarked that the operations, especially in northern waters and during the winter, would be attended by great difficulties, which might prevent the carrying out of the researches between narrow limits of time.

On the other hand, Mr. Ekman (Sweden) and others were of opinion that the hydrographic conditions changed so quickly in the more restricted areas (*e.g.* Kattegat, Skagerrak, North Sea) that the utmost simultaneity in the observations was desirable.

Upon the proposition of Messrs. Krümmel and Herwig the question was decided in the form given below (A. II., § 2).

Various minor changes were made in the hydrographical programme,

and Messrs. Krümmel and Mill were requested to incorporate the amendments in a revised programme to be submitted to the Conference for approval.

The meeting adjourned at 1.30 p.m.

2.30 p.m.

After the Chairman had communicated some telegraphic correspondence with the Belgian delegates, the Conference took up the consideration of the subjects of plankton and the bottom fauna.

A committee consisting of Messrs. Brandt, Cleve, Garstang, Heincke, Hoek, Knipowitsch, and Gran was appointed to draw up a set of proposals on these subjects in connection with the biological programme.

A committee consisting of Messrs. Krümmel, Mill, and Pettersson was appointed to draw up resolutions—(1) as to the desirability of working up the hydrographic material according to the methods of Bjerknes and Sandström (see Resolution J); and (2) as to the desirability of arranging for co-operation with the proposed researches on the temperature of lakes announced by Prof. Forel, of Zurich (see Resolution K). Dr. Herwig assumed that these matters would involve no extra charge on the international budget. As regards the first, the Chairman announced that Sweden was prepared to pay the cost of preliminary researches on the matter; and he supposed that, if these inquiries yielded very important results, the other States, as well as Sweden, would desire to continue the work.

THURSDAY, MAY 9TH.

11 a.m. Prof. Hoek (Holland) in the chair.

The Chairman submitted the printed proposals prepared by the various committees; viz.:—

(1) Additions to the hydrographical programme;
(2) The programme of biological investigations; and
(3) The supplement to the latter in regard to plankton and the fauna and flora of the sea-bed.

The hydrographical programme was accepted without change.

The biological programme was then adopted, paragraph by paragraph, with slight modifications and additions proposed by Messrs. Heincke, Brandt, and D'Arcy Thompson.

Prof. Henking (Germany) proposed that statistical data should be accumulated, with the assistance of fishermen, according to the method followed at Geestemünde.

A committee consisting of Messrs. Garstang, Heincke, Hjort, Hoek, Krümmel, Mill, and Gran was authorised to fix the final form of the

programme in accordance with the resolutions adopted by the Conference.

The Chairman read a telegram from the Belgian Government authorising the Belgian Consul to attend the Conference, owing to the illness of the delegates appointed.

The Conference rose at 1 p.m.

FRIDAY, MAY 10TH.

10.30 a.m. Sir Colin Scott Moncrieff (Great Britain) in the chair.

The Belgian Consul, M. Andvord, was present.

The Chairman proposed the despatch of a telegram to the King of Norway.

The Council of Vice-Presidents was authorised to prepare and sign the telegram; to consider the question of the establishment of a Central Bureau; and to consider a proposition of the Chairman's relative to an international understanding with regard to the conditional prohibition of the use of fishing appliances, as for example in the Moray Firth.

Dr. Knipowitsch (Russia) proposed the addition of Mr. Nordqvist to the Council of Vice-Presidents, on the ground that Finland, although to be regarded as part of the Russian Empire, was participating in the explorations in a special manner, and was contributing the necessary funds on its own account. The proposition was accepted.

The Chairman proposed that Dr. Knipowitsch take the chair on the morrow; but the latter declined so that the final meeting might be presided over by Prof. Nansen.

The meeting adjourned at 11 a.m., and met again at

3.30 p.m.

The Chairman read the following telegram addressed to His Majesty:

À sa Majesté le Roi Oscar II., Stockholm.

Réunis à Kristiania pour continuer les travaux préliminaires dont le but est l'étude des Mers du Nord de l'Europe et qui ont été inaugurés si heureusement à Stockholm il y a deux ans,

nous nous souvenons avec une profonde et respectueuse gratitude de l'initiative de votre Majesté et du grand intérêt qu' Elle a daigné témoigner à nos travaux.

L'exemple si élevé donné par votre Majesté, l'amour pour la science, montré à si differentes reprises, nous a encouragé et nous a été d'un très grand appui.

C'est grace à lui que nous comptons arriver avec nos délibérations à des résultats très favorables au developpement du bien-être humain.

(Signed by the President, Vice-Presidents, and General Secretary.)

The Chairman announced that the Council of Vice-Presidents, at a private conference, had been occupied with various propositions concerning the central organisation. They had come to a unanimous agreement in regard to these propositions, which would be forthwith communicated to the Governments concerned, but could not be regarded as matters for discussion.

The Chairman submitted to the Conference a resolution, drawn up by the Council of Vice-Presidents, which was accepted (Resolution G, concerning the Moray Firth).

Mr. Garstang (Great Britain) submitted a resolution concerning the publication of an annual report, which was unanimously accepted (see C, § 4).

Prof. Krümmel (Germany) submitted three resolutions, which were accepted (Resolutions D, H, J).

Dr. Mill (Great Britain) submitted a resolution, which was also adopted (Resolution K).

The Conference rose at 5 o'clock.

SATURDAY, MAY 11TH.

11.30 a.m. Prof. Nansen (Norway) in the chair.

The following reply from His Majesty the King of Norway was read:—

Congrès hydrographique, Kristiania.

Très reconnaisant pour l'aimable télégramme des Présidents et Vice-présidents, au nom du Congrès, je fais des vœux bien sincères pour le meilleur résultat de ses déliberations dans un but si utile et si intéressant.

Oscar.

M. Gilson, the Belgian delegate, read a programme of the researches which Belgium proposed to undertake as its share in the international explorations. He also proposed that M. Thoulet, Professor at the University of Nancy, should be invited to participate as if a member of the International Conference.

The Conference found it *ultra vires* to accept a proposition of this nature, while regretting that M. Thoulet was not included among the delegates.

The resolutions of the Stockholm Conference with regard to the central organisation were then approved after introduction of certain alterations (see below, Resolution C).

Dr. Herwig (Germany) submitted resolutions concerning the date at which the international explorations should commence, and concerning the first meeting of the International Council, which were accepted (Resolutions E and F).

The work of editing the minutes and arranging the Resolutions for publication was entrusted to a committee consisting of Messrs. Garstang, Heincke, Hjort, Knipowitsch, and Knudsen.

RESOLUTIONS OF THE CONFERENCE, UNANIMOUSLY ADOPTED BY THE UNDERMENTIONED DELEGATES.

Messrs. Brandt, Cleve, Drechsel, Ekman, Garstang, Heincke, Henking, Herwig, Hjort, Hoek, Knipowitsch, Knudsen, Krümmel, Mäckel, Mill, Moncrieff, Nansen, Nordqvist, Petersen, Pettersson, D'Arcy Thompson, Trybom, Wijkander.

Considering that a rational exploitation of the sea should rest as far as possible on scientific inquiry, and considering that international co-operation is the best way of arriving at satisfactory results in this direction, especially if in the execution of the investigations it be kept constantly in view that their primary object is to promote and improve the fisheries through international agreements, this International Conference resolves to recommend to the states concerned the following scheme of investigations which should be carried out for a period of at least five years.

Programme for the Hydrographical and Biological work in the Northern parts of the Atlantic Ocean, the North Sea, the Baltic and adjoining Seas.

A.

THE HYDROGRAPHICAL WORK.

I.

§ 1. The hydrographical researches shall have for their object: the distinction of the different water-strata, according to their geographical distribution, depth, temperature, salinity, gas-contents, plankton, and currents, in order to find the fundamental principles not only for the determination of the external life-conditions of useful marine animals, but also for weather forecasts for extended periods in the interest of agriculture.

II.

§ 2. As the hydrographical conditions are subject to seasonal changes, and as these strongly influence the distribution and life-conditions of useful marine animals, as well as the state of the weather and other general meteorological conditions, it is desirable that the observations should be made so far as possible simultaneously at definite points along

the same determined lines in the four typical seasons, so that the middle of the period of working shall be in the first half of February, May, August, and November respectively. The Central Council shall decide how much variation in the date of the seasonal cruises is permissible, having regard to the natural conditions of the different regions in which researches are to be carried out.

III.

The observations referred to in II. would consist of:—

§ 3. Observations of temperature, humidity, and pressure of the air every two hours. Assmann's aspiration thermometer should be used, and self-registering instruments (thermometer and barometer) for interpolation.

Opportunities on board the ships should be afforded to the meteorological offices to make physical observations on the higher levels of the atmosphere by means of kites.

The other meteorological observations are to be carried out according to the methods adopted by the meteorological offices of the nations represented.

The observations, meteorological as well as hydrographical, made on board the special steamers at the time of the survey in the typical months, are to be immediately worked out under the supervision of the Central Bureau (see C) for publication in a Bulletin, wherein the conditions of the sea and the atmosphere are to be represented by tables and synoptic charts in co-operation with the meteorological institutes of the nations represented.

§ 4. The temperature of the surface water shall be taken every two hours or, when necessary, more frequently. It is desirable that self-registering apparatus should be used for interpolation.

Observations on the vertical distribution of temperature are to be taken at the points mentioned in II., and should be taken regularly at intervals of 0, 5, 10, 15, 20, 30, 40, 50, 75, 100, 150, 200, 250, 300, 400 metres, and so on; but all critical parts of the curve must be determined by extra readings.

The bottom temperature is to be investigated with all possible care.

§ 5. At every point and from every depth where the temperature is observed, a sample of water shall be collected for the determination of its salinity and density.

By *salinity* is to be understood the total weight in grammes of the solid matter dissolved in 1,000 grammes of water.

By *density* is to be understood the weight in grammes of 1 cubic centimetre of water of the temperature *in situ* t°, *i.e.* the specific gravity *in situ* referred to pure water of + 4° C. $\left(= S\frac{t^\circ}{4^\circ}\right)$.

§ 6. Preliminary determinations of the salinity may be made on board ship with appropriate instruments, but the exact determinations of the salinity and density of water samples shall take place in a scientific laboratory on shore. The ratios between Salinity, Density, and Chlorine, given in Dr. Martin Knudsen's Hydrographic Tables, are to be adopted, and the salinity is to be calculated by the use of these Tables from the determinations of chlorine, or from the specific gravity.

§ 7. At certain depths at the points mentioned in II. and elsewhere on the surface, water samples should be collected for analysis of the gas-contents (oxygen, nitrogen, and carbonic acid).

IV.

§ 8. For measurement of depth the *unit* to be adopted is the metre, together with which the depth may be also recorded in English fathoms.

Geographical points are to be referred to the meridian of Greenwich, and horizontal distances are to be expressed in sea miles (= 1,852 metres).

§ 9. Thermometers to be used for the determination of the surface temperature may be either centigrade or Fahrenheit, but for publication all numbers are to be reduced to centigrade.

In the centigrade thermometers for observation of surface temperatures, the distance between two degree marks should be at least 5 mm., and the degree be divided into at least two parts, the Fahrenheit thermometer to be divided in a corresponding manner.

The use of an insulated water-bottle on Pettersson's principle is recommended for moderate depths, and the thermometers used for this apparatus should have a space of at least 10 mm. between the marks of one degree, and the degree should be divided into 10 parts.

For greater depths of the ocean, reversing or other similar thermometers should be used.

The glass to be used for the thermometers should be tested and approved, and the thermometers periodically verified by the Central Bureau (see C. III. § 12).

§ 10. For the determination of salinity and density, either chemical or physical methods may be adopted, provided that the salinity can be determined with an accuracy of $0{,}_{05}$ in a thousand parts (and the density up to $0{,}_{00004}$).

The determination of these constants can be founded either upon chemical analysis of the halogen by weighing or titration, or upon physical determination of the specific gravity by means of the hydrostatic balance, pycnometer, and hydrometer, provided that measures be taken to exclude disturbances arising from thermal effects, capillarity, viscosity, etc.

The same standard sea-water* shall be employed in all cases for standardising the solutions used for chlorine determinations.

The chemical analysis shall be controlled by physical methods, and the physical determinations by chemical analysis in the following manner: From every collection of samples examined at least three shall be selected and sent to the Central Bureau. *Standard samples* shall be sent in return.

V.

§ 11. Samples for gas analysis are to be collected in duplicate in sterilised vacuum tubes.

It is desirable that the existing tables of absorption of nitrogen and oxygen shall be revised.

VI.

§ 12. Qualitative plankton samples should be taken as frequently as possible from the surface by approximate methods simultaneously with the water samples, and also from deeper layers at the stations referred to in § 2 (see below, B. VI., § 12).

§ 13. Observations of the transparency and colour of the water should, when possible, be made at the same points.

VII.

§ 14. Observations on currents and tides should be carried out as frequently as the circumstances allow.

The currents should be examined, when possible, by direct current-meters, and by surface and intermediate floats, and by bottom-rollers.

The ship should be anchored occasionally in order to make frequent observations during a complete period of tide.

VIII.

§ 15. It is desirable that a chart should be prepared, showing the nature of the deposits on the sea-bottom.

The description of the deposits is to be carried out on a definite plan, to be afterwards settled by the Central Bureau.

IX.

§ 16. The normal observations are to be carried out along the lines provisionally drawn on the annexed chart, where *R* denotes the Russian, *F* the Finnish, *S* the Swedish, *G* the German, *Da* the Danish, *Du* the Dutch, *N* the Norwegian, and *B* the British lines; but the Central

* By *standard* water shall be understood samples of filtered sea-water, the physical and chemical properties of which have been determined with all possible accuracy by analysis, and statements of which are sent to the different laboratories, together with samples.

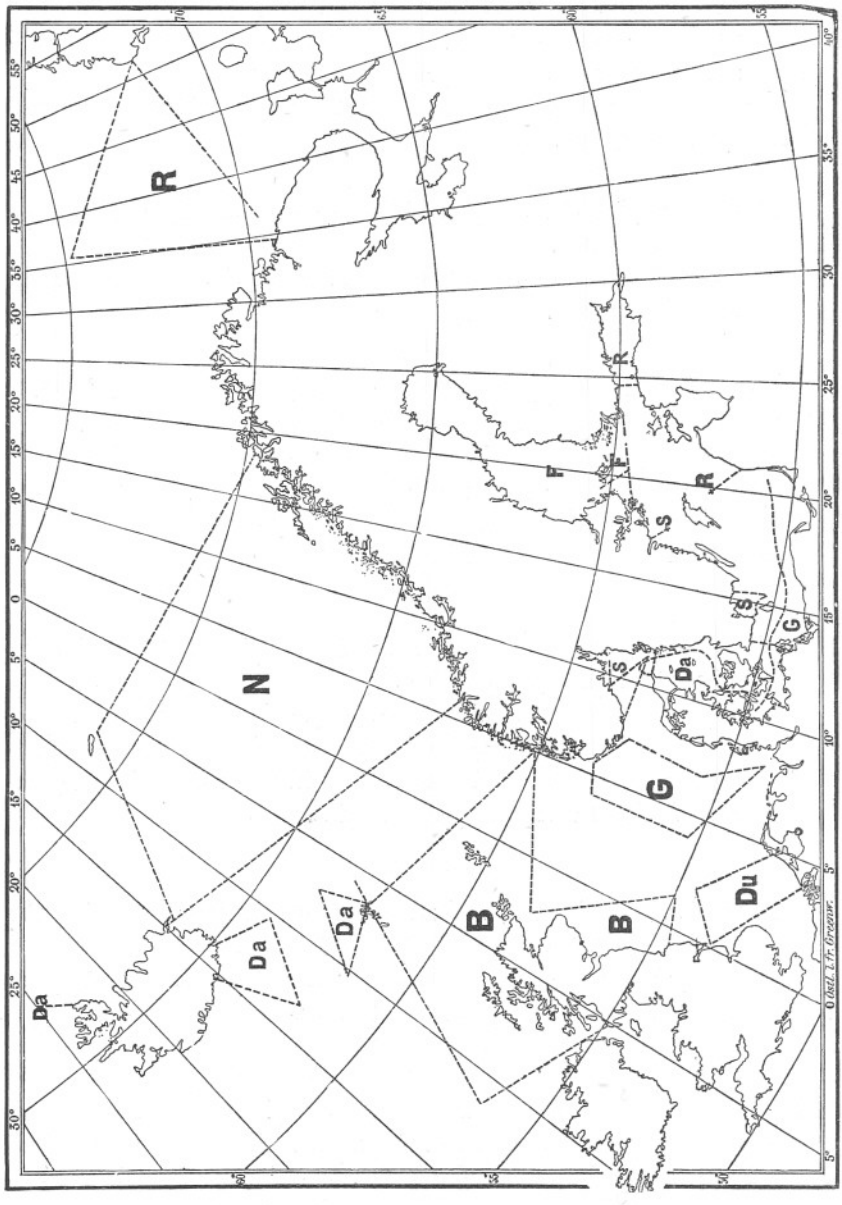

CHART SHOWING THE LINES OF OBSERVATION RECOMMENDED BY THE STOCKHOLM CONFERENCE, ADOPTED WITH SLIGHT MODIFICATIONS BY THE CHRISTIANIA CONFERENCE.

Council shall have authority to make any necessary alterations in these lines, or in the regions where each nation is to work.

The special points are to be decided by the respective nations, and when once chosen the subsequent observations are to be repeated at the same points.

The special instructions for the work will also be given by the respective nations, and the communications as to the extent and the nature of the observations shall take place through the Central Bureau (see C).

X.

§ 17. It is desirable to supplement these investigations by making use of regular liners, light-ships, etc., and coast-stations for the purpose of taking temperature observations and collecting samples of sea-water and plankton. These observations are to be taken not only in the typical months, but also during the intervening periods.

B.

THE BIOLOGICAL WORK.

In each section of the programme which follows, note that—

Roman type indicates those investigations which all the participating countries undertake to carry out simultaneously.

Italics indicate those parts of the complete programme, the carrying out of which is desirable, but optional.

Delimitation of Areas.

I.

§ 1. It is recommended that each of the nations taking part in the international investigation should undertake the biological study of a definite area to be decided on as in the case of the hydrographical work and to correspond with the divisions adopted for that purpose.

The following is suggested as a preliminary division :—

A. North Sea south of 54° N.

1. From 2° E. eastward to Borkum Reef: Holland and Belgium.

2. From Borkum Reef to the Elbe: Germany.

3. From 2° E. westward to the British coast, including the English Channel: Great Britain and Belgium.

B. North Sea, from 54° N. to 58° N.

1. From 2° E. eastward to Jutland and the Naze: Germany and Denmark.

2. From 2° E. westward: Great Britain.

C. North Sea, north of 58° N., and North Atlantic to about 62° N. (the Faröes): Great Britain, Norway, and Denmark.

D. Atlantic Ocean and Arctic Sea north of 62° N.: Norway and Russia.

E. Skagerrak and Kattegat: Norway, Sweden, and Denmark.

F. Western Baltic: Germany, Sweden, and Denmark.

G. Eastern Baltic.

1. Southern part, extending to Bornholm and the Gothland bank on the north and to Memel on the east: Germany.

2. Northern part, including the Gulfs of Finland and Bothnia: Sweden, Russia, and Finland.

It is impossible, as well as undesirable, to draw a hard and fast line between the areas allocated to the various states, and of course the suggested boundaries are not intended to hinder any nation from extending its researches beyond the special areas agreed upon.

Biology of Food-Fishes.

II.

§ 2. Preparation of charts showing the distribution of plaice, sole, turbot, cod, haddock, and herring in the North and Arctic Seas, and of flounder, cod, sprat, and herring in the Baltic, in their different stages of growth, from the earliest stage which is passed upon the bottom up to the full-grown condition.

The investigations to this end are to be carried out as often as possible and, as far as possible, with uniform apparatus, *e.g.* with trawls of different size and mesh, drift-nets, hooks, etc. Measurements of all the fishes caught on each occasion are to be made in such a way as to yield a graphic representation of the relative number of the fishes at every stage of growth. The fullest possible data are to be given concerning sex, degree of maturity, and contents of stomach.

Each fishing operation is to be treated as a scientific experiment, and all the conditions of the experiment are to be carefully recorded (viz. place, depth, nature of bottom, state of water, wind and weather, rate and duration of haul, kind and size of net, etc.). The scheme submitted by Dr. C. G. Joh. Petersen to the Conference may be cited as an example of the journal record of a catch treated in this way.

§ 3. *Efforts should be made to secure a methodic investigation of all marine food-fishes as well as of the most important of those species which make regular migrations from fresh water to the sea, from the egg up to the full-grown condition, and with reference to development, growth, nutrition, reproduction, fecundity, distribution, migrations, and local varieties, and with constant reference to the hydrographic conditions of life.*

As the most important means of carrying out these investigations, fishing experiments of different kinds are to be undertaken in order to elucidate the distribution of food-fishes in the various parts of the sea. In this connection attention should be especially directed to the determination of the depths (whether on the bottom or in the intermediate layers of water) at which particular species of food-fishes can be caught.

It is much to be desired that labelled (or marked) fishes of important species (e.g. plaice, salmon, etc.) should be liberated in as large numbers as possible and over wide areas.

Special researches should also be directed to determine the extent to which important food-fishes are destroyed by their natural enemies.

§ 4. *In connection with the fishing experiments it is desirable that investigations should be made to determine the extent to which the vitality of the fishes caught with the trawl and other fishing implements is affected thereby, and whether such fishes are, or are not, in a condition to live after liberation.*

III.

§ 5. Determination of the quantitative distribution of the eggs, pelagic larvæ, and young fishes of the species mentioned in II. § 2, during the periodic cruises proposed in the hydrographic programme and at the stations fixed for those cruises.

The investigations are to be carried out, firstly, by vertical hauls with Hensen's large egg-net, and secondly, with larger horizontal nets adapted thereto.

§ 6. *It is further desired that the eggs and larvæ of the above-mentioned food-fishes should also be collected and accurately studied in the intervals between the hydrographic cruises, and especially during the spawning periods of these fishes.*

§ 7. *Experiments are further desired upon the artificial fertilisation and hatching of the eggs of the most important of the food-fishes mentioned, not only on the steamers for scientific work, but also on board commercial fishing-vessels and on shore.*

IV.

§ 8. Investigations upon the local varieties of plaice, herring, and mackerel in the entire international area of research are to be assisted by the collection of suitable material in all countries, to be placed at the disposal of individual specialists for detailed investigation, through the agency of the Central Bureau.

§ 9. *It is desirable that such investigations should be extended also to other useful species of animals.*

V.

§ 10. With reference to the question of the extent of the destruction of immature (undersized) fish in the ordinary practice of sea fishing, it shall be a primary object of the fishing experiments to delimit those parts of the sea in which young food-fishes, especially plaice and haddock, occur in great abundance, and to subject these regions to exact biological investigation.

Attempts shall also be made in the larger fishing ports of the North Sea to determine the relative number of such young food-fishes below the average size of maturity (especially plaice and haddock). which are landed by the different methods of fishing, and at different times of the year.

§ 11. *It is desirable to determine the amount of the catches of immature (undersized) food-fishes, especially of plaice and haddock. To this end the official statistical records in the fishing ports should be utilised in the first place, and in the second place the fishing experiments and the analysis of their catches as specified under II.* § 2, *and V.* § 10. *Still richer material will be obtained, if favourable opportunities also occur for sending competent experts on board fishing vessels, in order to determine exactly the quantity and size of the immature (undersized) fishes on the fishing grounds themselves, and to record the same for each catch according to a uniform scheme to be determined.*

PLANKTON AND BOTTOM FAUNA.

VI.

§ 12. Qualitative plankton samples are to be taken as often as possible during the hydrographic seasonal cruises, and not merely from the surface, but also by vertical hauls.

§ 13. *It is desirable that qualitative plankton samples should also be regularly taken in large quantity on other cruises and at definite coast stations, in order to provide plentiful material for more detailed study of the plankton from systematic biological and chemical points of view. The use of closing nets and water-bottles, as well as the filtration of the smallest organisms, is recommended.*

VII.

§ 14. If circumstances permit, quantitative hauls shall be taken with Hensen's plankton-net at the chief hydrographic stations, and be placed through the agency of the Central Bureau at the disposal of those investigators who are prepared to undertake a thorough quantitative investigation.

§ 15. *Control experiments to check the accuracy of the quantitative methods are desirable, as well as quantitative hauls for chemical analysis.*

VIII.

§ 16. Endeavours shall be made with suitable apparatus to investigate more exactly the organisms which inhabit the lowest water layers immediately above the bottom.

§ 17. *Quantitative investigations of this material are also to be desired.*

IX.

§ 18. Systematic investigations upon the macroscopic animal and plant life of the bottom, with special reference to the nutrition of food-fishes.

§ 19. *More detailed investigations are desirable upon the bottom fauna and flora in general, as well as with reference to their dependence on the physical and chemical conditions of the ground.*

Efforts should be made to determine the general topography of the bottom fauna, in order to bring the main faunistic regions into relation with our knowledge of hydrographical conditions, and the distribution of marine food-fishes.

Opportunities should also be given to bacteriologists to carry out investigations upon the bacteria of the sea-bottom, as well as of the overlying water, and to make determinations of the inorganic nitrogenous compounds present in the water.

Fishery Statistics.

X.

§ 20. Elaboration of uniform critical statistics of the sea-fisheries of the participating states, especially giving particulars of the food-fishes landed from those parts of the sea which lie within the international area (especially from the Norwegian and North Sea), according to species, place of capture, time of capture, number and weight.

Particular care is to be given to the preparation of exact statistics of the herring fishery, according to place, time of year, degree of maturity, and dependence on special hydrographic conditions.

Material shall be collected for the preparation of fishery charts, on which the different fishing grounds, and the fisheries conducted thereon, shall be inserted.

§ 21. *In connection with the fishery statistics it is also desirable to determine as precisely as possible the fishing grounds from which the individual catches have been derived. Above all, in the ground-net fisheries*

should the attempt be made, with the assistance of reliable owners and captains of a large number of fishing vessels belonging to important ports, to obtain exact details concerning their catches, as regards place of capture, duration of fishing, species and amount (both number and weight), and to record these details in uniform schedules to be agreed upon.

C.

ORGANISATION OF AN INTERNATIONAL COUNCIL, A CENTRAL BUREAU, AND AN INTERNATIONAL LABORATORY.

The Conference recommends for the international hydrographic and biological investigation of the seas the establishment of an International Council with a permanent Central Bureau and an International Laboratory.

I.

§ 1. The permanent International Council shall consist of commissioners elected by the Governments interested. Each Government should appoint two commissioners who may be represented at meetings by substitutes, and may be accompanied by experts who, however, shall not be competent to vote.

§ 2. The Council elects its President and Vice-President, and appoints all officials of the Central Bureau. Should the General Secretary represent hydrographical science, one of his principal assistants should be a biologist, and *vice versâ*. The other assistant shall preferably be experienced in statistical work.

§ 3. The Council shall draw up its own order of proceedings.

§ 4. The Conference recommends that the Central Council shall issue, in addition to the ordinary periodical Bulletins, an Annual Report which shall include—

(1) A summary of the work done in each year by the participating countries in carrying out the international programme; (2) an announcement of those discoveries which are of direct practical importance for the fishing industry; and (3) a statement of such recommendations for international action as in the unanimous opinion of the Central Council follow clearly from the international investigations.

§ 5. It will be for the Governments concerned to decide among themselves the amount of the contributions to the central organisation.

The expenses of the central organisation are approximately estimated at £4,800 (96,000 mark) yearly.

Estimate of the Expenditure of the Central Organisation.

	£
1. General Secretary	750
2. Two principal Assistants	750
3. President, for incidental expenses other than travelling expenses	200
4. Vice-President, for incidental expenses other than travelling expenses	100
5. Office, scientific and technical assistants, draughtsmen, clerks, servants, postage, telegrams, and similar expenses	1,350
6. International laboratory	650 *
7. Travelling expenses	300
Note: Travelling expenses of commissioners attending meetings of the Council shall be borne by their respective Governments.	
8. Printing	500
9. Incidental expenses	200
	£4,800 *

II.

The purpose of the Central Bureau will be—

§ 6. To give uniform directions for the hydrographic and biological researches in accordance with the resolutions drawn up in the programme of the present Conference, or in accordance with such modifications as may be introduced later with the consent of the states represented.

§ 7. To undertake such particular work as may be entrusted to it by the participating Governments.

§ 8. To publish periodical bulletins which shall contain the actual data obtained in the cruises of all the participating states at the earliest possible date, and also such other papers as may prove useful in co-ordinating the international work.

§ 9. To make proposals for the graphic representations, scales, signs, and colours to be used in the charts for the purpose of obtaining uniformity in the publications, the decision regarding which shall rest with the International Council.

§ 10. In connection with the investigations, to make application to the telegraph administrations for the purpose of obtaining determinations from time to time of the changes in the resistance of the cables which cross the areas in any direction.

* To this sum is to be added a proposed extra grant from the Norwegian Government.

§ 11. The site of the Central Bureau, to be decided by the Governments concerned, shall at the same time be the residence of the General Secretary.

III.

The purpose of the International Laboratory shall be—

§ 12. To control apparatus and to ensure uniformity of methods.

The various apparatus and instruments now used for oceanic research should be examined, in order to settle which are the most trustworthy. Experiments may also be made to improve the apparatus and instruments, or to construct new and better ones.

§ 13. The water-samples sent by the workers of the participating states are to be analysed and examined at the central laboratory, from which also samples of standard water should be provided.

§ 14. In the central laboratory various important investigations of general interest for oceanic researches may be carried out. The various methods for determining salinity, temperature, gases, plankton, etc., of the sea should be carefully tested, in order that standard methods may be fixed.

§ 15. Facilities should be afforded to the participating states for sending students to the central laboratory to be trained for oceanic researches.

§ 16. The investigators of the participating states, or special expeditions, may, if desired, be supplied from the central laboratory with instruments, apparatus, etc., for oceanic research at cost price.

§ 17. The International Laboratory is subordinate to the Central Council, to which its accounts shall be rendered. Its operations shall be reported to the Central Bureau.

§ 18. The site of the central laboratory shall be decided by the Governments concerned, and should be conveniently situated for oceanic researches.

D.

The Conference considers it absolutely indispensable that each of the countries concerned should provide a steamer specially constructed for scientific fishery researches.

E.

It is very desirable that the first periodical cruise should take place as soon as possible, but be not postponed beyond May, 1902, at latest.

The Central Bureau shall commence operations as soon as possible, but not later than the beginning of 1902.

F.

The Conference recommends that the International Council should meet at Copenhagen as soon as the participating Governments have definitely accepted the programme of the Conference; and if that should not be possible, that each Government should send a delegate (accompanied, if desired, by specialists) with full powers to decide what regulations should be made for the prompt constitution of the Central Bureau.

G.

In distinct areas of the sea, as for instance the Moray Firth, in which any Government has undertaken scientific experiments in the interest of the fisheries, and in which the success of the experiments is being hindered by the operations of trawlers, it is to be desired that measures be adopted for the removal of such hindrances.

H.

The Conference recognises the extreme value of Dr. Martin Knudsen's hydrographic tables, and expresses its cordial thanks to him for his admirable work.

The Conference desires that the Central Bureau should be authorised to pay the balance of the expenses of the investigation not covered by the grants already received from Governments and scientific institutions, either out of the general funds, or from any special grants made for the purpose.

J.

The Conference considers it desirable that the hydrographic material should not only be published by the Central Bureau in tabular form, but also that the results should be worked up in such a form as to elucidate the currents of the different layers of water and their relations to wind and to differences of density as motive agencies, by methods similar to those of Mohn and Bjerknes.

K.

The Conference considers it desirable that the International Association for Limnological Studies should, as far as possible, adopt for the investigation of lakes the methods and times of observation approved by this Conference for the study of the sea; and recommends that the Central Bureau should arrange for the regular exchange of the observations made on lakes and on the sea.

L.

The Conference desires to repeat the declaration of the Stockholm Conference that it is of the greatest importance, both for deep-sea fisheries and for the weather forecasts for long periods, that the Faröe Islands and Iceland should be included in the European telegraph system as soon as possible.

(Signed) NANSEN, *President.*
HJORT, *General Secretary.*

Marine Biological Association of the United Kingdom.

Report of the Council, 1900–1901.

The Council and Officers.

There have been four ordinary and two special meetings of the Council during the year, at which the average attendance has been eight. All the meetings were held in the rooms of the Royal Society, and the Council desires to express to the Society the thanks of the Marine Biological Association for the courtesy extended.

The Plymouth Laboratory.

The Plymouth Laboratory has been maintained in a state of efficiency. The smaller of the two gas-engines, which is used for keeping the continuous circulation of sea-water through the aquarium tanks, has been replaced by a new Crossley engine of the latest pattern, and from experience up to date it is anticipated that this change will result in a considerable saving in the cost of working. The pumps have been repeatedly repaired, and will probably do their work for another year or two, after which considerable expense must be faced for their complete renewal.

The Boats.

A favourable opportunity having presented itself for the sale of the steamboat *Busy Bee*, this vessel was disposed of for the sum of £700. The *Busy Bee* was purchased by the Association in 1895 for £600, and £100 was afterwards laid out in fitting her with a steam-winch and other necessary gear for dredging and trawling. Since the date of her purchase she has been constantly at work, and has done good service in the exploration of the inshore waters in the neighbourhood of Plymouth.

The Council has now bought for £850 a larger vessel, the steamship *Oithona*. The *Oithona* is 69 tons gross register, as against the *Busy Bee's* 23 tons, 84 feet long, with a beam of 16 feet, and her bunker

capacity should suffice for a week's consumption. A vessel of this size will make much more extended work possible, and can be used for carrying out investigations over the whole of the English Channel and the southern parts of the North Sea.

In considering the low price at which this steamer was purchased, it must be recognised that within the next two or three years she will probably require a new boiler.

The Council was encouraged to face the additional expenditure which the maintenance of a vessel of this size will involve by the promise of the following donations towards a fund for the working expenses of the first four years, viz. G. P. Bidder, Esq., £200, T. H. Riches, Esq., £100, the Hon. R. Guinness, £20. The thanks of the Association are due to these gentlemen for their timely generosity.

The floating laboratory *Dawn*, kindly placed at the disposal of the Association by Mr. J. W. Woodall, was stationed last summer at Salcombe, and proved very suitable for the work required of her. Mr. Woodall has now further improved the boat by the addition of a well-lighted deck-house, which will be used as a workroom. She will be stationed this season at Exmouth.

During the winter months most of the collecting work at Plymouth was done with the sailing boat *Anton Dohrn*.

The Staff.

In consequence of an arrangement made with the Technical Instruction Committees of the Devon County Council and the Plymouth Borough Council, an additional naturalist for fishery research has just been added to the staff, the gentleman appointed being Dr. H. M. Kyle, of the Gatty Marine Laboratory, St. Andrews. Dr. Kyle will spend a portion of his time in conducting classes at the Plymouth Laboratory for the technical instruction of fishermen and in visiting the different fishing centres in the county for a similar purpose, whilst the remainder will be spent in carrying out fishery investigations.

By an arrangement with the Plymouth Technical School, the biological lecturer at that institution has been granted the free use of a table at the Laboratory on condition that he undertakes a definite research approved by the officers of the Association. This table has been occupied during the year by Mr. Stuart Thomson, who has been engaged in an investigation having an important bearing upon practical fishery questions.

The other members of the staff remain as before, namely the Director (Dr. E. J. Allen), the Naturalist in Charge of Fishery Investigations (Mr. Walter Garstang), and the Director's Assistant (Mr. R. A. Todd).

Notwithstanding the additions mentioned above, it may be pointed out that, especially with the larger steamboat now purchased, the staff of investigators is quite insufficient to get the maximum advantage from the plant provided by the Association. With a negligible addition to the working expenses, the Laboratory is now in a position to provide accommodation and material for several more naturalists working throughout the whole year, but the restricted balance-sheet leaves absolutely no funds for additional salaries.

Occupation of Tables.

In addition to the Officers employed by the Association, the following naturalists have been engaged in research work at the Plymouth Laboratory during the year:—

W. M. Aders, Marburg (Hydrozoa).
E. A. N. Arber, B.A., Cambridge (Marine Algæ).
G. P. Bidder, M.A., Plymouth (Sponges).
L. W. Byrne, London (Fishes).
Miss A. Collins, University College, London (General Zoology).
A. D. Darbishire, Oxford (Crustacea).
Sir Charles Eliot, K.C.M.G., C.B. (Nudibranchiata).
F. W. Gamble, D.Sc., Owens College (Mysidæ).
E. S. Goodrich, M.A., Oxford (Fishes).
T. V. Hodgson, London (Polychætes).
Dr. J. N. Langley, Cambridge (Fishes).
J. W. S. Macfie, Cambridge (General Zoology).
R. S. Punnett, B.A., St. Andrews (Fishes).
S. D. Scott, B.A., Cheltenham (Ascidians).
J. S. Thomson, Plymouth (Fishes).

Eleven students from Oxford, Cambridge, and the Yorkshire College attended Mr. Garstang's vacation class in Marine Biology.

The Library.

The thanks of the Association are due for the following books and current numbers of periodicals presented to the Library during the year:—

Transactions and Proceedings of the Royal Society of London.
Royal Society. *Reports of the Malaria Committee.*
Transactions and Proceedings of the Zoological Society of London.
Zoological Record.
Report of the British Association for the Advancement of Science. (Bradford, 1900.)
Journal of the Royal Microscopical Society.
Quarterly Journal of Microscopical Science. (Presented by Messrs. J. and A. Churchill.)
Report of H.M. Inspectors of Fisheries. (*England and Wales.*)
Salmon and Freshwater Fisheries Act. (Report by C. E. Fryer.)

Tenth Annual Meeting of Representatives of Authorities under the Sea Fisheries Regulation Act, 1888.
Sea Fisheries of the United Kingdom, Statistical Tables, etc., for 1900. (Board of Trade.)
Catalogue of the Radcliffe Library, Oxford.
Irish Fisheries. *Inspectors' Report.*
Proceedings of the Royal Dublin Society.
Proceedings of the Royal Irish Academy.
Annual Report of the Fishery Board for Scotland.
Proceedings of the Scottish Microscopical Society.
Report of the Millport Marine Biological Station.
Lancashire Sea Fisheries Committee. *Superintendent's Report.*
Lancashire Sea Fisheries Laboratory *Report.*
Transactions and Annual Report, Manchester Microscopical Society.
Proceedings and Transactions of the Liverpool Biological Society.
Northumberland Sea Fisheries Committee. *Report on Scientific Investigations.*
Proceedings of the Bristol Naturalists' Society.
Cornwall County Council. *Report of the Lecturer on Fishery Subjects.*
Transactions of the Royal Geological Society of Cornwall.
Rousdon Observatory. Meteorological Observations.
Annual Reports of the Department of Marine and Fisheries, Canada.
Transactions and Proceedings of the Royal Society of Canada.
Bulletin of the Natural History Society of New Brunswick.
University of Toronto. *Studies.*
Annals of the South African Museum.
Cape of Good Hope Department of Agriculture. *Report of the Marine Biologist.*
Cape of Good Hope. *Marine Investigations in South Africa.*
Illustrations of the Zoology of the Royal Indian Marine Survey Ship "Investigator."
Administration Report of the Madras Government Museum.
Bulletin of the Madras Government Museum.
Memoirs of the Bernice Panahi Bishop Museum.
Proceedings of the Linnæan Society of New South Wales.
Australian Museum, Sydney. *Memoir IV.;* Parts 2 and 10.
Records of the Australian Museum.
Proceedings of the Royal Society at Victoria.
Fauna Hawiiensis.
Bulletin du Museum d'Histoire Naturelle, Paris.
Bulletin Scientifique de la France et de la Belgique.
Mémoires de la Société Zoologique de France. Bulletin de la Société Zoologique de France.
Congrès International d'Aquiculture et de Pêche. (Paris, 1900.)
Congrès International de Pêches Maritimes et Fluviatiles. (Bayonne—Biarritz, 1899.)
Mémoires présentés au Congrès International des Pêches Maritimes. (Dieppe, 1898.)
Bulletin de la Société Centrale d'Aquiculture et de Pêche.
La Feuille des Jeunes Naturalistes.
Le Mois Scientifique.
Wissenschaftliche Meeresuntersuchungen. Aus der Biologischen Anstalt auf Helgoland.
Mittheilungen des Deutschen Seefischerei-Vereins.
Allgemeine Fischerei-Zeitung.

Mittheilungen aus dem Naturhistorischen Museum in Hamburg.
Bulletin de la Société Impériale des Naturalistes de Moscou.
Laboratoire Ichthyologique de Nikolsk. St. Pétersbourg.
Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg.
Bulletin du Laboratoire Biologique de St. Pétersbourg.
Russian Fishery Journal.
Revue Internationale de Péche et de Pisciculture.
Bergens Museums. *Aarbog.*
Bergens Museums. *Aarsberetning.*
Bergens Museums. *Meeresfauna von Bergen.*
An Account of the Crustacea of Norway. By G. O. Sars. (Bergens Museum.)
Norsk Fiskeritidende.
Svensk Fiskeri Tidskrift.
Oversigt over det Kongelige Danske Videnskabernes Selskabs Forhandlinger.
Jaarsverslag omtrent den Toestand der Visscherijen op de Schelde en Zeeuwsche stroomen.
Trondhjems Biologiske Station. Meddeleser fra stationsanlaeggets Arbeidskomite.
Bihany till Kongl. Svenska Vetenskaps Akademiens Handlingar.
Briefe von Johannes Müller an Anders Retzius.
Selskabet for de Norske Fisheriers Fremme.
Mittheilungen aus der Zoologischen Station zu Neapel.
La Nuova Notarisia.
The Danish Ingolf Expeditions. Zoological Museum, Copenhagen.
Report of the Danish Biological Station to the Board of Agriculture. Dr. C. G. J. Petersen.
Beretning fra Kommissionen for Videnskabelig Undersögelse af de danske Fravande.
Verslag van den Staat der Nederlandsche Zee Visscherijen.
Mededeelingen over Visscherij.
Tijdschrift der Nederlandsche Dierkundige Vereeniging.
Het Zoölogisch Station der Nederlandsche Dierkundige Vereeniging. Dr. P. P. C. Hoek.
La Cellule.
Bulletin de la Société Belge de Géologie.
Annales du Musée du Congo.
Publication de l'État Independent du Congo, 1901. Les Poissons du Bassin du Congo. G. A. Boulenger.
Revista de Pesca Maritima.
Annaes des Sciencias Naturaes.
Bolletino della Società di Naturalisti in Napoli.
Bulletin and Report of the United States Commission of Fish and Fisheries.
Bulletin and Memoirs of the Museum of Comparative Zoology at Harvard College
Bulletin of the United States National Museum.
Bulletin and Annual Report of the American Museum of Natural History.
Annals of the New York Academy of Sciences.
Bulletin of the Illinois State Laboratory.
Publications of the Field Columbian Museum.
Contributions to Biology from the Hopkins Seaside Laboratory of the Leland Stanford Junior University.
Johns Hopkins University Circulars.
Proceedings of the Boston Society of Natural History.
Proceedings of the American Philosophical Society.

Transactions of the American Microscopical Society.
Studies from the Zoological Laboratory, University of Nebraska.
Proceedings of the Natural History Association of Mirimichi.
Tufts College Studies.
Communicaciones del Museo Nacional de Buenos Aires.
Annales del Museo Nacional de Montevideo.
Revista Chilena de Historia Natural.
Journal of the College of Science, University of Tokyo.
Journal of the Fisheries Society of Japan.
Journal of the Fisheries Bureau. Tokyo, Japan.
Annotationes Zoologicae Japonenses.

To the authors of the Memoirs mentioned below the thanks of the Association are due for separate copies of their works presented to the Library :—

Photogenic Bacteria. J. E. Barnard.
Selachian Development. Dr. H. Brauss. (Presented by Mr. R. C. Punnett.)
The Maturation and Fertilization of the Egg of Limax agrestis, Linn. Miss E. F. Byrnes.
The Oyster Reefs of North Carolina. C. Cave.
Plankton from the Red Sea. P. T. Cleve.
Plankton from the South Atlantic and the Southern Indian Ocean. Notes on some Atlantic Plankton organisms. P. T. Cleve.
Report on the Plankton collected by the Swedish Expedition to Greenland in 1899. P. T. Cleve.
Freshwater Fishes and Batrachia of the Peninsular of Gaspe P. Q. and their distribution in the Maritime Province of Canada. P. Cox.
The Circulation of the Waters of the North Atlantic Ocean. H. N. Dickson.
Liste sommarie des Flores et Notes Floristiques. (Region de Paris et Champenoise.) A. Dollfus.
La Photographie des Animaux Aquatiques. M. Fabre Domergue.
Rapport présenté au Ministre de la Marine relative à la mission de la "Vienne" sur les fonds de Péches. M. Fabre Domergue.
Étude sur le rôle et les procédés de la Pisciculture Marine. M. Fabre Domergue.
Die Isolirten Blastomeren des Echinidenkeimes. Dr. H. Driesch.
Studien über das Regulationsvermögen der Organismen. Dr. H. Driesch.
Jamaican Actiniaria. Part 2. *Stickodactylinæ and Zoantheæ.* J. E. Duerden.
The Marine Resources of the British West Indies. J. E. Duerden.
On variation of the rostrum of Palæmonetes vulgaris, Herbst. Dr. G. Duncker.
The Anatomy and Classification of the Arenicolidæ, with some observations on their Post-larval stages. F. W. Gamble and J. H. Ashworth.
Hippolyte varians: a study in colour change. F. W. Keeble and F. W. Gamble.
The Atoll of Minikoi. J. S. Gardiner.
The Natives of the Maldives. J. S. Gardiner.
On the Turbinolid and Oculinoid Corals collected by the Author in the South Pacific. J. S. Gardiner.
On the Astræid Corals collected by the Author in the South Pacific. J. S. Gardiner.
Explorations de la mer sur les Côtes de la Belgique, 1899. G. Gilson.
Note on the name Balanoglossus. S. F. Harmer.

On the occurrence of the "Well Shrimp" Niphargus near Norwich. S. F. Harmer.
On the Structure and Classification of the Cheilostomatous Polyzoa. S. F. Harmer.
A revision of the genus Steganoporella. S. F. Harmer.
The Alcyonaria and Hydrocorallinæ of the Cape of Good Hope. S. J. Hickson.
Report of Crustacea Schizopoda of Ireland. E. W. L. Holt and W. I. Beaumont.
Morphology of the Central Cylinder in the Angiosperms. E. C. Jeffrey.
The Plankton of Echo River Mammoth Cave. C. A. Kofoid.
Molluscous Animals of Scotland. W. Macgillivray.
On Spongioporphyrin, the pigment of Suberites Wilsoni. C. A. MacMunn.
Notes on Polychætes. Miss M. Newbigin.
Museum Normanianum. VI. Supplement to Catalogue of 1890. A. M. Norman.
American Hydroids. The Plumularidæ. C. C. Nutting.
The Fisherman's Nautical Almanack for 1901. O. T. Olsen.
Experiments in Regeneration and in grafting of Hydrozoa. Miss Florence Peebles.
Anatomy of Neohelia porcellana. Miss E. M. Pratt.
On some South Pacific Nemertines collected by Dr. Willey. R. C. Punnett.
Sprot in de Haven van Nieuwediep en de Heincke'sche Methode. H. C. Redeke.
Rhynchodemus Howesi. Dr. R. F. Scharff.
Report on the Sarawak Museum. R. Shelford.
A Description of the Entozoa collected by Dr. A. Willey in the Western Pacific. A. E. Shipley.
The Sea Fisheries of Malabar and South Canara. E. Thurston.
Upon the development of the Enamel in certain osseous Fishes. C. S. Tomes.
Zur Morphologie der Antennen-und Schalendrüse der Crustaceen. F. Vejdovsky.
Certain laws of variation. The reaction of developing organisms to environment. H. M. Vernon.
Cross fertilisation among Echinoids. H. M. Vernon.
The Commoner Foraminifera of the English Channel, from the Hand Deeps to Start Point, at or near the 30-fathom line. R. H. Worth.

General Report.

An account of Mr. Garstang's examination of the experimental and statistical evidence bearing upon the alleged depletion of the Trawling Grounds has been published in the Journal of the Association, in an essay entitled "The Impoverishment of the Sea." This essay has attracted considerable attention, both from scientific experts and from those who take only a practical interest in fishery matters. Mr. Garstang was called upon to give evidence, based upon the results at which he had arrived, before the Select Committee of the House of Commons on the Sea Fisheries Bill, 1900, and before a departmental committee of the Board of Trade, which was making an inquiry into the best methods of collecting fishery statistics.

Mr. Garstang has also published a report upon the remarkable plague of octopus which occurred in the English Channel during the summers of 1899 and 1900, and proved most destructive to the crab and lobster fisheries.

With a view to the arrangement of international co-operation in scientific investigations dealing with sea fisheries, a second Conference recently met at Christiania upon the invitation of the Norwegian Government, and was presided over by Professor Nansen. At this Conference the Association was represented by Mr. Garstang, who was appointed one of the delegates of the British Government. The Conference has drawn up a detailed scheme for the hydrographical and biological investigation of the northern parts of the Atlantic Ocean, the North Sea, and the adjoining seas. The Council of the Association is taking steps to urge upon His Majesty's Government the great importance which it attaches to the successful carrying out of the programme of the Conference, and the desirability of Great Britain taking its full and proper share in the conduct of the work.

Since the commencement of the current year (1901), Mr. Stuart Thompson has been engaged in a research on the periodic growth of fish scales as an index of age. He has directed his attention more especially to the families Gadidæ and Pleuronectidæ, and has been successful in demonstrating that the periodic additions to the size of the scales during growth vary in extent according to the season of the year. The scales thus present a series of annual rings, which can be used to determine the age of the fish with great precision. The results of this inquiry will doubtless be of much value in various branches of fishery investigation.

The examination of the fish population in the estuarine waters of the Hamoaze, which has now been carried on for several years, has been continued regularly.

During the summer of 1900 a detailed investigation was made of the fauna of Salcombe Harbour. For the purposes of this work the laboratory-boat *Dawn*, which had been lent to the Association by Mr. J. W. Woodall, was stationed at Salcombe, and the different shores and channels of the harbour were carefully examined. The results of the investigation were published in the Journal of the Association issued in November.

The systematic examination of the fauna on the grounds in the immediate neighbourhood of Plymouth has been continued, and a large number of records of the local distribution of the various species living in the district have now been brought together in a form convenient for reference. These records furnish the basis for a detailed history of the distribution of the marine fauna of Plymouth.

The Association continues to send out to the Universities, Colleges, and Museums living and preserved specimens of marine animals and plants, and during the present year a large part of the necessary apparatus for dredging and trawling work required by several expeditions,

including the National Antarctic Expedition, has been constructed at the Laboratory under the superintendence of the staff.

It may be mentioned that a growing feature of the work done at the Laboratory is the correspondence with other institutions in various parts of the world, whereby an exchange of experience on definite problems is made, augmenting considerably the efficiency of any one institution.

Published Memoirs.

The following papers, either wholly or in part the outcome of work done at the Laboratory, have been published elsewhere than in the Journal of the Association :—

DARBISHIRE, A.D.—*On the habits of* PINNOTHERES PISUM. Reports Brit. Assoc., Bradford, 1900, p. 399.

DUNCKER, G.—*Variation und Asymetrie bei* PLEURONECTES FLESUS, L. Wissenschaftliche Meeresuntersuchungen, Bd. II. (Helgoland), p. 333, 1900.

GAMBLE, F. W., and ASHWORTH, J. H.—*The Anatomy and Classification of the Arenicolidæ, with some observations on their post-larval stages.* Quart. Journ. Micr. Sci., vol. xliii. p. 419, 1900.

GOODRICH, E. S.—*On the Nephridia of the Polychæta,* III. Quart. Journ. Micr. Sci., vol. xliii. p. 699, 1900.

SHIPLEY, A. E.—*On some Parasites found in* ECHINUS ESCULENTUS, L. Quart. Journ. Micr. Sci., vol. xliv. p. 281, 1901.

Donations and Receipts.

The receipts for the year include the grants from His Majesty's Treasury (£1,000), and the Worshipful Company of Fishmongers (£400), Special Donations (£67), Composition Fees (£15), Annual Subscriptions (£136), Rent of Tables in the Laboratory (£65), Sale of Specimens (£251), Admission to the Tank Room (£109). The expenses in connection with the up-keep of the laboratory-boat *Dawn* at Salcombe were met by Mr. J. W. Woodall, to whom the thanks of the Association are due.

In view of the fact that repairs to buildings and machinery must at some time be effected at considerable expense, the Council has resolved that the sum of £175 carried over for this purpose from the year 1899–1900 should be denominated the "Plant Repairs and Renewals Fund," and that a sum of not less than £25 shall be assigned annually out of income to this fund, only to be drawn on for exceptional expenditure on the plant or machinery.

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1901–1902:—

President.

Prof. E. Ray Lankester, LL.D., F.R.S.

Vice-Presidents.

The Duke of Abercorn, K.G., C.B.
The Earl of St. Germans.
The Earl of Morley.
The Earl of Ducie, F.R.S.
Lord Avebury, F.R.S.
Lord Tweedmouth.
Lord Walsingham, F.R.S.
The Right Hon. A. J. Balfour, M.P., F.R.S.
Sir Edward Birkbeck, Bart.
The Right Hon. Joseph Chamberlain, M.P.
Sir Michael Foster, M.P., F.R.S.
A. C. L. Günther, Esq., F.R.S.
Sir John Murray, F.R.S.
Prof. Alfred Newton, F.R.S.
Rev. Canon Norman, D.C.L., F.R.S.
Sir Henry Thompson, Bart.
Rear-Admiral Sir W. J. L. Wharton, K.C.B., F.R.S.

Members of Council.

Prof. F. Jeffrey Bell.
G. P. Bidder, Esq.
G. C. Bourne, Esq., F.L.S.
Francis Darwin, Esq., F.R.S.
G. Herbert Fowler, Esq.
S. F. Harmer, Esq., F.R.S.
Prof. W. A. Herdman, F.R.S.
Prof. G. B. Howes, F.R.S.
J. J. Lister, Esq., F.R.S.
Prof. E. A. Minchin.
D. H. Scott, Esq., F.R.S.
Prof. Charles Stewart, F.R.S.
Prof. D'Arcy W. Thompson, C.B.
Prof. W. F. R. Weldon, F.R.S.

Hon. Treasurer.

J. A. Travers, Esq.

Hon. Secretary.

E. J. Allen, Esq., The Laboratory, Citadel Hill, Plymouth.

The following Governors are also members of the Council:—

Robert Bayly, Esq.
J. P. Thomasson, Esq.
The Prime Warden of the Fishmongers' Company.
E. L. Beckwith, Esq. (Fishmongers' Company).
Prof. Sir J. Burdon Sanderson, Bart., F.R.S. (Oxford University).
A. E. Shipley, Esq. (Cambridge University).
Prof. W. F. R. Weldon, F.R.S. (Brit. Assoc. for Advmt of Science.

Dr. *Statement of Receipts and Expenditure for the Year ending 31st May, 1901.* *Cr.*

	£	s.	d.	£	s.	d.
To Balance from last year, being Cash at Bank and in hand, now allocated as follows:—						
On General Account	3	15	11			
On Plant, Repairs and Renewals Fund	175	0	0	178	15	11
„ Current Income:—						
H.M. Treasury	1,000	0	0			
Fishmongers' Company (for current year)	400	0	0			
Annual Subscriptions	136	9	0			
Rent of Tables	64	18	6			
Interest on Investment	19	1	9	1,620	9	3
„ Extraordinary Receipts:—						
Life Member's Composition Fee—						
J. W. S. Macfie	15	15	0			
Special Donations	67	9	8	83	4	8
„ Fishmongers' Company (on account of Subscription for year to 31st May, 1902)				200	0	0

Investment held 31st May, 1901, £500 Forth Bridge Railway 4% Guaranteed Stock.

Examined and found correct,
(Signed) EDWIN WATERHOUSE.
STEPHEN E. SPRING-RICE.
F. JEFFREY BELL.
GEORGE P. BIDDER.

£2,082 9 10

	£	s.	d.	£	s.	d.
By Current Expenses:—						
Salaries and Wages—						
Director	200	0	0			
Naturalist	250	0	0			
Director's Assistant	91	13	4			
Wages	522	18	0	1,064	11	4
Travelling Expenses				44	6	9
Library				87	17	5
Journal, Printing and Illustrating	122	8	3			
Less Sales of Journal	24	11	2	97	17	1
Buildings and Public Tank Room—						
Gas, Water, Coal, etc.	122	12	6			
Stocking Tanks, Feeding, etc.	24	12	4			
Maintenance and Renewals	137	8	2			
Rent of Land, Rates, Taxes, and Insurance	15	11	11			
	300	4	11			
Less Admissions to Tank Room	108	16	3	191	8	8
Laboratory, Boats, and Sundry Expenses—						
Stationery, Office Printing, and Postage	110	3	6			
Glass, Chemicals, and Apparatus £138 13 1						
Less Sales 40 12 11	98	0	2			
Purchase of Specimens	30	5	4			
Maintenance and Renewals of Boats, Nets, and Gear £419 6 11						
Less Sales 124 8 3	294	18	8			
Coal for Steamer	62	3	4			
Insurance	1	10	0			
Boat Hire	7	1	6			
	604	2	6			
Less Sale of Specimens	251	11	2	352	11	4
				1,838	12	7
By Extraordinary Expenditure—						
Cost and Expenses of Purchase of s.s. *Oithona*	858	8	0			
Less Amount realised by Sale of s.s. *Busy Bee* £700 0 0						
Less Commission on Sale 17 10 0	682	10	0	175	18	0
By Balance of Cash at Bank and in hand, Plant, Repairs, and Renewals Fund, including £25 added during year	200	0	0			
Less Amount overpaid on General Account	132	0	9	67	19	3
				£2,082	9	10

Director's Report.

THE year which has elapsed since the publication of the last number of the Journal has been marked by substantial progress in the work of the Association in one or two directions. In the first place, the small steamer *Busy Bee*, which had for several years done good service in collecting in the immediate neighbourhood of Plymouth, was sold on favourable terms, and a larger vessel, the s.s. *Oithona*, was bought to replace her. The *Oithona* is a much more capable seaboat than the *Busy Bee*, and is provided with excellent accommodation, so that she is able to make more extended cruises, and it is possible for our naturalists to live on board her for longer periods with comparative comfort.

Considerable extra expense is of course involved in running this larger vessel, but we have been materially assisted in this respect by the generosity of gentlemen interested in our work. Towards a fund intended to meet the working expenses of the first four years the following contributions have been received:—G. P. Bidder, Esq., £200; T. H. Riches, Esq., £100; the Hon. R. Guinness, £20; W. F. Thomas, Esq., £5. But even with this additional help we are only able to run the vessel for a portion of the winter months.

Secondly, in conjunction with the Technical Education Committee of the Devon County Council, our fisheries staff has been increased by an additional naturalist, one half of whose time is devoted to fishery research, and the other half to the technical instruction of fishermen. Dr. H. M. Kyle, formerly of Saint Andrews, has been appointed to this post. Mr. F. Balfour Browne has also been appointed an assistant (honorary) to Mr. Garstang for fishery research.

The Laboratory buildings and machinery have been maintained in a state of efficiency. It has been found necessary to replace the gas-engine which is used for circulating the sea-water through the aquarium tanks. The old engine had been in constant use since the opening of the Laboratory, and was not a new one when it became the property of the Association. One of the rotary pumps used for the same purpose has also been practically made new, so that considerable expense has been necessary for the up-keep of machinery.

The general detailed study of the distribution of the marine fauna

of the district has been continued by myself and my assistant, Mr. R. A. Todd. In this connection Mr. J. W. Woodall's floating laboratory *Dawn* was stationed during the summer at Exmouth, for the purpose of enabling us to study the fauna of the Exe estuary. Before leaving for Exmouth the vessel had been very much improved by Mr. Woodall by the addition of a deckhouse, which forms an excellent laboratory. A report upon the survey of the Exe estuary is contained in the present number of the Journal. Our thanks are again due to Mr. Woodall for placing the *Dawn* at our disposal and paying the expenses in connection with her up-keep at Exmouth.

The study of the fauna in the immediate neighbourhood of Plymouth has been continued, and as it proceeds detailed records of the work are kept at the Laboratory.

Mr. Garstang has been largely engaged during the year in working out the results of the periodic cruises which he has made at the mouth of the English Channel for the purpose of investigating the physical and biological conditions prevailing at different seasons of the year. This work, however, has been somewhat interfered with by the fact that Mr. Garstang was appointed by the Government to act as one of the British delegates to the International Conference for the Exploration of the Sea, which met at Christiania in May. Matters connected with this Conference have occupied a great deal of time and attention.

Experiments upon the rearing of larval fishes were again undertaken during the breeding season, and a substantial advance was made in the methods employed. These experiments will be continued during the coming season.

In conjunction with the Devon Sea Fisheries Committee, trawling experiments in the bays on the South Devon coast have been renewed. These bays have been closed to trawlers for several years, and the Committee are anxious that a thorough investigation should be made of the distribution of the various species of fish throughout the year, of their spawning grounds, of the distribution of immature fish, and of such other matters as may tend to throw light upon the working of their bye-laws. These investigations are being carried out by Dr. Kyle, and the *Oithona* is used for the trawling work, hauls being made every month at the different stations.

Mr. J. Stuart Thomson has been occupied with an investigation of the periodic growth of the scales of fishes as an indication of age. A preliminary account of the results at which he has arrived is now published (see p. 373).

A word of explanation is necessary with reference to the somewhat long interval since the issue of the last number of the Journal. It

was our intention to have published an enlarged number in October containing the detailed results of the plankton investigations at the mouth of the Channel. As there has been an unavoidable delay in the preparation of the report on this subject, it has been held over for the time and the present number issued.

E. J. ALLEN.

December 18th, 1901.

Marine Biological Association of the United Kingdom.

LIST

OF

Governors, Founders, and Members.

1ST DECEMBER, 1901.

I.—Governors.

The British Association for the Advancement of Science, *Burlington House, W.* £500
The University of Cambridge £500
The Worshipful Company of Clothworkers, 41, *Mincing Lane, E.C.* £500
The Worshipful Company of Fishmongers, *London Bridge* £5905
The University of Oxford £500
Bayly, Robert (the late) £1000
Bayly, John (the late) £600
Thomasson, J. P., *Woodside, near Bolton* £970

II.—Founders.

* Member of Council. † Vice-President. ‡ President.

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1884 The Worshipful Company of Mercers, *Mercers' Hall, Cheapside* .....£341 5*s.*
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1884 The Royal Microscopical Society, 20, *Hanover Square, W.*..... £100
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1885 Derby, the late Earl of £100
*1887 Weldon, Prof. W. F. R., F.R.S., *Merton Lea, Oxford* £100
1888 Bury, Henry, M.A., *Trinity College, Cambridge*..... £100
1888 The Worshipful Company of Drapers, *Drapers' Hall, E.C.* £315
1889 The Worshipful Company of Grocers, *Poultry, E.C.* £120
†1889 Thompson, Sir Henry, Bart., 35, *Wimpole Street, W.* £110
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C. signifies that he has paid a Composition Fee of Fifteen Guineas in lieu of Annual Subscription.

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*1895 Allen, E. J., D.Sc., *The Laboratory, Plymouth* ..... Ann.
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1893 Bailey, W. E., *Porth Enys Museum, Penzance* ..... *C.*
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1884 Bateson, Wm., F.R.S., *St. John's College, Cambridge* ..... Ann.
1897 Baxter, G. H., *Hutton Road, Brentwood, Essex* ..... Ann.
1884 Bayliss, W. Maddock, D.Sc., *St. Cuthberts, West Heath Road, Hampstead.* Ann.
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1885 Beck, Conrad, 68, *Cornhill, E.C.* ..... *C.*
*1889 Beckwith, E. L., *The Knoll, Eastbourne* ..... Ann.
1887 Beddard, F. E., F.R.S., *Zoological Society's Gardens, Regent's Park, N.W.* Ann.
1884 Beddington, Alfred H., 8, *Cornwall Terrace, Regent's Park, N.W.* ..... *C.*
1897 Bedford, Mrs., 326, *Camden Road, London, N.* ..... Ann.
*1884 Bell, Prof. F. Jeffrey, 35, *Cambridge Street, Hyde Park, W.* ..... Ann.
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1893 Bles, A. J. S., *Palm House, Higher Broughton, Manchester*..... Ann.
1889 Bolitho, T. B., *Chyandour, Penzance* ..... Ann.

1884 Bompas, G. C., 121, *Westbourne Terrace, Hyde Park, London, W.* ..... Ann.
1884 Bossey, Francis, M.D., *Mayfield, Redhill, Surrey*..... Ann.
1884 Bostock, E., *Stone, Staffordshire* ..... Ann.
1890 Bourne, Prof. A. G., F.R.S., *The Presidency College, Madras*..... Ann.
*1884 Bourne, Gilbert C., M.A., *Savile House, Mansfield Road, Oxford* ..... Ann.
1898 Bowles, Col. Henry, M.P., *Forty Hall, Enfield* ..... Ann.
1895 Bridge, Prof. T. W., D.Sc., *University of Birmingham* ..... Ann.
1890 Brindley, H. H., M.A., 4, *Devana Terrace, Huntingdon Road, Cambridge* Ann.
1886 Brooksbank, Mrs. M., *Leigh Place, Godstone, Surrey* ..... *C.*
1884 Brown, Arthur W. W., 37, *Evelyn Mansions, Carlisle Place, Victoria Street, S.W.* ..... *C.*
1893 Browne, Edward T., B.A., 141, *Uxbridge Road, W.* ..... Ann.
1893 Buchanan, Miss Florence, B.Sc., *The Museum, Oxford* ..... Ann.
1884 Buckton, G. B., *Weycombe, Haslemere* ..... Ann.
1896 Bulstrode, H. P., M.D., 4, *The Mansions, Earl's Court, S.W.* ..... Ann.
1887 Burd, J. S. (the late) ..... Ann.
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1884 Fison, Frederick W., *Greenholme, Burley-in-Wharfedale, Leeds* ..... *C.*
1897 Foster, Richard, *Windsworth, Looe, R.S.O.* ..... Ann.
*1885 Fowler, G. Herbert, B.A., Ph.D., 58, *Bedford Gardens, London, W.* ... Ann.
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1884 Fryer, Charles E., *Board of Trade, S.W.* ..... Ann.

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1885 Gaskell, W. H., F.R.S., *The Uplands, Shelford, Cambridge* ..... *C.*
1885 Gaskell, E. H. ..... *C.*
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1884 Gibson, Ernest, F.Z.S., c/o Fraser, Stoddart, and Ballingall, 16, *Castle Street, Edinburgh* ..... Ann.
1901 Giles, Col. G. M., *Byfield, Mannamead, Plymouth* ..... *C.*
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1884 Grove, E., *Norlington, Preston, Brighton* ..... Ann.
1884 Groves, J. W., *Wargrave Lodge, Wargrave-on-Thames* ..... Ann.
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1884 Haddon, Prof. Alfred C., M.A., F.R.S., *Innisfail, Hills Road, Cambridge* Ann.
1884 Halliburton, Prof. W. D., M.D., F.R.S., *Church Cottage*, 17, *Marylebone Road, London, W.* ..... Ann.
1884 Hannah, Robert, 82, *Addison Road, Kensington, W.* ..... *C.*
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1884 Head, J. Merrick, F.R.G.S., J.P., *Ardverness, Reigate* ..... Ann.
1884 Heape, Walter, *Heyroun, Chaucer Road, Cambridge* ..... *C.*
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1884 Herschel, Col. J., R.E., F.R.S., *Observatory House, Slough, Berks.* ..... *C.*
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1885 Marr, J. E., M.A., *St. John's College, Cambridge* ..... *C.*
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1886 Power, Henry, F.R.C.S., 37A, *Great Cumberland Place, W.* ..... Ann.
1885 Pritchard, Prof. Urban, 26, *Wimpole Street, W.* ..... Ann.
1884 Pye-Smith, P. H., M.D., 48, *Brook Street, W.* ..... *C.*

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1885 Ransom, W. B., *The Pavement, Nottingham* ..... *C.*
1893 Rashleigh, E. W., *Kilmarth, Par Station, Cornwall* ..... Ann.
1888 Rawlings, Edward, *Richmond House, Wimbledon Common* ..... Ann.
1892 Robinson, Miss M., *University College, London, W.C.* ..... Ann.
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1888 Scharff, Robert F., Ph.D., *Science and Art Museum, Dublin* ..... Ann.
1901 Schiller, F. W., *Burnham, Westcombe Hill, Blackheath, London, S.E.* ... Ann.
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1884 Sclater, W. L., *The Museum, Cape Town* ..... Ann.
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*1884 Shipley, Arthur E., M.A., *Christ's College, Cambridge* ..... *C.*
1886 Shore, T. W., M.D., *Heathfield, Alleyn Park, Dulwich, London, S.E.* ... *ann.*
1894 Simpson, F. C., J.P., *Maypool, Churston Ferrers, R.S.O.* ..... Ann.
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1891 Sinclair, William F., 102, *Cheyne Walk, Chelsea, S.W.* ..... *C.*
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1888 Spencer, Prof. W. Baldwin, M.A., F.R.S., *University of Victoria, Melbourne* Ann.
1884 Spring-Rice, S. E., C.B., 1, *Bryanston Place, Bryanston Square, W.* ... *C.*
*1884 Stewart, Prof. Chas., F.R.S., *Royal College of Surgeons, Lincoln's Inn Fields, W.C.* ..... Ann.
1897 Straker, J., L.L.M., F.Z.S., *Oxford and Cambridge Club, S.W.* ..... *C.*
1884 Sutherland, The Duke of, *Stafford House, St. James', S.W.* ..... *C.*

1894 Thomas, W. F., *Bishopshalt, Hillingdon, Middlesex* ..... Ann.
*1899 Thompson, Prof. D'Arcy W., C.B., *University College, Dundee* ..... Ann.
1890 Thompson, H. F., B.A., 35, *Wimpole Street, W.* ..... Ann.
1884 Thornycroft, John I., *Eyot Villa, Chiswick Mall* ..... Ann.
1888 Thurston, Edgar, *Government Central Museum, Egmore, Madras* ..... Ann.
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With Preface by

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

PROFESSOR OF COMPARATIVE ANATOMY IN THE UNIVERSITY OF OXFORD.

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, Lord AVEBURY, Sir JOHN HOOKER, the late Dr. CARPENTER, Dr. GÜNTHER, the late Lord DALHOUSIE, the late Professor MOSELEY, the late Mr. ROMANES, and Professor LANKESTER.

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

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

The Association has received some £32,500, of which £16,000 has been granted by the Treasury. The annual revenue which can be at present counted on is about £1,600, of which £1,000 a year is granted by the Treasury, the remainder being principally made up in subscriptions.

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

The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

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