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Report on the Present State of Knowledge with regard to the Habits and Migrations of the Mackerel *(Scomber scomber).*

By

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Prepared by order of the Council of the Marine Biological Association for the use of H.M. Inspectors of Irish Fisheries.

The mackerel (*Scomber scomber*) is a pelagic* and migratory fish, which during the warmer months of the year frequents the coastal waters in the northern temperate region of the Atlantic. The whole form of the fish is evidently well fitted for swift motion and the free-swimming mode of life. The spindle-shaped outline of the body, its perfect curves and rounded surfaces, the absence of all irregular projections which would tend to retard forward movement, the great muscular development of the tail, and the deep forking of the caudal fin, combine to produce an almost ideal adaptation for propulsion at high speed through the water.†

The mackerel may be called also a pelagic-feeding fish, in contradistinction to fishes such as many of the family of the Gadidæ, which are "ground" feeders; that is to say, the mackerel feeds entirely upon free-swimming organisms, whilst the ground-feeders hunt at the bottom and amongst rocks, capturing prey which is not pelagic. The difference is an important one in considering the habits of the fish.

During, at any rate, a great portion of the year mackerel swim in shoals or schools. These shoals often contain an immense number of fish, and the fish belonging to any particular shoal are usually of about the same size. Schools of small fish and schools of large may be found in the same neighbourhood at the same time, but they appear to remain separate. Little is known as to the manner in which fish keep together in shoals. From observations made in the Aquarium at the Plymouth Laboratory, Bateson ‡ concludes that grey mullet keep together by sight. In this case also the shoals appear to arrange them-

* The term *pelagic* is used in the sense in which it was originally employed by Johannes Müller, and subsequently by Haeckel. The mackerel is not a pelagic fish in the restricted sense adopted by Günther, who employs this term to include only such free-swimming fishes as inhabit the open ocean at a great distance from land.

† *Cf.* Bashford Dean, *Fishes, Living and Fossil*, pp. 2–6.

‡ *Journ. Mar. Biol. Assoc.*, N.S., vol. i. pp. 249–250.

selves according to the sizes of the fish. The shoal does not seem to have any definite leader, the fish following any individual which makes a dart in a particular direction. Bateson found that at night the fish lay on the surface of the water, with their heads pointing in different directions, and that they did not move about in shoals. Similar observations on the mackerel have never been made. Fulton suggests that the iridescent colouring on the sides of many fishes may assist them in keeping together in shoals.*

DISTRIBUTION.—The mackerel (*Scomber scomber*) occurs on the Atlantic coast of Europe, from Bergen in Norway, southward to the Straits of Gibraltar.† It is found also in the Mediterranean, being taken in large numbers along the Spanish coast, the south coast of France, the coasts of Corsica, and in the Adriatic. Mackerel are also mentioned as being captured on the coasts of Tunis and of Morocco, but no definite statement has been found as to whether the species is *Scomber scomber* or *Scomber colias*.

In America *Scomber scomber* is found off the Atlantic coast, from Cape Hatteras in the south, as far north as the coast of Labrador. From Cape Hatteras northwards to the shores of Long Island it is, however, only met with at some distance from land; hence in America it actually approaches the coast from Long Island to the coast of Labrador. In many seasons mackerel are only found as far north as Newfoundland, and there is little fishing of importance even so far north as this.

An allied species, *Scomber colias*, the Coly or Spanish mackerel of Europe, chub or thimble-eyed mackerel of America, has a more southern distribution, extending on the European coasts as far north as the south coast of Ireland, where, however, it is not taken in numbers, and southwards to Madeira. It is also plentiful at the Cape of Good Hope, where numbers were captured in 1889 and 1890 by American mackerel vessels, which had proceeded there for the purpose.‡ In American waters the species is found from the Gulf of Mexico to the coast of Maine, and also on the Pacific coast of the United States.

There is also a fish known in America as the "Spanish Mackerel" (*Scomberomorus maculatus*), which extends on the east coast from Cape Ann to Brazil. It is common in the Gulf of Mexico, but rare or unknown about Cuba.§

* *Fishery Board for Scotland.* 10th Report, 1891, p. 342.

† Occasional specimens may be taken further north and south than the limits here indicated, but they are not present in sufficient numbers to give rise to a fishery.

‡ *Report U.S. Fish. Com.*, 1889-91, p. 203.

§ JORDAN and EVERMAN. "Check-list of Fishes." *Report U.S. Fish. Com.*, 1895.

BREEDING.—The spawning of the mackerel was first investigated by Sars,* in 1865, on the coast of Norway. This naturalist found that the fish spawned near the coast, sometimes nearer than at others, and that the eggs floated at the surface of the sea like those of the cod, from which they could be distinguished by the presence of an oil globule. The same facts were ascertained in 1871 by Mr. Matthias Dunn, who obtained the spawning fish on the south coast of Cornwall, about six miles from land, on the night of May 10th.†

The subject has since been investigated by other naturalists, more especially by Cunningham, ‡ at Plymouth, who has figured and described the eggs and various stages of the larval fish.

The breeding season varies in different localities, occurring considerably later in the year in the north than in the south.

In the Mediterranean (Gulf of Marseilles) Marion § found mackerel with ripe reproductive organs chiefly in March and April, and considers these two months to be the principal spawning period. No ripe fish were ever found after May 19th. From the size of larvæ taken in May, the same author comes to the conclusion that some fish must spawn as early as January.

At Plymouth the spawning fish are found from 14 to 50 miles from the coast. Spawning takes place from the end of May to the latter part of July, and, according to Cunningham, appears to be distinctly limited within those times.||

On the south-west coast of Ireland, Green ¶ states that spawning takes place in May and June. Holt ** obtained ripe eggs off this coast in the tow-net on April 30th and May 4th. Mackerel examined on April 1st were half and three-parts ripe. On May 12th, out of 50 fish all the males were ripe. The females were mostly half and three-quarters ripe, but a few were ripe. Ripe fish were also seen as late as June 20th, the specimen examined at the latter date being called by Holt "a small autumn mackerel." The same author states that it appears that successive shoals approach the coast at different points and spawn in the neighbourhood, the larger fish being the first to arrive.

* Report for 1875. English translation. *Report of U.S. Fish. Com.*, 1877.

† *Land and Water*, May 20, 1871, p. 353.

‡ *Journ. Mar. Biol. Assoc.*, N.S., vol. i. p. 25.

§ *Ann. Mus. Nat. Hist. Marseille Zool. Appliquée*, i., 1889.

|| *Natural History of Marketable Marine Fishes.* London: Macmillan & Co., Ltd., 1896.

¶ "Notes on the Irish Mackerel Fisheries." *Bull. U.S. Fish. Com.*, 1893.

** (1) "Survey of Fishing Grounds on the West Coast." Royal Dublin Society. *Report of Council for* 1891.

(2) *Scientific Transactions Roy. Dublin Soc.*, 1893. Fishes.

Sars concludes that on the coast of Norway the spawning is confined to the first fortnight in July.

From the information derived from mackerel fishermen in America, and published in the *Reports of the United States Fish Commission*,* it is evident that the breeding season of the fish there also varies on different parts of the coast, becoming later the further north one gets. Although no definite statement by the naturalists of the Commission as to the exact limits of the spawning period in different localities has been published, it would appear that on the New England coast spawning takes place principally in May and June, whilst in the Gulf of St. Lawrence it is later, occurring during the latter half of June and in July. On the other hand, in the south (south-east of Cape Henry, and off the Virginia coast) spent fish were taken in April.†

The following table shows the chief spawning period of the mackerel in different localities, according to the information at present available:—

EUROPE.

Locality.	Spawning Period.
Mediterranean (Gulf of Marseilles)	March and April. (Possibly also January and February.)
South-west of Ireland	May and June.
South-west of England (off Plymouth)	End of May to end of July.
Norway	First half of July.

AMERICA.

Locality.	Spawning Period.
Virginia Coast	April.
New England Coast (Massachusetts Bay)	May and June.
Gulf of St. Lawrence	End of June and in July.

RATE OF GROWTH.—Considerable uncertainty exists as to the rate of growth of the mackerel, and the views of the authors who have paid attention to the subject differ widely. The largest amount of information bearing on the question has been collected by Marion and Gourret on the Mediterranean coast of France.‡ Young mackerel, from 2 to 10 cm. ($\frac{3}{4}$ to 4 inches), are caught in numbers at Marseilles and Nice, more especially at the latter place, in April and May, and Marion and Gourret both regard these fish as the young of the year. This, however, compels them to assume that the spawning season begins

* See especially *Report U.S. Fish. Com.*, 1881.

† *Report U.S. Fish. Com.*, 1895.

‡ *Ann. Mus. Nat. Hist. Marseille Zool. Appliquée*, 1889-91.

as early as January. As already stated, however, spawning fish were never obtained by them until March and April. The small fish, 2–10 cm. (¾ to 4 inches) long in April and May, are considered to have reached 10–13 cm. (4 to 5 inches) by August, and 15 to 18 cm. (6 to 7 inches) by the end of the year. In the following February fish from 20 to 24 cm. (8 to 9½ inches) are taken, the age of which Marion considers to be twelve months; and since these fish have their reproductive organs well developed, he is compelled to ask, not without some hesitation, Does the mackerel spawn when only one year old?

The question of the rate of growth of mackerel in the English Channel is discussed by Cunningham,* and he also gives detailed measurements of a large number of these fish caught in fine-meshed nets in November, which varied in length from 15 to 20 cm. (6 to 8 inches). The length of the larva at the time of hatching he states to be 4·23 mm.† He also describes some young mackerel obtained by Holt‡ in the North Sea. Twelve specimens taken on July 9th measured from 6 to 9 mm. (·24 to ·36 inch); three taken on the 27th and 28th July were from 13·5 to 19·25 mm. (·54 to ·77 inch). The largest of the specimens already showed the adult characters, and Cunningham regards them as being from one to two months old.

Day§ states, on the authority of Matthias Dunn, that at Mevagissey young mackerel are plentiful in the bays in August and September, when they are about 3 inches (7 to 8 cm.) long, reaching 6–7 inches (16 to 18 cm.) in November. They then leave for the deep sea, and return again in the following June, when they are 8 or 9 inches (21 to 23 cm.) long.

The best account of the growth of the mackerel in America is given on the authority of Capt. Atwood,‖ it being stated that the specimens were seen by Prof. Agassiz. According to this account the mackerel spawn in Massachusetts Bay in May and the first half of June. On July 10th schools of mackerel 2 inches (5 cm.) long were present in the bay, which had grown to about twice the weight (say 7–8 cm. long) on August 4th. During the latter part of October young fish from 6½ to 7 inches (say 16 to 18 cm.) were taken.

In the following table these various statements are placed side by side, all the evidence at present available being included:—

* *Journ. Mar. Biol. Assoc.*, N.S., vol. ii. pp. 230 to 233.

† *Journ. Mar. Biol. Assoc.*, N.S., vol. ii. p. 71.

‡ Holt himself also mentions these fish. *Journ. Mar. Biol. Assoc.*, vol. ii. p. 396.

§ *British Fishes*, vol. i. p. 89.

‖ *Report U.S. Fish. Com.*, 1881, p. 114.

Table showing the published evidence available for determining the rate of growth of the Mackerel.

	Marseille and Nice.		Mevagissey (Cornwall).		Plymouth (Devon).		Massachusetts.	
	Length of fish captured.	Age in Months. (Marion.)	Length of fish.	Age in Months. (Dunn.)	Length of fish.	Age in Months. (Cunningham.)	Length of fish.	Age in Months. (Atwood.)
January	*Spawning* (?)	—	—	—	— —	—	— —	—
February	*Spawning* (?) 20–24 cm.	12	—	—	— —	—	— —	—
March	*Spawning.* End of Month: 5–5·8 cm. in quantity at Nice; 15 cm., Marseille.	2	—	—	— —	—	— —	—
April	*Spawning.* End of Month: 4·5–12 cm. (Nice); 4–6 cm. (Marseille). 4–8·5 cm.	3	—	—	— —	—	— —	—
May	*2–6 cm. (quantity), Mars. 10–20 cm. „ „ 10–15 cm. „ „ 11 cm., plentiful. 6–11 cm., Nice.	2–4	*Spawning.*	—	31–33 cm.	24	*Spawning.*	—

June	12-15 cm. 10 cm.	6 4	*Spawning.* 21-23 cm.	12	*Spawning.* 22-23 cm.	12	*Spawning till 10th.*	—
July	15-20 cm. 10-13 cm.	—	*Spawning.*	—	*Spawning.* 9th. 6-9 mm. (North Sea). 27th. 1·35-1·925 cm. (N.S.)	1-2	5 cm.	2
August	10-13 cm.	4-5	7-8 cm.	3	— —	—	7-8 cm.	3
September	— —	—	—	—	30th. 13·8 cm. (1 specimen.)	14	— —	—
October	— —	—	—	—	18-25 cm.	15 to 16	End of Month : 16-18 cm.	5-6
November	15-18 cm. (Marseille).	9 ?	16-18 cm.	6	15-20 cm.	16	— —	—
December	— —	—	—	—	— —	—	— —	—

* At Marseille were taken :—
1891. May 10th. 30 kilos, 2-3 cm. long.
,, 11th to 17th. 31 ,, 3-4 cm. ,,
,, 23rd to 26th. 6 ,, 3-5 cm. ,,
,, 29th to 31st. 25 ,, 3-6 cm. ,,

Mixed with these :—
415 kilos, 10-15 cm.
298 ,, 10-20 cm.
20 ,, 15-25 cm.
120 ,, 20-25 cm.
25 ,, 20-30 cm.

The rate of growth required to meet the views of the different observers is approximately represented in the following table:—

Age.	Mediterranean.	Cornwall.	British Coasts.	America.	Cod.	Herring.
	Marion and Gourret.	Dunn.	Cunningham.	Atwood.	Dannevig.	Meyer.
1 month ...	—	—	1·35 to	—	1·5 cm.	1·7 cm.
2 months ...	4–5 cm.	—	1·925 cm.	5 cm.	5·5 cm.	3·4 cm.
3 ,, ...	6 cm.	7–8 cm.	—	7–8 cm.	7·0 cm.	4·5–5 cm.
4 ,, ...	10–11 cm.	—	—	—	8·5 cm.	5·5–6 cm.
5 ,, ...	12–13 cm.	—	—	—	11·5 to 15·7	6·5–7·2 cm.
6 ,, ...	14–15 cm.	16–18 cm.	—	16–18 cm.	—	—
7 ,, ...	—	—	—	—	—	—
8 ,, ...	17–18 cm.	—	—	—	—	—
9 ,, ...	—	—	—	—	—	—
10 ,, ...	—	—	—	—	—	—
11 ,, ...	—	—	—	—	—	—
12 ,, ...	23–24 cm.	21–23 cm.	22–23 cm.	—	—	—
13 ,, ...	—	—	—	—	—	—
14 ,, ...	—	—	—	—	—	—
15 ,, ...	—	—	—	—	—	—
16 ,, ...	—	—	14–20 cm.	—	—	—
22 ,, ...	—	—	—	—	35–40 cm.	—

Two columns are added showing the rate of growth of the cod, as determined by Dannevig from specimens reared in a large pond, and of the herring, as determined by Meyer for the river Schlei, the observations in the latter case being confirmed by the rate of growth of larvæ, which Meyer succeeded in rearing in confinement.*

It will be seen that the rate of growth suggested by Cunningham is much slower than that regarded as probable by the other observers. He considers the fish from 16 to 21 cm., which are taken in November, as being derived from the spawning of the previous year, being therefore 16 months old. At the same time he regards the mackerel, 22 to 23 cm. long in June, as only one year old, and explains the difference as due to the great individual variation in growth rate.

There are no doubt great difficulties in the way of accepting the very rapid growth suggested by the French and American observers, and by Mr. Dunn. If their view is correct, the rate of growth of the mackerel will be much more rapid than that of the herring, approaching more nearly that of the cod reared by Dannevig. The question is, however, one which can only be settled by further research.

Size and Maturity.—With regard to the size at which the mackerel begins to breed, practically nothing is known. Marion states† that the fish which are 20–24 cm. (9 inches) long in February, and which he regards as one year old, have the reproductive organs well advanced.

* See Cunningham. *Journ. Mar. Biol. Assoc.*, N.S., vol. ii. pp. 223 and 236.

† *Ann. Mus. Nat. Hist. Marseille Zool. Appliquée*, i., 1889, p. 87.

At Plymouth in June Cunningham* found no signs of maturity in fish 22·2 to 23·5 cm. (8·7–9·2 inches) long, nor in one female of 27·4 cm. (10·7 inches). The smallest ripe female, which he records, is 29·5 cm. (11·5 inches), and the smallest ripe male 30·3 cm. (11·8 inches). His observations are, however, far too few in number to enable any general conclusions to be drawn.

Food.—It has already been stated that the mackerel is a pelagic-feeding fish; that is to say, it feeds upon free-swimming organisms, and not upon those which live on the bottom of the sea. The food of this fish may be regarded as of two different kinds, and it adopts two different methods for procuring it. In the first place it feeds upon the smaller forms of the plankton, copepods and other crustaceans, larvæ of crustaceans, molluscs, echinoderms and worms, diatoms, and even siphonophores and medusæ, obtaining its food like the herring, by straining the sea-water through its gill-rakers, as it swims open-mouthed through the sea. This method of feeding would appear to furnish the fish with its principal food supply during the spring and early summer, when it first approaches the coast. During the latter part of summer, however, and in the autumn, small fish of other species become abundant, and the mackerel then makes these its chief article of diet. Young herring, sprats, pilchards, and rockling are all devoured. These young fish are hunted by sight, the mackerel darting at them and capturing them individually. The fine condition of the autumn fish is due to the abundance of food which they obtain in this way.

In its early stages the mackerel lives upon the small organisms of the plankton, including larval fish. Marion found in the stomachs of small mackerel at Nice, taken in May, copepods, zoeas of brachyura, and sardine larvæ.

Migrations.—The migrations of the mackerel have long been a subject of speculation, but it cannot yet be said that much definite knowledge, either as to their extent, or the causes which bring them about, has been acquired. The recorded facts, sufficiently trustworthy and precise to be of practical use in the consideration of the subject, are not numerous. The importance of the collection of statistics showing the quantities of fish landed at various ports during the different months of the year has not long been recognised, and without independent knowledge as to the localities where the fish have been caught those statistics which are published are very liable to lead to false conclusions.

* *Journ. Mar. Biol. Assoc.*, N.S., ii. p. 232.

A comparative study of the Board of Trade statistics for England and Wales has, however, proved of service, whilst the tables compiled by the Irish Inspectors are of value, principally in showing the fluctuations of the fishery in that country from year to year. By far the most satisfactory statistics are those which are now being published by the French authorities, but in their present complete form these only date from the end of the year 1895. For the two years previous to this valuable notes, giving statistics for some of the more important ports, appeared from month to month in the *Bulletin des Pêches Maritimes*, and these have been of considerable use. Sars* gives much reliable information about the Norwegian mackerel fisheries, and Marion and Gourret† about those of the Mediterranean coast of France. A considerable amount of information as to the mackerel fishery on the American coast is contained in the Reports and Bulletins of the United States Fish Commission, and these have here been freely made use of.

From the above sources a number of tables have been constructed, which give an insight into the distribution of the mackerel fisheries at different times of the year. In considering the information in these tables it must be constantly borne in mind that the figures represent the quantities of fish landed in particular districts or at particular ports. In the absence of definite information as to where the fish were caught, and also of the number and fishing power of the boats employed in the fishery, great care must be exercised in drawing conclusions from them as to the relative abundance of fish in different localities. They are of more use in giving an idea of the abundance of fish in the same locality at different times of the year.

Table I., which is to a large extent an arbitrary compilation, based, however, where possible on the statistical tables which follow, shows at what times of the year mackerel are present at the places mentioned, and during which months they are taken in the largest quantities at each place. Numbers from 0 to 5 are used to indicate the relative abundance; but the series is independent for each place, the figure 5 representing the maximum for the year at the place referred to. Thus the figure 5 stands opposite the month of May for both the south-west of Ireland and the south of England. This means that in both these districts mackerel fishing is most productive during that month. It does not imply that the fish are as abundant in the one district as in the other.

Where possible Table I. is constructed from the actual figures for three years. Where this cannot be done the results are derived

* Report for 1875. English Translation in *Report U.S. Fish. Com.*, 1877, pp. 667–680.
† *Ann. Mus. Nat. Hist. Marseille Zool. Appliquée.*

TABLE I., *showing the relative quantity of Mackerel landed at each of the places mentioned at different times of the year.*

The numbers 1 to 5 are independent for each place, 5 representing the maximum at the place to which it refers.

	MEDITERRANEAN.		WEST COAST OF EUROPE.									EAST COAST OF AMERICA.		
	MARSEILLE.	CETTE.	PORTUGAL.	WEST OF FRANCE.	SOUTH OF ENGLAND. Principally at Western Ports.	WEST OF ENGLAND.	SOUTH-WEST OF IRELAND.	WEST OF SCOTLAND.	NORWAY.	NORTH OF FRANCE. Eastern portion. St. Varley-sur-Somme & Dieppe.	NORTH SEA. Southern part.	CAPE HATTERAS TO CAPES OF DELAWARE.	NEW ENGLAND COAST.	GULF OF ST. LAWRENCE.
January	1	0	—	1	1	0	1	0	0	0	0	0	0	0
February	1	0	—	0–2	1	0	1	0	0	0	0	0	0	0
March	spawning 1	1	—	2	3	2	2	0	0	0	0	0–1	0	0
April	spawning 2	4	—	3	4	4	4	0 ?	0	2	0	5	0	0
May	3	5	plentiful	5	spawning 5	5	spawning 5	present	Commences about 20th 3 ?	2	1	—	spawning present	0
June	4	3	plentiful	4	spawning 4	4	spawning 4	ditto	5	3	2	—	spawning ditto	present
July	5	2	plentiful	2	spawning 3	2	2	—	spawning 3 ?	5	2	—	present	spawning present
August	4	1	—	3	2	2	Commences end of month, or beginning of Sept.	At Orkneys	?	4	1	—	ditto	present
September	3–5	1	—	4	3	1	5 ?	?	Autumn fishery in fjords	5	4	—	ditto	ditto
October	2	1	—	3	2	1	3 ?	?		1	5	—	ditto	ditto
November	0–1	0	—	2	1	1	1	?	0	0	3	—	ditto	ditto
December	0–1	0	—	1	2	0	1	—	0	0	1	—	0	0

from such general information as it has been possible to find, and the table does not pretend to anything more than rough approximation to accuracy.

Table II., compiled from the English and French official statistics, gives the average amount for three years of mackerel landed during each year on the east, south, and west coasts of England and Wales, and at Gravelines and St. Varley-sur-Somme on the north, Douarnenez on the west, and Cette on the south coasts of France. The full statistics for the French coasts are only published for 1896, but the ports selected may be regarded as representative. Cette and Douarnenez have the largest mackerel fisheries on their respective coasts. The fishery at St. Varley-sur-Somme, on the other hand, is less important than that at either Boulogne or Fécamp; but the statistics for this port are selected in preference, because the majority of the mackerel landed at the two other ports in the spring are the products of the fishery carried on off the south-west coast of Ireland. The figures for St. Varley-sur-Somme are therefore more representative of the fishing on the north coast of France. Gravelines, where mackerel are only landed in quantity during two months of the year, represents the important autumn fishery in the North Sea.

Table III. gives the actual quantities of mackerel landed on the three coasts of England and Wales for the three years 1893, 1894, and 1895, and shows the fluctuations of the fisheries from year to year.

Table IV. contains similar information for some representative French ports for 1894, 1895, and 1896.

Table V. gives the quantities landed at the more important French ports during 1896.

With the information contained in these tables it is possible to form a fairly correct idea of the distribution of the mackerel on the coasts of both Europe and America during the different months of the year. As the conditions change somewhat slowly, it will be most convenient for our purpose to consider them during periods of two consecutive months.

January and February: *Europe.*—Very few mackerel are taken in any locality during these months. Those which are captured are chiefly found in the western part of the English Channel, off the south-west coast of Ireland,* off the west coast of France (Douarnenez), and in small numbers in the Gulf of Marseille. Those caught in the English Channel are found 30 to 40 miles from the coast, some being taken at this distance south of Start Point, others south of Plymouth.† There is

* *Inspector's Report*, 1895. (Table, Spring Mackerel Fishery.)

† *Journ. Mar. Biol. Assoc.*, vol. ii. p. 7.

TABLE II., *showing the average quantity of Mackerel landed during each month on the coasts of England and Wales, and at certain French ports, compiled from the official returns for three years.*

	ENGLAND AND WALES.			FRANCE. North.		West.	South.
	East Coast. Average, 1893–1895.	South Coast. Average, 1893–1895.	West Coast. Average, 1893–1895.	Gravelines.	St. Varley-sur-Somme. Average, 1894–1896.	Douarnenez. Average, 1894–1896.	Cette. Average, 1895–1896.
	Cwts.	*Cwts.*	*Cwts.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*
January	—	124	—	—	—	908	—
February	—	72	—	—	—	49,984	—
March	—	10,137	1,597	—	—	37,689	920
April	—	31,829	44,327	—	—	236,960	60,377
May	68	65,781	60,011	—	1,650	1,138,175	76,850
June	2,756	30,371	31,300	—	38,667	437,403	49,500
July	5,247	10,719	3,739	1896 only. 945	73,333	34,187	10,900
August	124	4,880	1,397	1896 only. 1,275	56,000	214,450	3,500
September	15,600	9,498	637	1896 only. 149,140	66,207	446,138	2,640
October	32,675	3,761	136	Average, 1894-95-96. 135,265	8,167	225,672	1,350
November	8,406	645	95	—	—	76,280	1,003
December	72	2,277	1	—	—	27,044	1,006

TABLE III., *showing the quantity of Mackerel landed during each month of the year on the coasts of England and Wales, for the years* 1893, 1894, *and* 1895, *compiled from the official returns.*

	ENGLAND.—(EAST COAST).			ENGLAND.—(SOUTH COAST).			ENGLAND AND WALES.—(WEST COAST).		
	1893.	1894.	1895.	1893.	1894.	1895.	1893.	1894.	1895.
	Cwts.	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*	*Cwts.*
January	—	—	—	174	30	167	—	—	—
February	—	—	—	133	28	55	—	—	—
March	—	—	—	17,806	10,667	1,939	1,712	2,805	275
April	—	—	—	35,804	35,535	24,147	61,680	40,527	30,773
May	63	121	19	41,584	62,117	93,643	64,170	77,267	41,595
June	650	2,219	5,399	25,478	24,263	41,373	23,849	40,503	29,549
July	21	12,757	2,964	7,686	13,012	11,459	582	8,807	1,829
August	98	205	69	3,105	4,618	6,917	477	1,381	2,333
September	17,337	20,622	8,840	7,428	17,466	3,599	261	735	914
October..............	1,958	49,448	46,620	588	8,219	2,475	15	172	222
November...........	1,750	8,833	14,636	388	988	560	32	254	—
December	—	—	215	582	4,223	2,026	—	—	4

TABLE IV., *showing the quantities of Mackerel landed during each month of the year at certain French ports for the years* 1894, 1895, *and* 1896, *compiled from the official returns.*

	FRANCE (NORTH).—ST. VARLEY-SUR-SOMME.			FRANCE (WEST).—DOUARNENEZ.			FRANCE (SOUTH).—CETTE.		
	1894.	1895.	1896.	1894.	1895.	1896.	1894.	1895.	1896.
	Kilos.	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*
January	—	—	—	—	1,425	1,300	—	—	—
February	—	—	—	149,951	—	—	—	—	—
March	—	—	—	78,932	—	34,136	—	—	1,840
April	—	—	—	112,300	Appeared on 20th 240,000	358,581	150,200	19,400	101,354
May	3,750	1,200 Present last week of month.	—	1,136,625	1,800,000	477,899	Abundant	51,050	102,650
June	60,000	56,000	—	408,513	794,000	109,696	50,000 (?)	52,000	47,000
July	66,000	70,000	Gravelines,* 945 kilos. 84,000	33,948	60,700	7,913	10,540	13,000	8,800
August	75,200	59,200	Gravelines,* 1,275 kilos. 33,600	60,600	543,860	38,889	—	—	7,000
September	88,500	68,800	Gravelines,* 149,140 kilos. 41,320	1,042,810	229,870	65,734	—	—	5,280
October	Gravelines,* 108,000 kilos. 8,500	Gravelines,* 66,334 kilos. 8,000	Gravelines,* 231,460 kilos. 8,000	203,940	—	473,076	—	—	2,700
November	—	—	—	180,000	—	48,841	—	—	2,006
December	—	—	—	9,640	—	71,491	—	—	2,012

* These are the only months when Mackerel are landed at this port.

TABLE V., *showing the quantity of Mackerel landed at various French ports during each month of the year* 1896, *compiled from the official returns.*

1896.	GRAVELINES.	BOULOGNE.	ST. VARLEY-SUR-SOMME.	DIEPPE.	FECAMP.	DOUARNENEZ.	QUIMPER.	CONCARNEAU.	CETTE.	MARSEILLE.
	Kilos.	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*	*Kilos.*
January	—	—	—	—	—	1,300	—	—	—	750
February	—	—	—	—	—	—	1,020	1,600	—	482
March	—	—	—	—	—	34,136	9,820	3,500	1,840	370
April	—	681,086	—	35,400	171,900	358,581	411,740	82,380	101,354	33,200
May	—	1,598,136	—	31,700	48,157	477,899	298,000	71,710	102,650	47.300
June	—	489,550	—	60,900	47,730	109,696	95,600	17,600	47,000	55,320
July	945	114,830	84,000	68,600	48,387	7,913	2,500	29,900	8,800	60,870
August	1,275	54,000	33,600	31,400	16,170	38,889	2,400	87,800	7,000	54,000
September	149,140	367,200	41,320	9,200	1,374	65,734	346,000	80,030	5,280	44,800
October	231,460	242,700	8,000	—	36,720	473,076	—	67,500	2,700	20,200
November	2,375	14,520	—	—	—	48,841	—	2,800	2,006	7,450
December	—	—	—	—	—	71,491	—	—	2,012	5,800

also mackerel fishing at this time of the year off the Lizard. The fish taken are smaller than those captured later in the year, and are not mature.

On the west coast of France (Douarnenez) the mackerel may appear in February and remain from that time onwards (*e.g.*, 1894, 150,000 kilos were taken during this month). In other years (*e.g.*, 1895, which was extremely cold during the early months) they were not seen at Douarnenez until the end of April.

Marion* states that at Marseille the ovaries of fish taken in January were well developed. The eggs were 1 mm. in diameter, but were not extruded on pressure. He also mentions small fish 20 to 24 cm. (8 to 9½ inches) long in February, which he regards as one year old. The reproductive organs of these are stated to have been well developed. Gourret† records mackerel in January in the same locality, which were 20 to 30 cm. (8–12 inches) long.

No record has been seen of mackerel being taken during either January or February in other parts of Europe than those mentioned.

America.—There is little evidence of mackerel being near the American coasts at this time of the year. Brown Goode‡ mentions that instances are on record of mackerel having been captured in the Gulf of St. Lawrence in mid-winter, but these appear to be simply stray specimens. Captain J. W. Collins§ reports that in the latter part of February, 1882, many mackerel were taken from the stomachs of cod, which had been captured 10 to 12 miles off Egg Harbour, N.J., in 12 to 15 fathoms. The mackerel appeared to have been only recently swallowed. This observation is important, since it shows that mackerel may be at no great distance from the coast without their presence being easily detected.

MARCH AND APRIL: *Europe*.—During the early part of March, and often during the greater portion of the month, the conditions remain much as they were during February. The mackerel in the English Channel are still 20 to 40 miles from the coast, and they remain at about this distance during the whole of these two months, increasing, however, in abundance.

Towards the end of March, or early in April, large schools of full-grown fish approach the south-west coasts of Ireland and the west coast of France, and the great spring mackerel fishery commences.

* *Ann. Mus. Nat. Hist. Marseille Zool. Appliquée*, vol. i. p. 85.

† *Ann. Mus. Nat. Hist. Marseille Zool. Appliquée*, vol. ii. p. 58.

‡ *Report of U.S. Fish. Com.*, 1881, p. 97.

§ *Bull. U.S. Fish. Com.*, vol. ii., 1882, p. 273.

The date of the appearance of the spring shoals varies considerably from year to year. As already mentioned, in 1894 the fish were taken in numbers on the west coast of France, at Douarnenez and the neighbouring fishing ports, as early as February. In the following year, 1895, none were seen at Douarnenez until the 20th of April, whilst at Quimper they first appeared on March 22nd.*

The following dates, taken from the *Reports of the Inspectors of Irish Fisheries,* give the times of commencement of the fishery for different years at some of the principal Irish fishing ports:—

	1891.	1892.	1893.	1894.	1895.
Kinsale .	March 21 ...	April 8 ...	March 30 ...	March 21 ...	April 9
Baltimore .	,, 24 ...	,, 8 ...	April 4 ...	,, 27 ...	,, 3
Crookhaven .	,, 24 ...	,, 9 ...	,, 4 ...	April 6 ...	,, 11
Knightstown	... ...	,, 8 ...	,, 4 ...	March 21 ...	,, 11
Fenit . .	March (?) ...	,, 6 ...	March 31 ...	,, 26 ...	,, 2

Comparing the dates of arrival of the large shoals in the years 1894 and 1895 on the south-west coast of Ireland, and those already given for the west coast of France, it appears that the fish came earlier in 1894 than in 1895 in both localities, and in both years reached the French coast earlier than the Irish, the difference in time being from a fortnight to a month. In 1895, although the mackerel were at Quimper earlier than in Ireland, they did not appear at Douarnenez until some ten days after the commencement of the Irish fishery.

It is worthy of note that in certain bays on the west coast of Ireland the large fish are taken in nets shot from canoes and row-boats close to the shore some two or three weeks before they are captured by the larger vessels working in the offing, where the water is 40 to 80 fathoms deep.† As Mr. Green has pointed out, this seems to indicate that the mackerel when approaching the shore keep deep down, the fish which enter the bays being forced up into the upper waters by the rising of the sea-floor.

At about the same time as the appearance of the schools off the west coasts of France and Ireland—that is, towards the end of March—mackerel fishing commences in the Mediterranean. Large schools are found off Cette, on the south coast of France. At Marseilles, on the other hand, the fish do not enter the Gulf until considerably later.

* *Bull. Pêch. Mar.*, 1894 and 1895.

† GREEN, Rev. W. S. "Notes on the Irish Mackerel Fisheries." *Bull. U.S. Fish. Com.*, 1893, p. 357.

One important observation made during the early days of March, 1891, is recorded by Marion,* which shows that mackerel may be present in deep water when not visible at the surface. After a strong *mistral* the trawls of the "bateaux bœufs," fishing six miles from shore off Cape Couronne, caught numbers of mackerel at depths of 100 to 150 mètres. Marion considers that this accidental capture demonstrates completely that the mackerel leave the surface and descend into the deep water when the upper layers are agitated by strong winds. This observation will be again considered and discussed in relation to others.

After the advent of the spring schools fishing is abundant in the Mediterranean (Cette), off the west coast of France, off the south-west of Ireland, in the western portion of the English Channel, and off the north coast of Cornwall. Mackerel are not, however, yet (April) taken in numbers in the eastern portion of the English Channel, in the North Sea, or on the coast of Norway.

In the Mediterranean the mackerel caught in April are breeding fish. On the other coasts the shoals are composed of large fish about to breed, but their reproductive organs are not yet ripe. The fish captured off the south-west of Ireland appear to be the finest, and command the best prices.

America.—On the American side of the Atlantic mackerel make their first appearance at some distance from the coast, off Cape Hatteras, at about the same time of year as they appear on the Irish coast. The following list of dates of first catches is taken from the *Bulletin of the U. S. Fish Commission*, vol. vi., 1886, p. 107.

Year.	Date.	Year.	Date.
1879	April 13	1883	March 31.
1880	April 2	1884	,, 31.
1881	March 22	1885	,, 28.
1882	,, 31	1886	April 10.

During April the fish move gradually northwards, but do not go close to the shore. By the end of the month they are generally found off the capes of Delaware.

Until the year 1886 it was the custom of the American mackerel fishermen to go southwards in March, and capture these early shoals. Many of the shoals were composed of large fish just about to spawn, but the condition of the fish was not equal to that of those caught later in the year, which had been feeding on the coast for some time. As the fish did not readily take bait at this time, they were caught in purse-seines. In 1887, to endeavour to counteract the considerable

* *Ann. Mus. Nat. Hist. Marseille Zool. Appliquées*, 1891, p. iii.

decline of the mackerel fishery, an Act was passed by Congress prohibiting the landing of mackerel between the first day of March and the first day of June for a period of five years, the Act not to apply to fish caught off-shore with hook and line. As no great good was seen to result from this restriction of the fishery of the breeding fish, the Act was not renewed after its expiration in 1892.

MAY AND JUNE: *Europe.*—In May the spring mackerel fishing reaches its height, and continues into June, falling off considerably towards the end of that month. In the Mediterranean (Cette), on the west coast of France, on the south-west coast of Ireland, and in the western part of the English Channel, during both May and June, the fish are near the shore in large numbers, the quantities landed in all these localities being at a maximum in May. With the exception of the Mediterranean fish, which are all spent, spawning is actively going on. Mackerel are plentiful during both these months on the coast of Portugal.*

In the eastern portion of the English Channel (*e.g.*, St. Varley-sur-Somme) the fish are seldom abundant before June.† At Dieppe, however, some mackerel are taken in both April and May, but the maximum is not reached until June. At Guernsey fishing begins at the middle or end of May, and lasts ten to twelve weeks.‡

In the North Sea there is a small fishery on the Danish coast, which commences in May; but no fish are landed at the English North Sea ports before June, and then they are not numerous in proportion to those taken later in the year. The large Lowestoft and Yarmouth mackerel boats are at this time of the year working off the south-west coasts of England and Ireland.

In May and June mackerel are present off the west coast of Scotland, often, no doubt, in numbers, though there is no great fishery for them. On the southern coast of Norway, as far north as the heights of Bergen, along the Swedish coast, and in the Kattegat, the large shoals appear towards the end of May, and the principal fishery is carried on during the latter part of that month and in June.

In general it may be said that in the more southerly and westerly districts, where the fish arrive in April, they are most abundant in May, whilst in the northerly and easterly ones they do not arrive until towards the end of May, and are most abundant in June.

* BALDAQUE DA SILVA. *Estado Actual das pescas em Portugal.* See also *Mitt. Deutsch seefischereivereins*, 1895, p. 61.

† In exceptional years mackerel may be taken in this part of the Channel in numbers in February and March. In March, 1833, and in February and March, 1834, according to Yarrell, boats from Hastings had large catches; but it is not stated where the fish had been captured. YARRELL. *British Fishes*, pp. 125, 126.

‡ HOLDSWORTH. *Deep-sea Fishing*, p. 213.

It should be mentioned that in the English Channel and in the Mediterranean, although the fish are close in-shore along the coast in May, they do not enter Plymouth Sound and the Gulf of Marseille in great numbers until later, in the former case not until July, in the latter in June.

America.—We have already seen that towards the end of April the mackerel on the east coast of the United States are taken as far north as the capes of Delaware, but still at some distance from land. About the beginning of May the fish approach the coast in the neighbourhood of Long Island. They are present at about the same time in abundance in the neighbourhood of Nantucket and in Massachusetts Bay. Towards the end of the same month they are first taken off Nova Scotia (May 20th, 1883; May 16th, 1884), but it is often much later than this when they appear in the Gulf of St. Lawrence. At the Magdalen Islands, near the mouth of the Gulf, mackerel most frequently arrive during the first week in June. In 1884, which was a very late year, owing to the fact that the ice did not leave the Gulf until June 2nd, no mackerel were taken until August.* When the fish are late in appearing on the Massachusetts coast they are generally proportionately late in reaching the Gulf of St. Lawrence. The years 1871 and 1872 offer a good example of this, as will be seen from the dates given below:—†

WAQUOIT, MASSACHUSETTS.

1871. Date of first appearance of mackerel, April 25th.
1872. ,, ,, ,, ,, ,, May 10th.

Difference in time, 15 *days*.

MAGDALEN ISLANDS, GULF OF ST. LAWRENCE.

1871. Date of first appearance of mackerel, May 31st.
1872. ,, ,, ,, ,, ,, June 20th.

Difference in time, 21 *days*.

With reference to the passage of the mackerel into the Gulf of St. Lawrence, Captain J. W. Collins, of the U.S. Fish Commission,‡ states that during May and early June large bodies of these fish pass along the shores of Nova Scotia and Cape Breton, from west to east, some entering the Gulf by the Straits of Canso, others going round the north of Cape Breton Island.

JULY AND AUGUST.—*Europe.* At all the large fishing centres there is a great falling off in the quantity of mackerel landed during these

* *Bull. U.S. Fish. Com.*, vol. v. p. 60.
† *Report of U.S. Fish. Com.*, 1881, p. 136.
‡ *Report of U.S. Fish. Com.*, 1881, p. 121.

two months. On the south-west of Ireland fishing is almost suspended, and the quantities caught on the south and west coasts of England and on the west coast of France are very small compared with those taken during May and June.

In the eastern part of the English Channel and on the east coast, where the mackerel do not arrive until the end of May, the returns indicate that the fish are more numerous in July than earlier in the year; but there is a falling off in the number landed in August, which is, however, more marked in the North Sea than in the English Channel.

In Norway the fishing, which commences towards the end of May, and is at its height during June, continues to be good until the middle of July, about which time it practically ceases. Sars * draws attention to the fact that, according to Lowe (*Fauna Orcadensis*), mackerel are seen in large schools near the Orkney Islands at the end of July and the beginning of August, just after the Norwegian fisheries have closed. These he thinks are probably shoals returning from the Norwegian coast to the Atlantic.

In the Mediterranean, at Cette, and at the majority of the ports, the large fishing practically ends in June, and few mackerel are taken during the remainder of the year. At Marseilles, on the other hand, the fish seem to be plentiful until September. In 1896, according to the official returns, the maximum was reached in July, and the quantity taken in August was still large. Marion † states that the fish are generally most plentiful in September.

From the above facts, which will be seen in more detail in the tables, it is obvious that as a general rule a season of scarcity exists during these two months, July and August, between the great spring and autumn fisheries. The reason for this scarcity is not very clear. At Plymouth, at this time of the year, the mackerel seem to be scattered. There are undoubtedly large numbers present in the Sound and in-shore waters, where they are taken by whiffing and with the seine. Drift-net fishing, on the other hand, is practically suspended. It is to be noted, too, that during the hot weather of these two months mackerel are with difficulty kept in good condition, and although the supply is short the demand for them is not great, and prices are low. It is probable that this may have something to do with the small quantity landed.

America.—The marked falling off between the spring and autumn fisheries, which is observed in Europe, does not, from the information available, appear to be so great on the American coasts, if indeed it exists at all. In Fundy Bay, and in the Gulf of St. Lawrence, at any rate, the fish seem to be quite plentiful at this time of the year.

* Report for 1875. English Translation, *Report of U.S. Fish. Com.*, 1877, p. 671.

† *Ann. Mus. Nat. Hist. Marseille Zool. Appliquée*, i. p. 84.

SEPTEMBER AND OCTOBER.—*Europe.* During September and October the great autumn mackerel fisheries are carried on. On the west coast of France and the south-west of Ireland large numbers of fish are taken, the amount landed in Ireland being as great in some years as during the spring fishery. The fish are of good size and in good condition, but their reproductive organs are not mature. There appears to be a general idea amongst the fishermen that the autumn fish, both here and elsewhere, belong to a different race from those taken in the spring, but no successful attempt has ever been made by naturalists to prove or disprove this contention.

On the west coast of England an autumn fishery practically does not exist, and on the south coast, although more fish are in general landed in September than in August, the number is by no means large, and October shows a very great falling off. At Plymouth the mackerel leave the Sound after the beginning of September, and are then taken a few miles south of the Eddystone and off Start Point.*

In the eastern portion of the Channel (*e.g.*, St. Varley-sur-Somme), and in the southern part of the North Sea (east coast of England and Gravelines), on the other hand, by far the most important fishery of the year takes place at this time, the number of fish landed being greatest in October.

In Norway there is an autumn fishery of mackerel, which crowd into the deep-water fjords. These fish are feeding on the young herring and other small fish, and are in extremely good condition. As soon as the food gets scarce they go to sea again. Sars considers that they are schools which have separated from the chief summer schools, and instead of going out to sea, have commenced to chase the young herring and follow them into the fjords. Sars also states that these autumn fish frequent deeper water than the summer mackerel, probably because of the fresh water at the surface of the fjords.

On the French Mediterranean coast the only important autumn fishery is at Marseilles, there being practically none at Cette.

America.—In America, as in Europe, autumn fishing for mackerel is largely carried on. The vessels at this time of the year work chiefly in the Gulf of St. Lawrence, but mackerel are also taken along the New England coast. The information contained in the various reports of the United States Fish Commission does not, however, indicate that any marked increase of fish in September and October, over that taken during the two preceding months, regularly takes place, as we find to be the case in European seas. The autumn fish are in much better condition than those taken in spring, owing to the more

* CUNNINGHAM. *Nat. Hist. Mark. Mar. Fish.*, p. 316.

plentiful supply of food in the shape of young fish of other species. The idea, which is so prevalent amongst fishermen on the English coast, that the mackerel taken in the autumn are a different race of fish from those taken in spring, does not seem to be suggested by the American fishermen.

NOVEMBER AND DECEMBER: *Europe.*—Mackerel fishing is practically closed in November and December on all the European coasts, though a few fish are still taken in the North Sea in November, and a still smaller number in the English Channel. Mackerel landed at Plymouth are caught 15 to 20 miles south-west of Start Point, and about the same distance from the Eddystone. On the west coast of France the fish may be entirely absent, or a small number may be taken in both November and December. On the south coast of Ireland, in favourable years, fishing on a small scale may be continued up to Christmas.

America.—In America fishing ceases and the mackerel fleet is laid up in November. The fish are observed to leave the Gulf of St. Lawrence in large shoals, passing out by the same routes as they entered, viz., around the north of Cape Breton Island or through the Straits of Canso,* and they remain absent until the following summer.

EXTENT AND CAUSES OF THE MIGRATION OF THE MACKEREL.—Both the extent of the migrations of the mackerel, and the causes which bring about those migrations, are very imperfectly understood. For a long time both have been subjects for speculation amongst naturalists, but little definite or certain information has been arrived at.

Brown Goode,† who has discussed the general question of the migrations of pelagic fishes with some fulness, regards the temperature of the sea-water as one of the most important factors influencing their movements, and this view is shared by most naturalists who have paid attention to the subject. According to Brown Goode the appearance of the mackerel off the coast of America is synchronous with an average weekly temperature of not less than 45° F. in the harbours. At this time the temperature in the open sea is somewhat lower, and mackerel will remain active and contented at a temperature of 40°, or even less. Green‡ has shown that on the south-west coast of Ireland mackerel are first taken in the spring in large numbers off the land when the surface temperature of the sea is 50° F. At the same time he mentions that the smaller boats, shooting their nets close to the shore and in

* COLLINS, J. W. *Report of U.S. Fish Com.*, 1881, p. 121.

† "History of the Menhaden." *U.S. Fish. Com. Report*, 1877, especially pp. 50–70. "Materials for a History of the Mackerel Fishery." *U.S. Fish. Com. Report*, 1881.

‡ "Notes on the Irish Mackerel Fisheries." *Bull. U.S. Fish. Com.*, 1893, p. 357.

certain bays, get the large spring fish two or three weeks earlier, whilst the temperature is still low.

In the south of France, where the migrations are essentially similar to those which occur in America and on the Atlantic coasts of Europe, the temperature of the surface water on the coast is never below 50° F. (10° C.), even in January, the temperature in February and March being 54° to 59° F. (12°–15° C.) [Marion.]

From these facts it would seem that the large shoals first appear in American waters when the temperature is 40°–45° F.; off the coast of Ireland when it reaches 50° F., and on the Mediterranean coasts when it approaches 60° F. We must, therefore, suppose either that we are here dealing with three distinct races, which have become adapted to different temperature conditions, in which case the species must be capable of considerable variation in its habits in this respect, or that the temperature influences the migrations of the fish indirectly by determining the presence or absence of the particular organisms which serve for its food in each locality. The latter explanation, however, cannot be regarded as complete, since in some localities, *e.g.*, the North Sea, in autumn we have both herring and mackerel present at the same time, yet whilst the mackerel retire to the south the herring return to the north.

The first approach of the mackerel to the coast in spring or early summer is for the purposes of spawning, and the advantage to the species of the young fish being hatched out near the shore, where the smaller forms of pelagic organisms are present in abundance, and the plankton is increased by the numerous larval forms of those species which inhabit the coastal waters, is obvious. The presence of the fish in the in-shore waters during the summer and autumn, on the other hand, is to be explained by the fact that these waters are at that time crowded with the young forms of other fishes, which serve as a bountiful food supply to the mackerel.

It has already been noted that when the fish first approach the coast for spawning only the males can be captured with bait, the females having ceased to feed at this time. Hence the first migration towards the shore must be regarded as to some extent independent of the food supply, and we may call it, with Sars, the "spawning migration." The approach to the coast in the summer and autumn is, on the other hand, a "feeding migration."

What relation exists between the fish which take part in the two migrations it is impossible to say. The autumn fish are said to be smaller than those which come in the spring, and it has already been mentioned that the fishermen maintain that they belong to a different race. They are all of them, however, immature, and cannot therefore be compared to the winter and summer herrings, both of which are spawning fish, when they visit the coasts.* Sars regards the autumn fish, which in Norway are taken in abundance in the fjords, as fish which have left the main shoals in summer to follow the young herring upon which they feed.

Where do the mackerel go when they leave the coast? is perhaps the most important question connected with their migrations, to which no certain answer can yet be given. Sars and Brown Goode have both shown that the theory at one time held by some naturalists, that the fish hibernate during the winter at the bottom of the sea, in the neighbourhood of their summer haunts, is highly improbable, and it need not be further discussed here.

There are two alternatives in regard to the matter which are worthy of consideration.

(1) The mackerel may live near the surface of the ocean at considerable distances from land, in regions where they find a suitable sea temperature.

(2) They may live in deeper layers of the sea, at a greater or less distance—possibly never at a very great distance—from their summer localities, where it is possible that they may find the conditions favourable.

1. That the mackerel during the winter do not retire to more southerly latitudes, and continue to live according to their spring and autumn habits, near the coast and at the surface, is practically certain. There is no record of the fish being taken either on the coast of Africa or on the American coast, south of Cape Hatteras, during the cold months of the year.

Nor do any accounts exist of mackerel having been seen at the surface in the warmer regions of the open ocean at any time of the year. If they made these regions their winter home, and preserved their shoaling habits, it is practically certain that they would have been recognised, as the appearance of the shoals is well known to seafaring men, and is quite characteristic. If, on the other hand, the shoals broke up and the fish wandered independently or a few only together, it is possible that they might have escaped detection. This must remain, until the contrary is shown to be the case, one of the possible solutions of the question, although it is not very probable, since were it so specimens would almost certainly have been captured at some time or other.

2. The mackerel may live in deeper layers of the sea, at a greater or less distance—possibly at no very great distance—from their summer haunts. The facts on the whole seem to point to this conclusion.

* CUNNINGHAM. *Nat. Hist. Mark. Mar. Fish.*, p. 153.

That on the first appearance of the fish a certain amount of migration in a definite direction, generally from south to north, takes place cannot be denied. It is most conspicuous on the American coast, where the fish, as has been explained, first appear at some distance from land off Cape Hatteras, and gradually move northward until they reach the coast in the neighbourhood of Long Island, about a month after they are first seen. Even in this case, however, it is fairly obvious that large numbers of fish must be moving in towards the land from latitudes more northerly than that of Cape Hatteras, where the fish first appear.* The fact that the spawning season of the mackerel becomes later the further north they are captured is sufficient in itself to prove that such is the case. The fish which spawn in the Gulf of St. Lawrence in July cannot be the same as those which spawned in May and June on the New England coast. In the autumn, too, when the fish disappear, the facts do not point to an extensive southerly migration in the surface waters along the coasts. That the fish move out of the Gulf of St. Lawrence seems to have been established, but this does not take place until November, and the fishing is continued in this region quite as long as it is further south. There is practically no fishing on the more southerly coasts of the United States after the fishing in the Gulf has ceased.

On the Atlantic coasts of Europe the movements of the mackerel, after their first appearance, are a little more difficult to follow. Unfortunately no information has been found in the literature consulted as to when the fish first arrive off the coast of Portugal, and we only know that they are plentiful from May onwards. The earliest catches on this side of the Atlantic of which records exist are those made in the western part of the English Channel in January and February, and some also off the west coast of Ireland. In the former case the boats generally obtain their first fish about 20 miles south-west of Start Point, and subsequently work more to the westward, taking them 20 miles south-west of the Eddystone. This seems to suggest that we have here to do with the last of the autumn fish of the previous year moving down Channel.

On the west coast of France the spring shoals may appear as early as February (*e.g.*, 1894), although in other years none may be taken until late in March or April. It is generally somewhat later that the fish arrive off the mouth of the Channel and off the Irish coast. In Norway and the Kattegat the fish do not come to the coast until towards the end of May, and the fact that the spawning season of these fish is so much later than that of those in the Channel would, in this case also,

* See especially SPENCER BAIRD, "Sea Fisheries of Eastern North America," and Appendix. *Report of U.S. Fish Com.*, 1886.

render it unlikely that they had made any extended migration along the Irish and Scottish coasts.

There is, however, obviously a migration through the English Channel into the North Sea. Whilst mackerel are at the mouth of the Channel in March few fish are taken either in its eastern portion or in the southern part of the North Sea before the end of May or the beginning of June. In the autumn, on the other hand, the large fishery in the southern part of the North Sea seems to be due to the movement of the fish towards the Straits of Dover, on their passage back to the English Channel. The mackerel taken on the south coast of England in December, January, and February are possibly, as suggested above, the fish which have emigrated from the North Sea. In the present state of our knowledge of the subject this is, however, a mere speculation. An examination of the Board of Trade statistics from 1886 to 1895 does not show any constant relation between the number of mackerel landed on the south coast of England in December and January, and the success or failure of the previous autumn fishery on the east coast.

There is a certain amount of evidence that mackerel, when not at the surface near the coasts, may be present in deeper water not far off. This evidence has already been referred to in previous parts of this Report. In the first place there is the fact mentioned by Green, that in certain bays on the west coast of Ireland the large spring mackerel are captured close to the shore two or three weeks before the larger boats working in the offing, where the water is 40 to 80 fathoms deep, are able to obtain any. These early in-shore fish must have travelled in towards the coast in the deeper layers of water. There is also the record by Marion, that at the beginning of March, 1891, after a strong *mistral*, large numbers of mackerel were taken by the trawls of the "bateaux bœufs," fishing six miles from shore off Cape Couronne, in depths of 100 to 150 mètres. It is true that in this case the objection may be raised that the fish might have been captured in upper layers whilst the net was being drawn to the surface, but this does not appear to be a very likely explanation of the catch. Mr. Holt states that he has taken mackerel in the trawl in the North Sea, after heavy weather, and the Plymouth trawl fishermen say that they also obtain them under like circumstances.

Finally, we have the records of mackerel, but little digested, taken from the stomachs of cod on the American coast some time before the appearance of the schools at the surface.

If the mackerel, when away from the coast, retire to deeper water, where the temperature is more suitable to them, it becomes interesting to inquire where they would find such a temperature. The series of observations taken by the *Challenger* between Bermuda and Halifax, and New York and Bermuda, which are shown in two diagrams in Brown Goode's paper on the "Menhaden Fishery,"* prove that on the western side of the Atlantic extensive layers of water exist in April and May below the Gulf Stream having temperatures similar to those of the waters frequented by the mackerel when on the coast.

For the parts of the Atlantic lying off the European coasts no observations giving the required information during the winter months appear to have been made; but from the position of the isothermal for 50° F. for surface temperature in February, when such temperatures are at a minimum, it is clear that water of the required warmth must exist at no very great distance from the coasts frequented by the fish, with the exception of the coasts of Norway and the North Sea. In the latter case we have already seen that the fish probably retire in the autumn by way of the English Channel.

* *Report of U.S. Fish. Com.*, 1877.

APPENDIX.

The American Investigations of the Habits and Migrations of the Mackerel.

SINCE its first foundation the United States Commission of Fish and Fisheries has paid great attention to the habits and movements of the migratory fishes, more especially of those of the mackerel and menhaden. In the early years of the Commission an endeavour was made to obtain information by the issue of circulars to fishermen and others, who were likely to be in a position to observe the movements of the fish. In this way a large amount of material was got together, and was embodied in two comprehensive memoirs, published in the Report of the Commissioner:—

(1) "The Natural and Economical History of the American Menhaden," by G. Brown Goode. *Commissioner's Report*, 1877, pp. 1–529.

(2) "Materials for a History of the Mackerel Fishery," by G. Brown Goode, Joseph W. Collins, R. E. Earlle, and A. Howard Clark. *Commissioner's Report*, 1881, pp. 93–531.

The information, however, so obtained was not of an altogether satisfactory nature, and it was seen that if the various problems presented were to be satisfactorily solved, special investigations for that purpose would have to be made.

It was largely with a view to undertaking researches into these questions that the schooner *Grampus* was built for the Commission. This vessel was completed in 1886, and since that year she has been very largely employed in such work.

The *Grampus* is a two-masted, schooner-rigged vessel, 90 ft. long over all, 22 ft. 2 ins. beam, and 10 ft. depth of hold; her registered tonnage is 83·30 tons. She is supplied with all kinds of fishing appliances and scientific instruments suitable for the work she has to do.

The appended extracts from the *Commissioner's Reports*, issued since 1887, will show the various steps which have been taken to investigate the subject. It is evident that a large amount of material, consisting of observations systematically taken for a number of years, must now be in the hands of the Commission; but up to the present neither the detailed observations made during the last few years, nor any general discussions of the habits and movements of the mackerel, based upon the recent work, have been published.

Report for 1887, p. 54.—"From the latter part of April until the last of May, 1887, while in command of Captain D. E. Collins, and with Dr. T. H. Bean as naturalist, she [the *Grampus*] was engaged in cruising on the early mackerel grounds between Cape Hatteras, North Carolina, and Cape Cod, Massachusetts, for the purpose of studying the schools of mackerel as they approach the coast, and their subsequent movements with relation to temperature, the abundance of food, etc. The schooner was well equipped with the necessary scientific and fishing appliances, and succeeded in obtaining many valuable observations, which have been published in the *Fish Commission Bulletin* for this year. A part of the time she kept company with the fishing fleet, and at others was cruising independently, with the view of ascertaining whether the mackerel could be found in advance of the fishing centres or in other directions. During the first part of the season the mackerel were scarce and small. Sea birds, cetaceans, and various other marine forms, which generally accompany the schools and indicate their position and size, were less abundant than usual. Bad weather also prevailed most of the time, and this undoubtedly interfered with the schooling of the fish at the surface. Most of the schools sighted, even during the latter part of the cruise, were too deep in the water to be reached by seining, and it is probable that a large proportion of the fish passed northward unobserved. They also appeared to move nearer the land than has generally been recorded.

"During the following summer, beginning the first part of July, the *Grampus* extended its researches respecting the distribution and abundance of mackerel along the coasts of the British Province as far north as Labrador. She was then in charge of Captain J. W. Collins. The principal object of the trip was to verify the recent reports concerning the appearance of mackerel off the north-east coast of Newfoundland. Following the coast of Nova Scotia as far as Canso, the *Grampus* entered the Gulf of St. Lawrence, and sailed as far north as the Magdalen Islands. Thence she proceeded to St. John's, Newfoundland, and along the outer side of Newfoundland to the Straits of Belle Isle. No mackerel were observed at this point; but many natural history specimens and physical observations were obtained. Mr. F. A. Lucas and Mr. William Palmer, of the U.S. National Museum, accompanied the schooner as naturalists, and in addition to the regular work of the cruise they were allowed to land and make shore collections at the different harbours visited.

"The work begun in the spring of 1887 was continued by the *Grampus* during April, May, and June, 1888, Captain D. E. Collins being again in command, and Dr. T. H. Bean acting as naturalist. The cruising ground was the same as in the previous year. Only small schools of mackerel were encountered, and those not until late in May. Low water temperatures prevailed during the early part of the season, and the mackerel food was found to be abundant only in streaks or scattered patches. The experiment of carrying living mackerel in the schooner's well proved successful, and it will therefore be possible to undertake the reproduction of this species at one of the coast stations of the Commission."

During the winter of 1888-89 the *Grampus* was chiefly at work in the Gulf of Mexico, making general investigations into the fisheries.

Commissioner's Report, 1888, p. 15.—"Being impressed with the importance of a systematic study of the temperature, conditions, and the changes of conditions in our off-shore waters, I have instituted a systematic investigation to this end, and have assigned the Fish Commission schooner *Grampus* to this work. Prof. William Libbey, of Princeton College, has been selected to take charge of the investigation, and the vessel is now being fitted with the necessary apparatus and appliances for the work, and will enter upon it at the beginning of the next fiscal year."

Commissioner's Report, 1889-91, p. 5.—"The physical inquiries in the mackerel region off the southern New England coast, under the direction of Prof. William Libbey, jun., referred to in the last Annual Report, were conducted during a part of July and August, 1889, and again during the summer of 1890. The former season the work was performed by means of the schooner *Grampus* alone, but during the latter the Coast Survey steamer *Blake* was detailed to act in co-operation with the *Grampus*, and, through the courtesy of the Lighthouse Board, a party of observers was also stationed on the Nantucket New South Shoal Light-ship. Parallel lines of observing stations were carried seaward from the coast for distances of 130 to 150 miles, the lines being 10 minutes of longitude apart and the stations 10 miles apart. At each of these stations, which numbered several hundred in the course of the two seasons, the temperature of the water was taken at regular intervals between the surface and bottom, or down to depths of 300 to 500 fathoms, where the depth of water exceeded that amount, and at the same time a full set of meteorological observations was recorded. The result has been to furnish a large series of vertical temperature sections through the water, which show very clearly the relations of the Gulf Stream with the colder waters of the Arctic current; and the surface variations are accompanied by very complete meteorological data, with which, it is hoped, a correlation may ultimately be rendered possible. These observations will undoubtedly throw much light upon the habits of several species of pelagic fishes, of which the mackerel is most conspicuous, and even the movements of such bottom fishes as the tile-fish will probably find their explanation in a knowledge of these physical characteristics."

Ditto, p. 129.—"From May 5 to June 8, 1891, the schooner *Grampus* was engaged in making a series of observations over the mackerel grounds, from

Delaware northward to Massachusetts. This was in continuation of similar inquiries made in previous years to determine so far as possible the temperature and other physical phenomena connected directly with the northerly movement of the advance schools of mackerel along the coast.

"The principal object of the cruise was to locate the early schools of mackerel; to follow their movements northward, or in whatever direction they might take; and to learn everything possible regarding the conditions of the air and water in connection with their habits. As it was somewhat late in the season before the trip began, it was expected that the schools were already upon the grounds, and that it would not be necessary to proceed very far south before meeting them. Such was found to be the case; but the observations were carried southward from Woods Hole until the fish were encountered, and thence over a part of the area through which they had passed, in order to obtain the necessary data for comparing the conditions in advance of the first schools with those existing in their rear. Subsequently the *Grampus* followed the schools as far as Marthas Vineyard, taking ripe males the last of May and ripe females the first of June in that vicinity. The physical observations have not yet been reduced and compared."

Commissioner's Report, 1892, p. 91.—"The physical inquiries respecting the waters off the southern New England coast, begun in 1889 by the schooner *Grampus*, and conducted the next year by the same vessel in conjunction with the Coast Survey steamer *Blake*, were continued during the summer of 1891 by the *Grampus* alone. The work was carried on, as in previous years, under the direction of Professor William Libbey, jun., of Princeton College."

Commissioner's Report, 1893.—"The Act of Congress, passed in 1886, which virtually prohibited the spring mackerel vessel fishery prior to June 1 of each year, during a term of five years, ceased to be operative after 1892. In order to determine, so far as possible, if any immediate benefits had resulted from this series of close seasons, and also to obtain information for the use of the Joint Fishery Commission between Great Britain and the United States, the schooner *Grampus*, Captain A. C. Adams in command, was detailed to follow the progress of that fishery throughout its entire course in the spring of 1893. Sailing from Woods Hole at an early date, Captain Adams was directed to conduct a detailed series of physical observations on the way south until the body of mackerel had been discovered, after which he was to keep track of the movements, habits, and abundance of the latter, and to study the conditions of their environment as far north as Nova Scotia. The presence of a large fleet of purse-seiners on the grounds afforded excellent opportunities for learning of the distribution of the fish at all times, and through their means it was expected that specimens for examination would be obtainable. The *Grampus* also made use of the fishing apparatus she had on board, and an hourly record of physical determinations was maintained day and night, besides which the surface tow-nets were frequently employed to discover the presence of mackerel food. The natural history observations were conducted by Mr. W. C. Kendall. Mr. B. L. Hardin was stationed at Fulton Market, New York City, to inspect all arrivals of mackerel there from the purse-seine fleet, as well as from the shore apparatus tributary to that market.

"The *Grampus* sailed from Woods Hole on April 10, and reported at Lewes, Del., April 21, having experienced heavy weather up to that date. Very few fish had been observed, and the fishing fleet had accomplished comparatively nothing. The latter also sought shelter at the same place. Poor success, both in the catch of fish and in the opportunities to make observations upon them, continued thence to the close of the season, and by the middle of May nearly all the purse-seiners had left the southern grounds for the coast of Nova Scotia. The small catch made this season was partly due to stormy weather, but even when all the conditions seemed favourable, mackerel were either scarce or difficult to capture. More light will probably be thrown upon this question when the elaborate series of notes obtained have been worked up; but the fishermen have failed thus far to recognise any beneficial results from the restrictions placed upon their spring fishery during the previous five years.

"On May 23, the southern fishery having ended several days before that time, the *Grampus* left Woods Hole, where she had put in for supplies, and proceeded to Nova Scotia to continue the inquiries on the same plan as at the south. The entire fleet had assembled there, but no fish were taken on this coast, except in trap-nets on the shore, until after June 1. By June 5 some of the fleet had done fairly well, the others poorly. The *Grampus* returned to Woods Hole the latter part of June, bringing a large quantity of specimens bearing upon the breeding habits, food, size, etc., of the mackerel, together with very complete records of the daily observations.

"Mr. B. L. Hardin remained at New York from April 12 to June 3, and examined every fare of mackerel landed from the southern fishery, as well as the smaller catches made in the pound-nets along the shores. Notes were kept upon the abundance, sizes, and spawning conditions of the fish, and interviews were held with the masters of the different schooners relative to the more important incidents connected with their several cruises."

Ditto, p. 57. *Division of Statistics.* "In May and June, 1893, the field force was placed in the New England States for the special purpose of making a detailed investigation of the commercial aspects of the mackerel fishery. This inquiry was in progress at the close of the fiscal year.

"Owing to the great attention the mackerel has recently been receiving, on account of the unprecedentedly long period of scarcity, it was important for the purposes of the Commission, in order to afford the best basis for determining the cause and extent of the scarcity, to have accurate and detailed information relating to the various topics which could be legitimately considered by this division. To facilitate the collection of uniform data provision was made for having the agents to obtain the statistics on two printed forms, relating respectively to the fisheries carried on with vessels, and to those carried on from boats and the shore.

"For the vessel fishery the following information was obtained for each vessel: Name of vessel, hailing port, rig, net tonnage, present value; value of outfit; number and value of each kind of fishing apparatus used; the number of crew, specified by nativity and nationality; the kinds, quantities, and value of bait caught by the vessel or purchased in America or British provincial ports; the number of entries of foreign ports, and the expenditures therein for each purpose; the lay of the crew; the quantity and value of each grade of mackerel taken in each region with each kind of apparatus; the fishing season in each region; the number of trips from each region and to each port; and the kinds, quantities, and value of other fish taken with mackerel.

"In the case of the shore and boat fisheries the information secured for each proprietor-fisherman included the number and value of each form of apparatus employed, the number and value of boats, the fishing season; the number, nativity, and nationality of the fishermen; the wages received; the kind, quantity, and value of bait utilised; and the quantity and value of each grade of mackerel taken with each appliance.

"A special feature of the inquiry was the provision to obtain complete figures showing, for fresh mackerel, the quantity and value of each standard size of fish taken, and for salt fish the quality and grade of the mackerel packed. While satisfactory figures relating to the different grades of salt mackerel inspected in Massachusetts are available, no attempts to obtain complete data for the grades of salt mackerel packed in other States, or for the various sizes of fish sold in a fresh condition, were ever before made.

"Owing to the importance of having statistical data for the mackerel fishery covering each year of the 'close-time' law, which took effect in 1888, and terminated in 1892, the inquiry was addressed to the years 1890, 1891, and 1892, information for the two earlier years having been previously obtained.

"Some supplementary inquiries regarding mackerel were also instituted by the division, by securing the co-operation of fishermen on various parts of the coast, in recording observations concerning the mackerel during the fishing season of 1893. For this purpose blank books of convenient size were prepared and distributed. They provided for a daily record of the number of extra large, large, medium, small, and tinker mackerel taken each day; a statement as to the nature of the weather, direction of the wind, etc.

"In the first week in April, 1893, the writer visited New Jersey for the purpose of engaging for this inquiry the services of the pound-net fishermen on the northern part of the coast of that State. This section is the most southern part of the United States coast on which mackerel are regularly taken in considerable numbers with fixed apparatus. The fishermen, who during the previous season had operated pound-nets, were personally visited, and the objects of the inquiry explained to them. They entered very heartily into the matter, and agreed to record the daily catch as requested.

"Record books of a similar character were placed among the pound-net and trap-net fishermen of the Massachusetts coast. The distribution was accomplished through Mr. F. F. Dimick, local agent at Boston, Mass.

Fishermen at a number of points on the Maine and Virginia coasts were also communicated with by mail, and asked to record their mackerel catch.

"While it is not probable that all the fishermen receiving the blanks will keep the records requested, there seems no reason to doubt that some valuable information will thus be obtained.

"In conjunction with his other duties Mr. E. F. Locke carried on an examination of the spawning condition of the mackerel taken in the vicinity of Gloucester. His work on this subject continued until the temporary withdrawal of the mackerel from that part of the coast, and the ending of the spawning season brought the work to a close."

Commissioner's Report, 1894, p. 91.—"The investigations respecting the habits and abundance of the mackerel, and the fisheries to which this important species gives rise, were continued again this year upon the same general plan as in 1893, but on a more elaborate scale and during a greater part of the season. The schooner *Grampus* and the steamer *Fish Hawk* were both utilised in connection with this inquiry, and several land parties were employed to study the subject from the standpoint of the in-shore fisheries along the entire coast covered by the range of the species. The information sought to be obtained from this series of observations was desired for the use of the Joint International Commission, as elsewhere explained; and the practical importance to the American fishermen of reaching a more complete and definite understanding of all the circumstances connected with the natural history of the mackerel, in relation to the several methods employed for their capture, has long been acknowledged.

"Until this work was started by the Fish Commission a few years ago most of the facts at hand were such as had been obtained incidentally, and it is only within a year or two that the matter has been taken hold of in the systematic and comprehensive manner which it deserves. The mackerel fishery has long been the subject of a vigorous controversy, both domestic and international. Each year the same phases are repeated; the fish first appear off our coast above Cape Hatteras, whence they spread rather rapidly toward the north and east as far as Labrador, giving rise to one of the most active and persistent fisheries of the world. Their abundance, within the scope of observation of the fishermen, varies from year to year, and at times the fluctuations are very great; periods of plenty, of greater or less duration, being followed by others of scant supply, bringing consternation to those whose fortunes are mainly linked with this species.

"The improvement of methods for the capture of mackerel has kept pace with the steady development in other lines of industry, until it would appear as though the limit of perfection had practically been reached. One of the most important questions of the day is whether, as some affirm, the modern devices are proving too destructive and are causing a depletion, in view of the lessened catch during several years past. To those who are at all acquainted with the history and character of the mackerel fishery, it will be evident that this question cannot be answered off-hand, and that the published observations respecting the natural history of the mackerel do not meet the requirements of a thorough consideration of the matter. To supply this *desideratum*, so far as possible, has been the object of the inquiries now in progress.

"These inquiries have been directed so as to cover at least the more essential features in the history of the mackerel during that part of each season when their presence along the coast becomes apparent through their surface distribution, the only period when they can be fished for. It has been attempted to trace their movements and all the principal circumstances connected therewith, from the time of their first appearance in the spring, until cold weather causes their return to winter quarters; to learn the extent and relations of the schools, the conditions which accelerate or retard their progress, and the factors which influence their swimming at different depths, whereby the great body of the fish may travel long distances unobserved; to settle definitely their spawning places and seasons, and their habits in that connection; to ascertain the effect upon the schools of the different fishing methods apart from the simple question of the quantity of fish so captured; and from the data thus secured, as well as from statistics of the catch, to determine, so far as possible, if the stock is being decimated, and the causes which may be directly responsible therefor.

"The schooner *Grampus* started south from Gloucester, Mass., on April 7, to repeat the customary examinations on the southern grounds during the early spring season; but heavy gales retarded her movements in the beginning, as well as interfered with the operations of the fishing vessels. Lewes, Del., was made the headquarters from April 20 to May 10; but the *Grampus* remained constantly with or in the neighbourhood of the fleet, as the best means of keeping track of the schools of fish, making a careful series of physical observations at hourly intervals, towing for mackerel food, and recording all facts obtainable from the fishing captains, or by personal observations, respecting the positions of the schools each day, their extent, movements, depth, the abundance, size, and condition of the fish, etc. From the extreme south the *Grampus* followed the main body of the fish to the region off New York, and thence proceeded eastward over Georges Bank to Cape Sable and the Nova Scotia coast. Here the mackerel were studied during their progress to the Gulf of St. Lawrence as far as Cape North, stops being made at Shelburne, Liverpool, Beaver Harbour, and North Sidney, in search of such information as could be gained from the local fisheries in the neighbourhood of those places.

"On June 13, the main part of the down run of mackerel having ended and the spring season closed on the cape shore, the *Grampus* left North Sidney and returned to Gloucester, first passing around the north side of Cape Breton and through the Gut of Canso in quest of further data. Gloucester was reached on June 25, and the remainder of the month was spent in preparations for a summer cruise on the mackerel grounds in the Gulf of Maine. This work was in charge of Mr. E. E. Hahn, master of the *Grampus*, with Mr. W. C. Kendall as naturalist.

"Mr. B. L. Hardin was stationed again this year at Fulton Market, New York City, from April 21 to the last of May, his observations being mainly supplemental to those conducted on board the schooner *Grampus*, and directed chiefly toward completing the records bearing upon the early off-shore fishery. Every fare landed by the purse-seiners from the southern grounds, as well as all specimens received from the shore fisheries tributary to New York, were inspected by Mr. Hardin, and everything that could be learned relating to their capture and conditions was fully noted. Convenient office and laboratory accommodations were supplied gratuitously by Hon. E. G. Blackford, through whom, and the other prominent fish-dealers of the city, Mr. Hardin was afforded the fullest opportunity for the successful prosecution of his inquiries.

"Mr. H. F. Moore, of the University of Pennsylvania, was detailed to the study of the shore fisheries from their southern limit at Virginia Beach, Va., to Rhode Island. His work was begun at the south at the commencement of the season, and was carried northward, all of the principal fishing centres being visited, the fishermen interrogated, specimens examined wherever possible, and blanks left to be filled in with daily records of the catch. In this manner a very complete account was secured of the shore relations of the mackerel during the period of their early movements, a subject which had not hitherto been given much attention.

"Dr. W. E. Wolhaupter was given the section of coast from Rhode Island to the outer side of Cape Cod, including the important spawning and hooking grounds between Block Island and Nomans Land, and the extensive trap-net fisheries of Vineyard and the Nantucket Sounds. The steamer *Fish Hawk* also assisted in the work here during a part of June. The region between Cape Cod and the Bay of Fundy, including the coast waters of Massachusetts, New Hampshire, and Maine, and the Gulf of Maine, was assigned to Captain A. C. Adams, formerly in command of the schooner *Grampus*, and having a long experience in connection with the mackerel fishery. His inquiries were started at Province Town on Cape Cod, about the middle of May, and were thence extended along the shores of Massachusetts Bay, Cape Ann, and the coast farther north to Portland, where he was joined by the steamer *Fish Hawk* and Dr. Wolhaupter in the latter part of June. By the close of the year the examination had been carried as far east as Boothbay Harbour."

Commissioner's Report, 1895, p. 80.—"The observations made in 1893–94, respecting the natural history of the mackerel and the fisheries to which it gives rise, were repeated during the past year in accordance with the same plan, and on practically the same basis. The capricious habits of the species, its fluctuating abundance as indicated by the size of the catch, its wide distribution and far-reaching movements, make it one of the most difficult of all the commercial fishes to study or to comprehend. It is thought, however, that the series of investigations, which has been in progress for several years, and which is still to be continued, will throw much new light upon the practical questions connected with its history, and will aid in determining to what extent, if any, the supply may be affected by the several methods employed for its capture.

"At the beginning of the fiscal year the schooner *Grampus*, E. E. Hahn, master, and W. C. Kendall, naturalist, was investigating the off-shore mackerel fisheries in the Gulf of Maine, with headquarters at Gloucester, Mass. The latter part of July and the first half of August, 1894, were spent in cruising in the Gulf of St. Lawrence, the season's work terminating at Gloucester the last of August. In the spring of 1895 the *Grampus* was again detailed to the study of this species, and continued to be so employed until the end of the fiscal year. The inquiries were of the same character as in previous seasons, being designed to secure as complete a history as possible of the early movements of the mackerel as they approach and work up the coast on the way to their several spawning and summer-schooling grounds. The cruise began on April the 12th. Lewes, Del., was made the headquarters until May 10, when, the body of fish having left southern waters, the *Grampus* proceeded to the region off New York, and thence eastward over Georges and Browns Banks to the coast of Nova Scotia. Here the schools of fish were closely followed to Cape North, Cape Breton Island, and a short cruise made into the Gulf of St. Lawrence. The schooner returned the last of June to Gloucester, where preparations were made to continue the inquiries during the summer in the Gulf of Maine.

"Shore parties were at work at all seasons of the year during which the mackerel were present on the coast. During July and August, 1894, Captain A. C. Adams and Dr. W. E. Wolhaupter, with the assistance of the steamer *Fish Hawk*, were engaged on the coast of Maine, their investigations extending eastward from Portland as far as Jonesport. All important fishing localities were visited, the nets and catch inspected, and the fishermen interviewed. Subsequently, and until late in the fall, Captain Adams was occupied mainly with the study of the fishery from the ports of Gloucester, Boston, and Portland, while Dr. Wolhaupter returned to the southern coast of New England to complete his observations begun there the previous spring. Both of these assistants again took up the field work in April, 1895. Captain Adams' inquiries during the spring season were restricted to the coast of Massachusetts, north of and including the waters about Cape Cod. Dr. Wolhaupter began at Virginia Beach, Va., which is nearly as far south as the mackerel strike the shore, and proceeded thence northward along the coast as far as Cape Cod, visiting in succession nearly all localities where mackerel are taken in shore nets. For a short period in the course of his trip he was stationed in New York City, and then continued to the important spawning region off Rhode Island and south-eastern Massachusetts, where most of the month of June was spent.

"Mr. B. L. Hardin was detailed as heretofore to conduct the customary inquiries at Fulton Market, New York City, his observations being mainly supplemental to those made on board the schooner *Grampus*, and designed to complete the records bearing upon the off-shore fishery. Every fare landed by the purse-seiners, which were then at work exclusively on the southern grounds, and also catches marketed there from the shore fisheries, were carefully inspected, and all information that could be obtained relating to the capture and condition of the fish, etc., was fully noted. Through the courtesy of Hon. E. G. Blackford convenient office and laboratory accommodations were provided; and to him, as well as to the other prominent fish-dealers of New York, Mr. Hardin was indebted for the means of carrying on his work successfully. Mr. Hardin reached New York about the middle of April, and continued there until the end of the first week in May, when he was replaced by Dr. Wolhaupter, who remained until the close of that month.

"Some of the observations made this year at Fulton Market relative to the spawning season and habits of the mackerel were especially interesting. The first fish received were two individuals caught in shad nets on the coast of North Carolina on April the 6th and 8th. The first fare brought in from the off-shore grounds consisted of 7700 mackerel taken in a purse-seine on April 17, about 65 miles south-east of Cape Henry. They measured from 10 to 17½ inches long. In some of the larger of these fish the reproductive organs were found to be spent, indicating that they had already spawned, and giving an earlier date for the beginning of the spawning season, at least in some years, than had previously been supposed. The location where the spawning had taken place could not, of course, be told; but that it was not situated close to the shore would seem to be shown by the fact that never more than small quantities of mackerel are ever taken so far south in the shore apparatus. In several subsequent purse-seine catches made off the Virginia coast up to the last of April, and even into May, the same conditions were observed, more or less, of the fish having apparently spawned, while in others the eggs were approaching maturity; but in no case did the fish seem actually to have been spawning at the time when taken. It should be explained in this connection, however, that only a relatively small number of the fish from each fare marketed could be obtained for examination, and are the basis for the facts above mentioned.

"About May 1st the shore nets on Long Island and along the southern coast of New England began to take their first mackerel, which appeared latest and continued longest at the eastern end. The fish which reached New York from this region were either in spawning condition or nearly ripe."

Preliminary Notes on the Reproduction of Teleostean Fishes in the South-Western District.

By

Ernest W. L. Holt.

During the present year tow-netting has been carried on with such continuity as the weather permitted, and the fish-ova and larvæ thereby obtained have been studied by Mr. S. D. Scott during the winter months, and by myself since the spring. While reserving a general account of the results until the close of the season, it seems advisable to deal now, in however preliminary a manner, with a few species, an addition to the existing knowledge of which may be found of immediate use by workers in the same field. I take this opportunity of expressing my indebtedness to Mr. Scott for observing certain eggs which I was obliged to leave at the Laboratory at a stage too little advanced for specific determination.

Capros aper.—*Linn.*

The ova of this fish were artificially fertilized by Cunningham (*Journ. M. B. A.*, N. S., I., 1889, p. 10) on August 15th, 1897, and lived until a stage immediately prior to the outgrowth of a free tail, the embryo exhibiting black chromatophores at the sides, near the dorsal median line. The dimensions of the ovum at the latest stage studied are stated to be 1·2 by 1·5 mm., that of the oil-globule ·19 mm.

One pelagic egg with a single oil-globule is very like another until the embryo is so far advanced as to exhibit specifically diagnostic characters, and I was unable to identify tow-net eggs from the above description. However, on the 25th June, 1897, I was able to fertilize ova taken from ripe parents trawled on the Eddystone ground; and some of these hatched out in due course, and, indeed, survived until of the yolk there remained nothing but the oil-globule. I am therefore able to give a sufficiently exact description of the development *in ovo* and early larval stages.

Artificially fertilized eggs measured from ·915 to ·955 mm.; the single oil-globule ·15 to ·16 mm. The oil-globule was colourless, but dark and smoky.

Tow-net eggs, which can be identified with this species without any risk of error, measure from ·97 to ·99, the oil-globule from ·15 to ·165 mm.; and it may be noted that the oil-globule is usually, but not invariably, of a bright yellow colour—a matter of no real specific importance. Including all tow-net eggs, which seem to me to belong to this species, the diameter varies from ·93 to 1·01 mm.

The zona presents no features of interest, the surface corrugations observable in the newly-extruded ova disappearing as development proceeds.

Black pigment, as stated by Cunningham, appears before the outgrowth of a free tail. At the stage when that organ manifests itself as a short prominence I find that faint black chromatophores are present along the head and trunk, but chiefly on either side of the middle line. At the posterior end they extend on to the yolk sac, forming a small marginal group outlining the end of the trunk. The oil-globule at this stage is postero-ventral.

Before the tail has attained any considerable length yellow chromatophores appear along the sides of the embryo, and a few of each colour associate themselves with the oil-globule, which has (usually) become posterior in position. The chromatophores are very frequently on the hinder face of the globule. The skin shows a tendency to become papillate.

By the time the tail is of equal length with the trunk large black and yellow chromatophores extend along the sides of the latter, upon the rectal region, and rather irregularly along the tail, showing a tendency to form a posterior pigment bar. In all specimens which I have seen the epidermis is by this time more or less distinctly papillate, especially on the yolk sac. The papillæ are ovoidal, and not connected with each other by apparent ridges or striæ. Usually they are extremely conspicuous, and as characteristic of the species as such variable structures ever are in Teleostean embryos.

The newly-hatched larva measures, in one instance, 2·09 mm. The hind end of the yolk is 1·38 mm. from the snout, and ·25 in front of the anus, which is thus considerably posterior to median. The wide interspace between yolk and anus is characteristic of all larvæ which I have seen, but there are minor differences of dimension. Thus another specimen, soon after hatching, is 2·85 mm. long, and there is a space of ·44 mm. between yolk and anus. In some cases the yolk is ovoidal, and extends in front of the snout, but usually it appears to be more oblong in profile. The oil-globule is normally posterior, but may be ventral, in which case it is unaccompanied by pigment; and it may be remarked that minor differences in the position of oil globules do not deserve the attention that has sometimes been bestowed on them.

Pigment is rather variable, but is never present on the marginal fins nor about the yolk, except along its posterior edge and about the globule. Chromatophores of both colours (the yellow being golden-brown by transmitted light) are scattered along the head, trunk, and tail of the larva. These are of large size, stellate or dendritic, and arranged for the most part along the dorsal and ventral regions. There may be an approach towards a postanal bar by discontinuity posterior to the rectal region, but this is never well marked. Chromatophores extend some way along the hind wall of the rectum, and, as we have seen, along the hinder profile of the yolk. The skin is markedly papillate, but the margins of the fins are devoid of the digitiform cells noticeable in *Arnoglossus* or *Coris*. The notochord is multicolumnar.

In later stages the larva becomes characterised by the development of a very strongly marked renal band of very large black chromatophores, extending from the otocyst to about the anterior third of the tail. A dorsal band, corresponding posteriorly to the first, extends forward about half-way along the abdominal region. A third ventral abdominal band occupies the greater part of the abdominal length, and the chromatophores on the dorsum may form a fourth, extending from the cerebellar region to a little behind the shoulder girdle. Yellow pigment seems to be everywhere associated with the black, but is almost completely masked where the latter exists. It is conspicuous, however, on the sides, especially post-anally, and on the snout, mid-brain, and otocystic region. More or fewer black chromatophores are present about the head in the regions named, and also on the lower jaw and isthmus. The fins are absolutely devoid of pigment, except where a little extends post-anally from each margin of the tail. There is no pigment at all about the posterior two-thirds of the tail of the larva.

At this stage, the most advanced reached by my artificially fertilized ova, as also by tow-net specimens, the larva measures 2·98 mm., of which 1·55 is anterior to the anus, and 1·97 is pigmented. The yolk is only represented by the remains of the oil-globule. The liver and gut are well developed, the latter still without convolution. The mid-brain is elevated, and there is a distinct approach to the rostral prominence of the adult. The trunk is only of moderate depth, but the posterior half of the tail tapers rather suddenly. The marginal fins are only of moderate width, the dorsal having its origin behind the mid-brain. The epidermis remains markedly papillate, but the outline of the fin-ridge is unbroken, save at the caudal extremity, where it is somewhat pectinate, embryonic rays occurring basally in this part. The pectoral fin is of the usual fan-like type, and of the ordinary dimensions. The otocyst is smaller than the eye, which is pigmented and obviously functional. The gape is of moderate extent, the lower jaw, as usual, slightly projecting.

Older stages of this larva seem to me to be represented by a number of examples taken in the bottom tow-net about two miles off Fowey river, on the 29th and 30th June. I did not measure, nor very closely examine, any of these in the fresh condition. None were alive when the nets came on deck, so that the present dimensions of the smallest are no doubt less than the original, since young fish-larvæ always shrink unless they are actually killed in a suitable fixing medium. At present the dimensions, roughly measured, are from 5 to 6·5 mm.

The smallest specimens agree with the oldest of those which I reared from the egg in the distribution and arrangement of the black pigment, and in the general conformation, allowing for the difference in age. Thus the trunk is somewhat deeper, and the flexure of the caudal extremity (by hypural development) more accentuated. The rostral prominence is no longer conspicuous.* Yellow pigment, if present, was not a prominent feature, and its disappearance is in accordance with the known developmental phases of other species.

From this stage the series passes without a break to the largest example, which measures 6·6 mm. in total length, of which ·90 mm. is occupied by the caudal fin, and about 1·50 by the head. The greatest height of the body, without vertical fins, is 1·25 mm. In general conformation the larva bears some resemblance to a *Labrus*, save that the anterior profile is more rounded. The mouth is large, the snout shorter than the eye, which measures ·54 in horizontal diameter. The body is laterally compressed, but the dorsal and ventral profiles are still nearly parallel, and not arched, as in the adult: posteriorly the tail tapers rather rapidly, but the caudal peduncle is, nevertheless, of considerable vertical width. The caudal fin is almost completely "homocercal." The dorsal and anal fins are represented by embryonic rays.

Of yellow pigment I saw none in the fresh condition, but black chromatophores are abundant, and very strikingly distributed. A sheet of stellate chromatophores, irregularly arranged in about ten longitudinal rows, clothes the side of the fish from the shoulder girdle to the hind end of the (permanent) anal fin. Dorsally the sheet does not extend quite so far, as its hind margin is oblique. Its dorsal

* In *Callionymus* an approach to the rostral prominence of the adult has been noted in the early larva, but is shown to become masked in subsequent stages, to reappear with the final assumption of the adult characters (Cf. *Trans. R. Dub. Soc.*, v., ii., pl. iii.).

outline does not quite reach the middle of the back, and, post-anally, it is not quite continuous with a row of chromatophores which appears at the base of the anal fin. In front the outline is also oblique, the anterior edge passing from the top of the shoulder girdle to a point on the abdominal margin somewhat posterior to the ventral end of the clavicle, and, on the abdomen generally and its dorsal parts in particular, the chromatophores are less closely set than elsewhere. There are some large chromatophores on the top and otocystic regions of the head. Beyond these there are only a few quite insignificant chromatophores at the base of the dorsal and on the caudal peduncle; but the eyes are, of course, fully pigmented. The larva thus appears, to the naked eye, to be clothed in a continuous sheet of grey, except on the head and caudal peduncle. I do not know at what period the red colour of the adult is assumed, but have seen Mediterranean specimens of about 1½ inches, which were dull grey in colour.

Day (*Brit. Fish.*, i. p. 137), writing of the colours, regards the fish as "remarkable, in that it may be banded or plain, the bands, it having been suggested, being due to the example having been in a dark locality." In all examples which I have seen a number of bands could be detected by careful observation, viz., curved bands about the dorsal parts, which are never at all conspicuous, and a series of vertical bands. I found, on examination, that the vertical bands were the most conspicuous in those examples in which the general red colour was of a bright scarlet, and that these fish were males in breeding condition. The females, also in full sexual production, were much duller in general colouration, with only very faint vertical bands. Day, previous to the conclusion noted above, quotes Dunn to the effect that the bands fade after spawning, but no one seems to have remarked their apparent sexual significance. I do not know if this colour dimorphism is accompanied by any structural difference, but mean to examine the matter.

Phrynorhombus unimaculatus.—*Risso.*

Our knowledge of the reproduction of this fish rests upon the single record, by the late George Brook (4th Rep. S.F.B.), of the capture of a ripe female. The ovarian eggs, which were observed to contain a single oil-globule, measured ·96 mm. after preservation.

On the 1st June of the present year three examples were trawled in Teignmouth Bay by Mr. S. D. Scott and myself, and proved to consist of a male and two females in breeding condition. An attempt to artificially fertilize the ova from one of these was only partially successful, since the male, which was dead, was not quite ripe, and only a little milt could be obtained by cutting up the testes.

However, a certain number of ova were impregnated, but while several survived up to a late stage of development, only one hatched.

The unfertilized ova immediately after extrusion were found to measure from ·92 to ·93 mm. in diameter. After fertilization, ova measured during the progress of development varied from ·90 to ·99 mm. The single oil-globule measured from ·16 to ·18 mm. In the early condition the globule exhibited a distinct yellow or greenish yellow colour, a trace of which remained almost up to the time of hatching.

Sixty-six hours after fertilization the embryo had a free tail equal in length to the head and trunk. Pigment was present in the form of small black chromatophores rather profusely distributed over the embryo, except at the extremity of the tail, and more sparsely over the yolk. Pale yellow pigment was present on the embryo, imparting a uniform yellow tinge, the individual chromatophores not being visible under a moderately high power. The epidermis was beset with a not very conspicuous reticulation of minute papillæ.

Ninety hours after fertilization a single larva had hatched; it measured 2·38 mm. in total length, the marginal anus 1·07 mm. from the snout, being slightly anterior to median. The rectum was distinctly separate from the yolk. Yellow pigment was present on all parts of the larva (except the end of the tail), but in greatest abundance, in so far as concerns those parts, along the dorsal and ventral regions of the head, trunk, and tail. On the marginal fins and yolk-sac it was present in scattered dendritic chromatophores, rather more abundantly on the fins of the posterior half of the tail than anteriorly. Small black chromatophores occurred sparsely over the entire general surface, more diffusely on the posterior part of the tail (not fins) than at any other point, but on the dorsal fin were confined to the immediate neighbourhood of the margin. A small pectoral fin was observable, and opposite to this was a slight inflection of the margin of the dorsal fin, which latter commenced to rise, as is usual in newly-hatched larvæ, near the level of the hind end of the otocyst. The oil-globule was posterior in position. The epidermis was beset with minute papillæ or tubercles, with some indication of connecting ridges or striæ.

The larva did not survive to exhibit any more advanced stage of development, and none of the remaining eggs hatched.

I am in some doubt as to whether this observation of the early stages of *P. unimaculatus* throws any light on previously known but undetermined ova and larvæ. The form that at once suggests itself in this connection is the Species F of McIntosh and Prince, which has also been described by myself (*Trans. R. Dub. Soc.*, s. ii., v. pt. ii. p. 101), and has more recently been recognised by Ehrenbaum at Heligoland (*Eier u.*

Larv. v. Fisch. d. deustch. Bucht, i., 1897, p. 317). The dimensions are no obstacle to the identity of the two forms, since, if Species F is truly a single species, its diameter ranges from ·75 to ·9906 mm. The extremes are rather far apart, though I am not prepared to say that the variation is too great, since one is constantly encountering fresh evidence of the elasticity of the dimensions of Teleostean ova. In comparing the larval *P. unimaculatus* with my own notes and drawings of Species F, I find no discrepancies of pigment and general conformation that are in themselves of specific importance.

In discussing the affinities of the egg and larva, McIntosh* and Ehrenbaum have laid stress on the absence of *P. unimaculatus* from the fauna of their respective districts. With all respect, I would submit that such absence may well be more apparent than real, recalling the use which Cunningham has shown the Topknots to make of their marginal fins. A fish which habitually clings to the vertical faces of rocks is well fitted to elude the ordinary collecting apparatus, and is taken, if at all, largely by chance.

I do not say that *P. unimaculatus* is present in the neighbourhood of Heligoland or St. Andrews, but I think that it might be, without attracting human attention.

The real objection to the identity of Species F with the Topknot now under discussion seems to me to lie in the epidermal structure. My solitary larva certainly did not exhibit the reticulo-papillate arrangement of epidermal cells in a degree nearly as well marked as in the few specimens of F which have come under my notice; and formerly I should have considered this difference an absolute bar to the identity of the species. Recently, however, I have had the opportunity of studying the development of two species of Arnoglossus, in the larval condition of which the reticulo-papillate condition may be even more strongly marked than in Species F, and I find that the condition is variable, not only in individuals, but in the same individual. Certain circumstances, which I cannot clearly associate with the health of the individual, operate in such a way as to render the degree in which the epidermal peculiarities are apparent a matter of no value for specific identification. Thus, while I do not feel in a position to positively affirm the identity of all examples of Species F with *P. unimaculatus*, I am strongly of opinion that some, at least, of them may have belonged to that species.

I have remarked that the ova of *P. unimaculatus*, taken from one female, had yellow oil-globules. Probably all observers of Teleostean embryology will agree that the presence or absence of colour in the globules is of no specific moment.

* McIntosh and Masterman, *British Marine Food Fishes*, p. 348.

I have long ago pointed out the resemblance between Species F (my Species xii., *Trans. R. Dub. Soc.*, *loc. cit.*) and the series of metamorphosing larvæ which I described and figured (*op. cit.*, p. 104, pl. xi.) under the title of Species xiii., and, in discussing the probable affinities of the latter, I was led to the belief that they were the young of *P. unimaculatus*. Whether or no they are identical with all specimens which have been included in Species F, I do not feel qualified to decide, but a comparison with the actual larva of *P. unimaculatus* inclines me strongly to the opinion that this species is the parent of the metamorphosing series comprised in Species xiii. Without the assistance of figures it is idle to discuss the matter farther, but I hope soon to have an opportunity of enforcing my own opinion by the illustration of my material.

Arnoglossus laterna.—*Günther.*

It is only quite recently that the developing ova and larvæ of the scaldfish have come under the notice of naturalists. Raffaele certainly observed the ovarian eggs of several species of Arnoglossus, of which *A. conspersus* was presumably one. The latter, if not identical with, is at least very closely allied to the common Atlantic species; but in any case, Raffaele failed to secure the embryo or larva, either by artificial impregnation or by the use of tow-nets.

During the summer of 1895 I was led to the conclusion that certain tow-net eggs from the Gulf of Marseilles must belong to *A. conspersus*, but the publication of my results has been anticipated by Dr. Ehrenbaum, who has recently (*op. cit.*, p. 298), described the earliest stages of *A. laterna* from Heligoland. Petersen (*Rep. Dan. Biol. St.*, 1894, p. 44) had already obtained the ripe ovarian ova, but was fain to content himself with a naked eye observation thereof, while Ehrenbaum was obliged to rely on tow-net material. There is, nevertheless, no doubt as to the correctness of his diagnosis.

In British waters the spawn of this fish has hitherto entirely escaped attention. During the Irish survey, though I obtained many specimens, I never saw a ripe female, and on this coast, where the species is even more abundant, there is no record of any observation of its reproduction. Moreover, of the many undetermined species of eggs which have from time to time been described by British writers, none can possibly be assigned to the scaldfish.

So far as concerns the observation of fish in the process of reproduction, I am now able to supply the deficiency, but have never been able to hatch artificially fertilized eggs.

On the 1st and 2nd June, in Teignmouth and Tor Bays, we trawled a number of ripe examples of both sexes of the undifferentiated form originally defined by Günther as *A. laterna*.

Ova were taken from five females, $5\frac{1}{2}$ to $6\frac{1}{2}$ inches long, and impregnated with milt from three males, 5 to $5\frac{1}{4}$ inches.

The ova underwent the early phases of segmentation, but died before the formation of the head. Half an hour after fertilization six specimens measured from ·675 to ·690 mm. in diameter, the single oil-globule measuring ·14 to ·15 mm. It was dark, with a smoky margin, but quite devoid of colour. The yolk and zona presented no feature of importance.

On the 9th July, in the outer part of Falmouth Bay (*Echinus* and *Pecten* ground) we trawled a number of scaldfish chiefly of the differentiated form once known as *A. lophotes*, Gthr., with a few of the smaller undifferentiated type. The same experience was repeated on the 10th July.

On each occasion I found that the larger differentiated forms comprised some females from which the eggs could readily be extruded. They measured from $6\frac{1}{8}$ in. to $6\frac{5}{8}$ in., and exhibited a distinct prolongation of the anterior dorsal rays. The smaller females of the *A. laterna* type were two in number, and measured $5\frac{1}{8}$ in. to $5\frac{3}{8}$ in. These were also full of spawn, but not quite ready for extrusion.

Ova were obtained from two of the large females and impregnated with milt from a number of large males $6\frac{3}{4}$ in. to 7 in. long; and although the testes appeared to be ripe, I found, as also with the small males of the Devon coast, that milt could only be obtained by removing the organs and squeezing them in water. About seven hours later I measured six eggs, which appeared to have been successfully fertilized. The diameter ranged from ·75 to ·76 mm.; that of the oil-globule from ·12 to ·13 mm. Apart from dimensions, the ova were in all respects similar to those of the smaller forms, save that the zona appeared rather thicker in the latter. A number of the eggs survived for nearly a day, but were subsequently killed, as I suppose, by the intense heat of the 10th July. It was noted that they floated buoyantly in the water of the outer part of the bay, but without crowding at the surface of the vessel in which they were placed.

It is necessary to remark, in the first place, that my observations deal only with a few individuals, and that I do not know exactly, having mixed the ova obtained from the several specimens, to how many parents those measured should be ascribed. Such as they are, the results suggest that the smaller females produce smaller eggs (which is known to be the case, *teste* Maitland, in individuals of the Salmonidæ). A much more remarkable suggestion is that the eggs of the *A. lophotes* type have smaller globules than those of the undifferentiated *A. laterna*; but this may prove to be merely a matter of variety, or may be explained by developmental physiological changes of which I have no knowledge. For the present I have been prevented by bad weather from obtaining such a series of examples as would enable us to state the relation of dimension of egg to that of parent with anything like certainty.

It has already been suggested by Calderwood and myself (*Trans. R. Dub. Soc.*, v. p. 504) that the absence of the *A. lophotes* type from regions, *e.g.* Scandinavia, where *A. laterna* is well known, is quite intelligible in the light of Maitland's researches on *S. levenensis;* and I think that the establishment of well-marked differences in the dimensions of the ova from large and small scaldfish parents would go far to support this view.

The tow-nets have not yielded any scaldfish eggs at the times when spawning fish have been trawled, and, indeed, I have only found the egg on two occasions in British waters. Ehrenbaum failed to obtain the eggs at the surface on any occasion, and, concluding that they might be confined to the deeper layers of water, secured them finally by the use of the vertical net between 18 and 40 m. (say 9 to 22 fathoms). I have not been able to keep artificially fertilized eggs long enough to speak with certainty as to their specific gravity throughout the developmental period, but I have no hesitation in saying that the buoyancy of an egg in ordinary off-shore sea-water is subject to fluctuations which are explicable neither by species, degree of development, nor obvious physical and meteorological causes. I have not actually seen scaldfish eggs at the surface, but on the 6th June I found newly-hatched larvæ of *A. laterna* amongst ova and larvæ taken at the surface (four miles south of the Plymouth Mewstone) two days previously. The only other egg obtained was taken in the bottom tow-net on the 30th June, about two miles off Fowey river. The larvæ hatched from these eggs agree exactly with Ehrenbaum's figure of *A. laterna,* as also with the Mediterranean forms, which I myself associate with *A. conspersus.* The ova and larvæ of *A. Grohmanni* must undoubtedly exist on our coasts, and it may therefore be of use to point out that the larva (as I hope shortly to show in a communication to the *Annales Mus. Nat. Hist. Marseille*) is readily distinguished from that of *A. laterna* by the presence of two post-anal pigment bands. It is, in fact, the larva figured by Raffaele as hatched from ova resembling those of various species of *Arnoglossus* and of *Rhomboidichthys* and *Citharus.*

Note added in Press.

Arnoglossus Grohmanni.—Two eggs, which proved to belong to this species, were taken at the surface on the 27th July between the Eddystone and Hand Deeps.

Note on New or Rare British Marine Polyzoa.

By

S. F. Harmer, M.A., B.Sc.

1. *Hypophorella expansa*, Ehlers.

Hypophorella expansa, Ehlers, *Abh. Ges. Götting.*, xxi., 1876, *Phys. Cl.*, 1; Prouho, *Arch. Zool. Exp.* (2), x., 1892, p. 594.

Delagia chætopteri, Joyeux-Laffuie, *C. R. Ac. Sci.*, cvi., 1888, p. 620, and *Arch. Zool. Exp.* (2), vi., 1888, p. 135.

This species was originally found by Ehlers at Spiekeroog, an island off the coast of E. Friesland, in the North Sea. It has more recently been found by Joyeux-Laffuie at Luc-sur-Mer (Normandy), and by Prouho at Roscoff and at Banyuls. Its wide distribution, from the North Sea to the Mediterranean, made it almost certain that it would be found in British waters when looked for in the right place. Ehlers discovered it in the substance of the tubes of *Terebella* (*Lanice*) *conchilega*, while Joyeux-Laffuie and Prouho found it in the tubes of *Chætopterus*.

On one of the last days of my stay at Plymouth in April last, a few *Chætopterus* tubes, dredged near the Eddystone in thirty fathoms, were brought to the Laboratory. Several of these tubes contained *Hypophorella expansa*, which I had no difficulty in finding by following the directions given by Joyeux-Laffuie. The tube should be slit open, and a thin lamella of its substance, stripped off from the inner side, should be examined with the microscope. Even if the delicate zoœcia are torn by the operation, or if the lamella be too thin to include any zoœcia, the presence of the Polyzoon may be recognized by the holes through which the tentacles can be protruded into the interior of the tube. Each of these holes appears to the naked eye as a minute, opaque, white spot. The spotted appearance of the inside of the tube is a convenient indication of the presence of the *Hypophorella*, which can at once be recognized by the very long, thread-like connexions between the zoœcia, and by the two curious vesicular cavities which occur, one on either side of the distal end of the zoœcium. Excellent figures of the species are given by Ehlers and by Joyeux-Laffuie in his second paper.* Prouho's account contains some interesting details with regard to the mechanism of burrowing in the tube of the host, and with regard to the character of the larva, which, as Prouho has shown, belongs to the *Cyphonautes* type.

Hypophorella is probably common wherever *Chætopterus* occurs. I have not made any careful examination of the tubes of *Terebella conchilega*, but it may be worth while to point out that Ehlers discovered the Polyzoon most commonly in the parts of the tube which do not project above the surface of the sand.

2. *Escharoides quincuncialis*, Norman.

The history of this species, which was described from a single fragment, not more than a quarter of an inch long, is given on p. 339 of Hincks' *British Marine Polyzoa* (1880). The original specimen came from deep water in the Minch.

I obtained a single piece, closely resembling Dr. Norman's specimen, in April, 1889. The fragment was dredged off Plymouth, but I am not able to give either the exact locality or the depth from which it was obtained. The specimen was mounted in glycerine-jelly, which has unfortunately completely decalcified it, but from my examination of it, made in 1889, I can state that its agreement with the original description was very close.

3. *Micropora complanata*, Norman.

Lepralia complanata, Norman, *Ann. Nat. Hist.* (3), xiii., 1864, p 85 ; Hincks, *Ibid.* (5), xix., 1887, p. 304.
Micropora complanata, Hincks, *Brit. Mar. Polyzoa*, 1880, p. 175.
Membranipora smittii, Manzoni, *SB. Ak. Wien*, lxi , 1 Abth., 1870, p. 333.

Dr. Norman's original specimens were from Mr. Barlee's collection; and although they were believed to be British, their locality was unknown. Hincks (1887) has described specimens from the Adriatic, and Manzoni (1870) had previously found the same species in the Pliocene of Calabria. I believe I am correct in saying that no British localities have yet been recorded.

I found this species on the north-east side of the island of Tresco (Scilly Isles) in the spring of 1895. It occurred commonly as large white encrustations on the sheltered surfaces of the granite rocks exposed between tide-marks. The empty Lamellibranch valves on which *Laminaria* picked up on the shore had grown also afforded one or two specimens. Dr. Norman kindly verified my determination, and suggested to me that this is a southern species which only just

* *Arch. Zool. Exp.* (2), vi. pl. viii.

reaches our shores. Although I believe it to be one of the commonest littoral forms in Scilly, I have not found it at Plymouth.

Mr. Hincks, in his later reference to this species (1887), refers it to the genus *Lepralia*. He there states that the "marginal callosity," described by Manzoni (pl. iii. fig. 16), in the specimens from the Italian Tertiaries, is well developed in the specimens from the Adriatic, but that "there is scarcely a trace of it in British examples." This statement is not confirmed by my specimens from Scilly, in which the marginal callosities are at least as well developed, in many of the zoœcia, as in those figured by Manzoni.

4. *Schizoporella cristata*, Hincks. (See *Brit. Mar. Polyzoa*, 1880, p. 254.)

This is a species described by Mr. Hincks from a single small colony found at Hastings. It is of some interest to record the discovery of two similar small colonies on the inside of an empty valve of *Pecten maximus*, from twenty fathoms on the Mewstone Ledge at Plymouth.

On *Tubularia crocea* in Plymouth Sound.

By

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During my visit to the Plymouth Laboratory in September, 1895, Mr. Roach brought in, on the 28th, some fine colonies of Tubularia which he had found attached to the stern of a large three-masted sailing ship, the *Ballachulish*, of Ardrossan. This ship had come direct from Iquique, Peru, and after staying a few days in the Sound left for London. The Tubularia was kindly given to me for identification by Mr. E. J. Allen. After making drawings and noting the variation of the different organs, I came finally to the conclusion that as it agreed so closely with *Parypha crocea*, Agassiz, from Boston Harbour, there was no need to add another species to the genus. I was fortunate to meet with colonies of both sexes, and to find the ova in various stages of development. I believe enough material has been preserved to trace the development of the ovum, which shows a remarkable similarity to the development of the ova from the medusa of *Hybocodon prolifer*.

Actinulæ were being liberated in large quantities when the colonies were taken from the ship, so it is possible that this hydroid may become an interesting addition to the fauna of Plymouth Sound.

To distinguish this species it is necessary to examine the female gonophores, and count the number of apical ridges. Agassiz states that the number varies between six and ten, but only eight were present in my specimens. The male gonophore is destitute of ridges, and usually terminates in a blunt apex. In the European species of Tubularia the gonophores are either without ridges, or when they are present their number does not exceed four.

The stolon ramifies and gives off numerous stems which are branched, twisted, and contorted near the base, so forming a thick, matted mass, from which the simple stems arise to about two inches in height. The stems are not often straight, and are always annulated at the base, and at intervals higher up. The annulations on the stems are neither constant in position nor in number. There are usually three to five sets, and the number of rings in each set varies from two to twelve, but usually three or four are found together.

The colour of the colonies showed considerable variation. At first I thought the colours showed a distinction of the sexes, but further examination upset this view. The colours of the different colonies may be separated into two well-marked groups, the one extending from a pale yellow to a dark brown, the other from a brilliant reddish brown to crimson. The hydranth carries twenty to twenty-four proximal and distal tentacles. The clusters or racemes of gonophores show variation in number, which is chiefly due to their not all developing at the same time. The species is described with gonophores in ten to twelve pendulous racemes, which are disposed in two to three rows one over the other, and which surpass in length the proximal tentacles of the hydranth. To judge from the specimens which I have examined, the gonophores in each row are of about the same age. At first there is only one row, then follows a second between the first row and the proximal tentacles, and lastly, a third row on the outer side of the second row. There is apparently a great difference in the age of each row, and usually only one row is mature at a time. There are usually about eight racemes of gonophores, arranged in two rows; the greatest number counted was twelve, arranged in three rows. The racemes are not as long as the proximal tentacles, and do not hang down as figured by Agassiz.

A description of *Tubularia crocea* is given by Allman in his monograph on the Gymnoblastic Hydroids.

Hjort's Hydrographic-Biological Studies of the Norwegian Fisheries: a Review.

By

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Scandinavia has been for a number of years past the centre of interest in hydrographic inquiries. The waters of the Baltic, Skagerack, and Cattegat, have been thoroughly investigated by Swedish men of science; the complicated currents of those seas and their periodic alterations have been determined and explained; and a relation has been found to exist between the movements of herring and mackerel and the periodic changes in the character of the water which bathes the Swedish shores. The brilliant results attained by the Swedish hydrographers have been fully described by Prof. Otto Pettersson in the tenth volume of the *Scottish Geographical Magazine* (1894), and a critical summary of these results is included in Cunningham's paper on the "Physical and Biological Conditions of the North Sea," published in this journal last year. (Vol. iv., 1896, p. 233.)

The fruitfulness of Pettersson's methods has, however, led other countries to co-operate with the Swedish hydrographers in extending the area of investigation, and in 1893 a series of investigations was carried out simultaneously in different parts of the North Sea by Swedish, German, Danish, British, and Norwegian vessels. The investigations on the part of our country were undertaken by the Fishery Board for Scotland, and were carried out by Dickson in H.M.S. *Jackal.* His results were published in the *Twelfth Report of the Fishery Board for Scotland,* and a further account of their bearings on the fishery problems appeared in *Natural Science* for January, 1895.

The Norwegian investigations were entrusted by the Norwegian Government to Dr. Johan Hjort, Stipendiate of State Fisheries, and his results are contained in the volume of 150 pages before us,* published

* *Hydrographic-Biological Studies of the Norwegian Fisheries,* by Dr. Johan Hjort. (*Videnskabsselskabets Skrifter.* I. Math. Naturv. Klasse. 1895. No. 9.) Christiania. 1896.

in the Norwegian language in 1895, and in English in 1896. In the present article I propose to give an account of Hjort's investigations, since the main problems which they were designed to elucidate concern the fisheries of the British Isles almost as closely as they concern the fisheries of Norway.

Hjort's enquiries may conveniently be described under three heads: (1) Hydrography, (2) Plankton (floating fauna and flora), and (3) Fisheries.

These will be discussed in the order mentioned.

I. Hydrography.

Hjort's investigations were limited to the waters bathing the shores of Norway from the Christiania fjord to the Lofoten Islands. The bulk of his work, moreover, was deliberately confined to the region of the West Coast Spring Herring Fishery, *i.e.*, the immediate neighbourhood of the mouth of the Hardanger fjord, in order that a complete knowledge might be obtained at this one spot of the periodical changes in the character of the water throughout the year.

His methods consisted in the analysis of a great number of samples of water obtained in many localities at various depths, the temperature of the different samples having been registered at the time of collection. He was successful in enlisting the interest and co-operation of a number of navigating and fishery officers, and the Norwegian Government placed a suitable steamship, H.N.M.S. *Heimdal*, at his disposal.

It will be remembered that Pettersson showed that the waters of the Skagerack and Cattegat consist of two principal layers, having different salinity and different temperature relations—a layer of light water (*i.e.*, of little salinity) on the surface, and a layer of dense water below. These two principal layers are separated by an intermediate layer of water, whose character, in regard to salinity and temperature, is intermediate between those of the principal layers.

The surface layer is Baltic water, the bottom layer is North Sea water, and the intermediate layer, which crops up at the surface over the shallow banks of Jutland and the west coast of Norway, is termed by Pettersson "bank water" ("coast water" of Cunningham).

The depth of the surface layer at different seasons depends on the amount of fresh water liberated from the Baltic Sea, and ultimately derived from the rivers which flow into it. This amount naturally increases enormously in the spring and summer (April to September), owing to rainfall and the thawing of ice and snow, and decreases in autumn and winter (October to March), owing to the locking up of the rivers by frost.

In spring and summer the Baltic water flows out over the surface of the Cattegat and Skagerack and along the west coast of Norway like a broad, deep river, at a rate of twenty miles daily. It is then of a high temperature, being warmed by the sun.

In autumn and winter the volume of outflowing Baltic water is greatly reduced, and from obvious causes it becomes ice-cold.

The difference in density between the Baltic water and the water in the North Sea basin inevitably results in perpetual efforts of the denser water to fill the Baltic basin; but after it has gained admittance as a bottom current its density becomes reduced by mixture with the fresh water of the Baltic, it rises towards the surface, and is swept out again with the Baltic stream. The varying force of the Baltic current necessarily induces variations in the amount and strength of the inflowing bottom current. The character of the inflowing water also depends on the season and the weather: in summer it is normal North Sea water which enters the Skagerack; in autumn and winter "bank water" of less salinity from the western shores of Jutland and Norway takes its place.

It only remains to add that the outflowing Baltic current, after rounding the Naze, flows northwards along the Norwegian coast. Here it is well known to mariners, and may attain the high velocity of twenty miles a day. (Mohn, 1887, p. 169.)

It might well be imagined that variations in a current of such magnitude would exercise a considerable influence upon the state of the sea water off the west coast of Norway, and Hjort's enquiries have furnished a striking confirmation of this expectation. This will be clear from the statements made in the following sections:—

1. *Seasonal Contrasts.*

The seasonal contrasts in regard to hydrographic conditions off the west coast of Norway are seen from Hjort's account to be essentially similar to those recognized by Pettersson in the Skagerack. The great arbiter of cold and heat, and the principal agent in the reduction of the salinity of the water, is the same in both cases, viz., the Baltic current, although the salinity of this current is not so low off the Norwegian coast as in the east part of the Skagerack. This current, wide, thick, and hot in summer, is, as a rule, narrow, thin, and cold in winter.

In certain winters, generally accompanied by south-west gales (*e.g.*, that of 1893–4), the Baltic current is dammed up in the Cattegat, and the shore along the whole west coast is then washed with a thick layer of bank water of high salinity (33 per thousand and over) from the surface down to a depth of fifty or sixty mètres, beneath which is a thick layer of North Sea water. In such winters the sea along the coast is of uniformly high salinity and temperature.

In other winters, either calm or marked by a predominance of south-east gales (*e.g.*, that of 1894–5), the cold Baltic current is released from the Cattegat, and flows along the west coast in a slender stream. This layer in itself is much less thick (usually ten or twenty mètres) in winter than in summer, but it covers the sea with a cold sheet of water of very low salinity and temperature, which serves to dilute and cool the upper layers of bank water to a considerable degree. Thus the surface temperature was, in February, 1895, 2·9° C., although 6·5° in February, 1894, while the salinity of the inshore waters down to a depth of thirty, forty, or even seventy mètres, did not exceed 33 per thousand.

Such variations as these in the character of the inshore waters during the winter season are of the highest interest and importance, as we shall see below in the section dealing with the Fisheries.

The deeper water off the coast also undergoes considerable changes in successive seasons. The summer season, for example, is characterised by the great height to which the Atlantic water rises off the shore (within 100 mètres of the surface), and also by the thinness of the layers of bank water and North Sea water; while in winter Atlantic water is only found at great depths (250 mètres), and the layers of bank water and North Sea water are of great thickness.

These seasonal contrasts will best be comprehended by a comparison of the statements made in the following parallel columns:—

Water-layer (and Salinity).	Summer.	Winter.
Baltic current (up to 32°/₀₀) . (Salter off Norway than in E. part of Skagerack).	Thick and wide . . (50 mètres × 80 miles).	Thin and narrow. . (10 or 20 mètres × 16 or 20 miles); sometimes absent.
Bank water (32°/₀₀ and 33°/₀₀).	Thin and inconsiderable . (10 or 20 mètres thick).	A broad thick belt along the whole west coast (50 to 150 mètres thick).
North Sea water (34°/₀₀). .	About 50 mètres thick .	100 to 150 mètres thick.
Atlantic water (35°/₀₀) . .	Much nearer surface than in winter (100 mètres).	Only at great depths (below 250 mètres).

2. *Temperature Changes.*

The Baltic current is hot in summer, cold in winter. Since the low salinity of its water ensures its occupying the surface of the sea at all seasons of the year, the seasonal change in its temperature causes the maximum temperature to sink below the surface in autumn, and the minimum temperature to ascend to the surface in winter.

The complete cycle of changes is shown in the following tables compiled from Hjort's data:

TEMPERATURE.	SUMMER. July-Sept.	AUTUMN. Oct.-Dec.	WINTER Jan.-March.	SPRING. April-June.
MAXIMUM .	Surface (Baltic water).	Below surface (N. Sea water).	Bottom (Atlantic or N. Sea water).	Begins at bottom; ends at surface.
MINIMUM .	Bottom (Atlantic water).	Bottom (Atlantic).	Surface (Baltic).	Begins at surface; gradually sinks through Bank water to N. Sea water.

In the "typical winter period" (February and March) the temperature of the sea rises as one descends from the surface through the successive layers of increasing salinity. We have just seen that the minimum temperature is at the surface in the cold fresh water from the Baltic, while the maximum temperature is at the bottom in the salt Atlantic water. The interesting thing to notice is that at this season of the year increase of temperature and increase of salinity go together; and that, within certain limits, the temperature of the water during this period may be used as an index of salinity. Thus, as a rule:

6° to 7° C.	indicates	Atlantic water.
5°	„	North Sea water.
4° to 3°	„	Bank water.
2° to 1°	„	the Baltic current.

The establishment of this relation is valuable, since it enables the temperature data of previous years to be translated—so far as the winter season is concerned—into terms of salinity, and thus permits to a considerable extent the study of the winter characters of the water off the Norwegian coast for many years back. Hjort's results under this head will be found below in the section on "Fisheries."

3. *Origin and Fate of Bank Water.*

The facts that bank water lies between Baltic water and North Sea water, that its characters are for the most part intermediate between those of these two layers, and that bank water is most abundant in autumn and winter, when the Baltic current is usually at its lowest, render it probable that bank water is produced by a mixture of the summer water of the Baltic current with the subjacent water of the North Sea.

This view, at any rate, is taken by Hjort (pp. 22, 27), although he is careful to state that his investigations are insufficient to determine the relative amounts of bank water due to local mixture and to transference from other parts. He points out, however, that the time when the bank water thickens (autumn) is coincident with the period of heavy westerly gales, which may be presumed to assist in forming the mixture, as well as to drive it onwards towards the coast.

Probable as this explanation may at first appear, it must be pointed out that the difference in the amount of bank water present off the west coast during the winter seasons of 1893–4 and 1894–5 lends no apparent support to the view. The former winter was excessively stormy, owing to the prevalence of westerly gales, yet the thickness of the layer of bank water did not attain an average of 60 mètres. On the other hand, the latter winter was calm, without westerly gales, but with occasional south-east storms, and the thickness of the layer of bank water exceeded the high average of 90 mètres, thus :—

	November.	December.	January.	February.	March.	Average.
Winter 1893–4 . (stormy).	50 m.	?	?	60 m.	60 m.	57 m.
Winter 1894–5 . (calm).	50 m.	150 m.	90 m.	?	80 m.	92 m.

Hjort further states (p. 24) that the bank water in November, 1894, was "of far less thickness" than in the same month of 1893. Nevertheless, I do not find in his charts or tables any substantiation of this statement, for, as will be gathered from the subjoined figures taken from his data, the average thickness of the bank water was identical in the two periods under comparison :—

November, 1893.		November, 1894.	
Station 28, Nov. 24th. Plate III. fig. 2.	70 m.	60 m. (probably more, according to tables, p. 26)	Station 92, Nov. 26th. Plate III. fig. 4.
Station 24, Nov. 15th. Plate III. fig. 1.	30 m.	50 m.	Station 90, Nov. 26th. Plate I. fig. 4.
Station 36, Nov. 21st. Plate III. fig. 3.	50 m.	40 m.	Station 93, Nov. 26th. Plate I. fig. 12.
Average	50 m.	50 m.	Average.

The thick winter layer of bank water begins to be dissipated in spring about the month of April, synchronously with the reappearance of the Baltic current. According to Hjort, the disappearance of the bank water is effected partly by mixture with and conversion to North Sea water, and partly by dilution with and conversion to that of the Baltic. (p. 37.) This explanation is borne out by a comparison of the soundings and salinities for March and April.

Pettersson's assertions concerning the inflow of Norwegian bank water into the Skagerack as a bottom current during the winter period (commencing at the end of December) are not adverted to by Hjort. Nevertheless, Hjort's tables and charts throw light on a difficulty in Pettersson's account to which attention has already been drawn by Cunningham. (*loc. cit.*, p. 236.) Pettersson states that the autumn herring-fishery with floating-nets in the Cattegat and S. Skagerack begins simultaneously with the inflow of *Danish* bank water of high temperature in the early autumn (August–September). Now, as Cunningham points out, " we cannot consider the herring as a southern fish," and " the association of herrings with southern coast water is a fact which requires further examination."

I may briefly remark that the only difference recognized by Pettersson between the Norwegian (or northern) and the Danish (or southern) bank waters is one of temperature. Danish water having a temperature up to 15° or 16° C. is stated to enter the Skagerack with westerly gales in August and September, and to be eventually replaced towards the end of December by an influx of Norwegian water, having a temperature varying between the limits of 4° and 6°. The high temperature of the Danish water and the low temperature of the Norwegian are the principal characteristics of the two masses of bank water.

Nevertheless, Pettersson admits that the bank water which abounded in the eastern part of the Skagerack in November, 1893, was of Norwegian origin, owing to the prevalence in it of a characteristic assemblage of Arctic and North Atlantic organisms (*Scot. Geog. Mag.* x., 1894, p. 461); and it is important to notice that the temperature of this bank water considerably exceeded the maximum limit assigned to Norwegian bank water, being as high as 7·7° or 8·3° C.

It is clear, therefore, that bank water of Norwegian origin may enter the Skagerack as early as November, and that under such circumstances it has a fairly high temperature (8° C.).

The question accordingly arises whether bank water of Norwegian origin may not enter the Skagerack at a still earlier period (*e.g.*, September), when its temperature would no doubt be higher still. Hjort's surface chart for November, 1893, shows clearly that the bank water in the Skagerack during that month, in spite of its high temperature (7·7° and higher), was only part of a continuous mass of bank water which bathed the west and south coasts of Norway during the autumn of that year, and that the temperature off the west coast, in the latitude of Stavanger, attained the height of 9·5°. In Christiania fjord the bank water lying below the thin surface layer of Baltic water had a temperature of from 11·5° to 12·2° C. The chart for August in the same year shows, moreover, that the Norwegian and Danish bank waters were continuous with one another off the coast of Jutland, and that the temperature of the Norwegian portion was almost as high as that of the Danish water (15°).

There seems, therefore, to be no reason to doubt that the bank waters of high temperature which enter the Skagerack in autumn may consist of Norwegian as well as Danish water. The difficulty which Cunningham has very pertinently raised in regard to the association of herrings with purely Danish water would be satisfactorily met by the explanation which Hjort's charts enable me now to suggest.

II. Plankton (Floating Fauna and Flora).

Hjort's investigations of the distribution of plankton were confined to the surface layers of the sea, his only available apparatus being a simple net of fine silk gauze. Collections were made throughout the year, principally from the west coast, but to some extent also from the north coast, and from Christiania fjord. The results of his examination of these collections are given in a series of tables and in a summary, from which the author's opinions on his results may be gathered. Hjort's conclusions, however, are cautiously expressed, and it would be premature to regard any generalisations from the slender observations which he records as at all final in character, although the accuracy of the records themselves will enable them to be utilised for comparison with future observations.

1. *The Baltic Current.*—In summer, in Christiania fjord, the plankton of the thick Baltic surface layer (temperature 17·2° C.) was found (August, 1894) to consist principally of the Copepods, *Halitemora longicornis* and *Centropages hamatus;* the Cladoceran, *Evadne Nordmanni;* and great numbers of Cilioflagellata, particularly *Ceratium tripos.* On the west coast, in July and August, 1894, the Baltic current (temperature 15°) contained few Cilioflagellata, but large numbers of the following Copepods, *Calanus finmarchicus, Centropages hamatus, Pseudocalanus elongatus,* and *Paracalanus parvus,* together with *Evadne Nordmanni* and *Podon, Sagitta,* Appendicularians, and a moderate number of Radiolaria.

In the autumn, 1894, in Christiania fjord, the Baltic surface water formed a thick layer, and in December (temperature 5·1°) contained little except Cilioflagellata (*C. tripos*), which abounded. The deeper layers also contained *Sagitta,* and a certain number of Diatomaceæ. On the other hand, in the autumn of 1893, the Baltic water was dammed up in the Cattegat, and formed but a shallow surface layer in Christiania fjord. On November 12th the surface temperature was 4·3°. The tow-nets brought up plankton consisting almost exclusively of vegetable organisms, viz., a few Cilioflagellata and an abundance of Diatomaceæ, especially *Chætoceros curvisetus* and a species of *Rhizosolenia*. The abundance of Diatomaceæ within a short distance from the surface (0 to 10 mètres) was clearly correlated with the shallowness of the Baltic layer, whereas in 1893, owing to the great thickness of the Baltic layer, these organisms were only plentiful at a considerable depth.

On the west coast, in the autumn of 1893, Baltic water was only found inside the fjords. In Hardanger fjord, on November 22nd, (temperature 7° to 8° C.) the tow-net brought up only a few Copepods and *Evadne*, but a mixed collection of numerous Cilioflagellates (*C. tripos*) and Diatomaceæ (*Chætoceros didymus* and *borealis*). In November, 1894, on the other hand, the Baltic current was very extensive, and the surface collections (November 26th, temperature 7·5°) showed accordingly a sparsity of Diatoms and an abundance of Cilioflagellates (*C. tripos*), together with numbers of *Oithonella pygmæa* (Copepod) and *Evadne Nordmanni*.

In winter the surface waters were mostly bank or North Sea waters, and no collection of plankton were taken in Baltic waters.

In spring (April 16th, 1894) on the west coast the Baltic currents, having a salinity of 30 per thousand and a temperature of 6° C., contained principally Cilioflagellates (*C. tripos*), *Halosphæra viridis*, *Evadne Nordmanni* (with young), and young Calanids.

2. *The Bank Waters.*—Attention has been previously drawn to the fact that bank water bathed the whole west coast of Norway in the autumn of 1893. In the Norwegian channel off Ekersund on November 15th the salinity of the surface water was 33·38 per thousand, and the temperature approximately 9° C. The plankton was abundant, and con-consisted principally of the Copepod *Pseudocalanus elongatus*, *Evadne*, *Sagitta*, Radiolaria, Cilioflagellates (*C. tripos*), and Diatomaceæ (*Chætoceros borealis* and *curvisetus*).

Off Espevær, on December 15th, 1894, on the other hand, the salinity of the surface bank water was somewhat lower (32·98 per thousand), and the temperature 7°. Nevertheless, the plankton was very abundant, and consisted principally of Cilioflagellata (*C. tripos*), together with numbers of the Copepod *Oithonella pygmæa* and a few *Pseudocalanus elongatus*. The absence of Diatomaceæ will be noticed.

In the winter of 1894, on the west coast, the surface bank water had a high salinity, and on February 28th was practically North Sea water (salinity 33·92 per thousand, temperature 5°). It contained an abundant plankton, consisting principally of the Copepods *Cynthilia Clausi*, *Calanus finmarchicus*, and *Metridia lucens*, together with a large number of the Diatom *Coscinodiscus*. On March 20th, 1894, the salinity was lower (33·51 per thousand, temperature 4·9°), and the plankton consisted chiefly of *Pseudocalanus elongatus*, *Paracalanus parvus*, *Sagitta*, and the Diatoms *Cosciniodiscus* and *Chætoceros decipiens*.

In the winter of 1895, on the west coast, the salinity of the surface water inshore was lower than in 1894. Thus on February 9th west of Utsire it was 33·67 per thousand, and the temperature 4°. Further inshore the salinity was only 32 per thousand, and the temperature 2°. The plankton was correspondingly sparse, consisting principally of Cilioflagellates and a few Copepods. On the 25th of the same month west of Utsire the salinity* at the surface was 33·14 per thousand, and the temperature 4·3°. Except for a number of fish eggs, the plankton consisted principally of Diatoms (especially *Chætoceros decipiens*) and *Halosphæra viridis*. Further north, off Vigten, on February 21st (salinity 33·34 per thousand, temperature 5·1°), the chief contents of the tow-net were *Calanus finmarchicus* and *Metridia lucens*, the plankton consisting principally of Crustacea, though not in quantity.

3. *North Sea Water.*—In the winter of 1894 the surface water on the 22nd of February eight miles west of Utsire (West Coast Spring Herring Fishery District) had a salinity of 34·01 per thousand. The plankton consisted principally of the Copepods *Calanus finmarchicus* and *Pseudocalanus elongatus*, *Sagitta*, species of *Coscinodiscus* and *Chætoceros decipiens* (*cf.* also the plankton obtained on the 28th February in bank water, having the high salinity of 33·92 per thousand).

The general tendency of Hjort's results, considered by themselves, appears to be towards the following conclusions:—

(1) Cilioflagellates (especially *Ceratium tripos*) are particularly characteristic of Baltic water (*i.e.*, water of very low salinity).

(2) Diatoms of the genus *Chætoceros* are particularly characteristic of bank water of rather high salinity (33 per thousand).

(3) Diatoms of the genus *Coscinodiscus*, in the absence of Cilioflagellates, are particularly characteristic of bank water of still higher salinity (33·5 per thousand to 33·9 per thousand) and of North Sea water (34 per thousand). It will be remembered in this connection that in the winter of 1894, when *Coscinodiscus* was so plentiful, North Sea water was found on the surface a very short distance from the west coast of Norway, while in 1895 the absence of *Coscinodiscus* from the plankton was correlated with the great superficial extent of bank water of low salinity.

* The salinity and temperature are taken from the hydrographic tables, p. 61, not from the figures given in the plankton tables, p. 48, which are clearly erroneous. The figures given in the latter table appear to have been accidentally transferred from the hydrographic record for station 297, January 26th.

(4) The Copepod *Calanus finmarchicus* (= *Cetochilus septentrionalis* is rarely found in water of low salinity, but is characteristic of North Sea water and bank water having a high salinity (above 33·5 per thousand). It occurs in company with the Diatom *Coscinodiscus.*

(5) The Copepod *Pseudocalanus elongatus* (= *Clausia elongata*) flourishes in bank water of high salinity (*i.e.*, above 33 per thousand). In the salter waters it is found along with *Calanus finmarchicus*; in the fresher waters with *Paracalanus parvus.*

(6) The Copepods *Centropages hamatus* and *Halitemora longicornis* were only found in waters of low salinity (Baltic current).

(7) Radiolaria were only found in Baltic water and in bank water having a salinity below 33·5 per thousand.

In formulating these generalisations from Hjort's data, I must be understood to have considerably exceeded Hjort's own cautious and reticent attitude. Nevertheless, I think it desirable to generalise his results, not for the purpose of basing any conclusions upon them, but in order to present them in a form which will at once suggest points for further examination.

III. Fisheries.

1. *The West Coast Spring Herring Fishery.*—The spring herring fishery on the west coast of Norway is due to the annual "spawning migration," and takes place in the months of January, February, and March. Formerly the fishery extended over a much more extensive area than at present, viz., from the Naze to Christiansund; but now the fishery is practically limited to the neighbourhood of the mouth of the Hardanger fjord. The spawning grounds are the shallow banks lying around the groups of islets and rocks in this district, bounded by the 60-fathom line, and covered with sand and fine shells. In favourable years the spawning herrings advance up to the very beach in all the sounds and bays, and the roe is then found covering great stretches of the bottom.

1894 was such a year. Enormous bodies of herrings abounded close inshore, and quantities of roe were obtained at a depth of only 3 to 4 fathoms. It will be remembered that in the spring of this year, owing to a succession of heavy westerly gales, North Sea and Atlantic water was found close inshore.

It would thus appear that on the Norwegian coast herrings abound close inshore for spawning purposes when the shore water attains its maximum salinity for the year (North Sea water, 34 per thousand).

This view was confirmed for the season in question by the fact that early in February, when the Baltic current had rounded the Naze, and had reached the southern portions of the Fishery district, fishing for herring was only carried on away from the mainland, *e.g.*, at Utsire, and none between that island and the shore, the explanation being that the intervening channel was occupied by the fresher and colder waters of the Baltic current. Similarly at a later period, in the month of April, the herrings disappeared from the whole district, when the Baltic current, at last released from the Skagerack, had displaced the North Sea water to a depth of 60 mètres.

Hjort does not stop at this point, but proceeds to examine the records of the fisheries for previous years in the light of contemporary data as to the temperature of the sea along the coast. I have already shown in the section on "Hydrography" that Hjort's investigations have established a relation between temperature and salinity during the "typical winter period" (*i.e.*, February and March), so that, within certain limits, the temperature of the water during this period is an index of its salinity. Thus, as a rule,

6° to 7° C.	indicates	Atlantic water.
5°	„	North Sea water.
4° to 3°	„	Bank water.
2° to 1°	„	Baltic current water.

Upon examination of the records in the light of this assumption, Hjort has discovered the following interesting series of correlations:

In 1881 (Jan., Feb.) herrings occurred in swarms, but did not come close inshore (except when isolated shoals of them were chased by whales), thus depriving fishermen of the most profitable and regular method of capture, viz., "night netting." Eventually, in mid-February to March, the herrings spawned in deep water (70 and 80 fathoms), away from shore. The temperature of the water during this season was very low—

2·3°	at surface.
2·7°	„ 38 mètres.
3·3°	„ 75 „
4·8°	„ 113 „

thus indicating a very thick layer of Baltic water of low salinity.

In 1883 (Feb.), on the other hand, the temperature was high, being 5° at the surface, thus indicating the presence of North Sea water. Abundant catches of herrings were made close inshore, even at a depth of 10, 16, and 20 mètres, "reminding one of the rich fisheries of olden days."

In the winter of 1885–6 the temperature was again low. Again the herrings were down at extraordinary depths, where spawning took place (110–120 mètres). On February 15th, when spawning had taken place, a temperature of 5° was first found at a depth of 120 mètres; and on March 1st the temperature at the surface was 0·3°; at 40 fathoms, 1·5°; at 80 fathoms, 3·9°; and even at 120 fathoms, only 4·3°, indicating conditions similar to those which prevailed in 1881.

It thus appears to be satisfactorily determined that the influx of herrings along shore during the spawning season depends on the temperature of the water, which is an index of the prevailing salinity and currents.

The fish come right up to land during warm—often stormy—winters; but in cold winters, when the Baltic current flows along the coast, and when a thick layer of cold water covers the shallow spawning places, the shoals of herring stop far out on the outer margins of the shallows.

The explanation which Hjort adduces is of the following character. Sars showed that during the greater part of the year the herring and cod keep out to the open sea, the herring far out in the surface layers, the cod on the edge of the coastal banks, and thence possibly far out in the Northern Ocean at a similar depth.

In both places the water in winter is salt "Atlantic water," and the temperature is probably from 6° to 7° C. (*fide* Mohn's charts.)

Accordingly, when the large shoals approach the shores to spawn, they may enter salt water of approximately the same temperature (North Sea water at 5° or more), when they will continue their course without interruption up to the shallow beaches; or they may encounter a deep layer of cold, comparatively fresh water (Baltic and bank water, under 5°) all along the coast.

In the latter case the conditions are so different from those prevailing at the places from which the fish have migrated that the fish make a halt: "The fish mope"—they say in the Lofotens of the cod; "The herring want stirring up"—they say on the west coast.

In each region, under the conditions which have been described, the fishery is a failure.

As to the relative importance to the fish of the two factors "temperature" and "salinity" Hjort is silent. For the Norwegian fisheries a knowledge of this point may be superfluous, since the two factors work together; but for English fisheries further discrimination may be of considerable importance, since we have no single agency of the magnitude of the Baltic current that is capable of inducing such extensive changes—temperature and salinity alike—in the quality of the water around our coasts.

2. *The East Coast Autumn Herring Fishery.*—The autumn herring fishery on the East Coast of Norway is due, according to Hjort, to the

"feeding migration," and takes place at the mouth of Christiania fjord in autumn (November).

The movements of the herrings during this fishery are determined, according to Hjort, by the movements of the bank waters at this season.

Thus, in November, 1893, the Baltic current was dammed up in the Cattegat, and warm bank water (11° to 12° C.) flowed from the Norwegian channel between all the islands at the mouth of the Christiania fjord. The herrings then abounded. At the same time the "prey of the herring," the Diatom *Chætoceros*, was abundant.

In November, 1894, on the other hand, Baltic water covered a much larger area, and bank water was both of less thickness and deeper down. Along shore the Baltic current was 50 mètres deep, though further from shore (a few miles) it was very thin. Herrings abounded at sea (16 to 20 miles off), but would not venture in between the islands and the land. The fishery was largely a failure. The food of the herring (*Chætoceros*) was not met with in the upper layers (0–10 mètres), though it was present at greater depths, and was abundant further out to sea, many miles from the coast.

It will be remembered that Pettersson has also remarked upon the coincidence of the autumn herring fishery in the Cattegat with the arrival of bank water of salinity 32 per thousand to 33 per thousand, but according to him this arrival may occur as early as August and September. He discriminates between an autumn fishery (August and September), due to the arrival of the Danish bank water of high temperature, and a winter fishery (October or November to February or March), due to the arrival of Norwegian bank water of low temperature. The former fishery is carried on by means of floating nets 10 to 20 miles from shore, the latter by means of nets (seines) along the shore. But I have already shown in this paper (p. 62), when discussing the nature of bank water, that the sharp distinction drawn by Pettersson in regard to the bank waters is difficult to understand, since the temperature of undoubtedly Norwegian bank water in the eastern part of the Skagerack in November may extend from 8° to 12° C. It is equally doubtful whether there is any racial difference between the autumn herrings caught in warm bank water and the winter herrings caught in cold bank water. Pettersson shows that quantities of herring arrive with the former in August and September, and that the winter herring fishery ceases as soon as the bank water is swept out by the Baltic current in the spring. The fact that the first bank water to enter the Skagerack in the autumn has a high temperature and that subsequent inflows of bank water have a lower temperature is explicable without the necessity of assuming that the former is of southern and the latter of northern origin. Both may be of northern origin, since the temperature of the bank water on the Norwegian coast is high in summer, and gradually diminishes through the autumn and winter.

If this be admitted, we see that the presence of herrings in the eastern part of the Cattegat from August to March is associated with the presence of bank water, and that this bank water, while retaining a fairly constant salinity, undergoes a considerable reduction of temperature during the successive autumn and winter months—from 14° or 15° C. to 4° C. The fluctuations which determine the movements of the herring are probably, therefore, in this case not so much changes of temperature as changes of salinity. The herrings arrive with the bank water and disappear with it.

The relation of these herrings to the spring herrings of the west coast of Norway is not quite clear. The herrings present in the autumn (November) are regarded by Hjort as immature herrings undergoing their "feeding migration." Whether they spawn on the west coast of Sweden in the following January is not stated, although Pettersson's statement that the winter herring are, as a rule, inferior in quality to the autumn herring tends to support such a view.

Reference to Gerhard von Yhlen's *Report of the Sea Fisheries of the Län of Göteborg and Bohns* for 1877 (translated in *U. S. Fish. Com. Rep.* for 1877, p. 741), however, shows that in that famous herring year the fish arrived in November, 1877, and remained until March, 1878. The herrings were of different sizes and in different conditions, many being immature, both "year-old" and nearly full-grown, and many being mature breeding herring (12 inches long) and many spent. From November to January 10th the two last classes were most abundant; after January 10th the larger class of immature herrings were the most abundant; while before, and at the end of the season, the immature "year-old" fish were alone. The mature fish spawned in November and December, and in February great quantities of herring-fry, two inches in length, appeared in the district of Fjellbacka, on the eastern shore of the Skagerack.

3. *Growth of Herring.*—Hjort concludes his work with an examination of the question as to the rate of growth of the herring. During the spring fishery fish of two sizes are met with simultaneously, one of 250 mm. length, the other of 300 mm. These presumably represent two "yearly classes," *i.e.*, fish hatched in different years.

In the fjords herring of three different sizes live together.

In summer the three classes are distinguishable by the following sizes:

(1) 50– 60 mm. ($2\frac{1}{4}$ ins.) = (presumably) $\frac{1}{2}$ year old (Mussen).
(2) 120–140 mm. (5 ins.) = (presumably) $1\frac{1}{2}$ year old (Bladsilden).
(3) 160–185 mm. ($6\frac{1}{4}$ to 7 ins.) = (presumably) $2\frac{1}{2}$ year old (Five-point herring).

It is consequently to be inferred that the smaller class of spring herring (250 mm.) represents simply the third class of fjord herring (five-point herring) after an additional half-year's growth. Some of the spring herrings, however, only measure 200–220 mm., and it is therefore possible that these fishes constitute an intermediate "yearly class," in which case the spring herring measuring 250 mm. would be four, instead of three, years old. In any event, the smaller class of spring herring is three or four years old, and with the larger class of spring herring, *has moved in from the sea to shore.*

Thus the life-history of the ocean herring may be summarised as follows. In its young condition the herring inhabits the inshore waters of the fjords until it attains a length of about 8 ins. ($2\frac{3}{4}$ years old), when it gradually moves out to sea and into deep water, gradually assuming the habits of the ocean herring, of which it forms the youngest yearly class. The young herring are clearly much more independent of changes in the coastal waters than the full-grown fish, since they live in the fjords during all seasons of the year.

Readers of Hjort's interesting contribution to fishery literature will be spared some trouble by noting the following errata, which have clearly escaped the author's attention :

Text, p. 25, seven lines from bottom—for 31·44 read 31·34 (cf. Hydrographical tables, p. 25, and Plate I., fig. 4).

Text, p. 47, station 170—for 34·51 read 33·51 (cf. Hydrographical tables, p. 43).

Hydrographical tables, p. 13—for Plate II. read Plate III.

Chart I. The meridians on this chart are based on Christiania = 0, instead of Greenwich. The longitude of particular stations, however, seems to be always based on the system generally adopted.

Chart II. The parallel of latitude marked 60° should be 59° 30′.

An Account of the Scientific Work of the Northumberland Sea Fisheries Committee.

By

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Just as a small marine laboratory is being fitted up at Cullercoats, it may be desirable to present to a wider audience a short account of the scientific work already done—work which has, in fact, given origin to the building now almost ready for occupation. As regards the laboratory, a word may be said. It is small, but it will be provided with a tank-room and the essential requirements for carrying on, at any rate, biological investigations. The tanks are made of wood, and will be supplied by gravitation in succession. At the same time a series of glass cylinders can be added in any number, and supplied with sea water in a similar manner. The workroom is very cheery, well lighted and well ventilated, and will accommodate six or even more workers. We are indebted for this most desirable adjunct to the biological department of the College to the Vice-Chairman of the Committee, who has already done so much for local fishery questions. The laboratory will, we hope, not only help in the development of our biological work, but form a centre for enquiry, and thus take a share in the general work of investigation now going on in this country.

It owes its inception, in fact, to the contributions to this work already made by the Committee. The trawling excursions conducted by Mr. Dent were begun in 1892, and have been continued in successive years since. Mr. Dent can remember when he could get as many as ten fine turbot with a harpoon any night on Blyth Beach (1860-65); at which period, also, he could almost fill a boat with the fish caught in a small drift-net. He witnessed the depletion of these and other bays which occurred after the steam-trawlers commenced to fish in the district (1877). He has seen the consequent great development of North Shields, and the decline of the ordinary fisheries in the smaller villages and towns.

The three-mile restriction was adopted in 1891, and with the view of ascertaining how far this was to be valuable in restoring the fish to the bays along the coast, Mr. Dent kindly placed one of his steamers at the disposal of the Committee, and personally superintended the expeditions. The trawl used is an ordinary one of twenty-two feet beam, and a day of eight to nine hours is devoted to each bay.

The results have previously been published in yearly tables for the information of the Committee, but it will be more valuable for our present purpose to give the results for each bay. They are interesting in that these bays lie side by side, or, at any rate, within a district of forty miles; they are near to the stations of the similar but naturally more elaborate Scottish experiments, and it seems, from Dr. Fulton's investigations on currents, that we should get our supplies from the spawning grounds of the north. There is no necessity, however, of dwelling upon the results. A glance over each of the following tables shows only too plainly that the bye-law has made little improvement in the numbers of the mature fish. It ought to have been stated that the gurnards were not counted in the first two years. Blyth Bay does show an increase in all kinds, practically. Cambois Bay shows an improvement also as regards turbot, soles, dabs, and gurnards, but the plaice have decreased, though they seem again to be improving in numbers. It would be hard to point to any change occurring in regard to the fish of Druridge Bay. The numbers remain very steady for each year. The increase in the plaice of Alnmouth Bay is very marked. Soles are also increasing. Dabs scarcely show any change. In Skate Roads turbot and soles seem to give better returns, but plaice have decreased. It will be noted that flounders are not recorded for 1895, but it is highly probable that a few occurred and were overlooked, for they are very characteristic of this bay.

The undersized fish were taken particular note of at last year's excursions. By this term is meant such fish as were caught in the trawl and too small to be retained.* At Alnmouth Bay, on the 23rd July, they were roughly counted after the first haul before being returned to the sea. There were some 20 flounders of 6 in. or less; some 25 plaice of 7 in. or less; and 12 gurnards 8 in. or less. It was calculated that quite 100 immature fish were returned to the sea at each haul. It is the custom at these excursions to return the fish which are not

* It may be a rough classification, this, into mature or saleable, and immature or undersized; but in our anxiety to return the small fish as quickly as possible we do not as a rule make measurements, or even always count them.

retained as quickly as possible, and in every case it is noted that the flat fish swim away at once, evidently little the worse for being dragged along with the trawl for often two or even three hours, their visit to the deck of the steamer, and being swept overboard.

Druridge Bay possesses many young dabs and plaice. Skate Roads is rich in young flounders and plaice, and small turbot and brill are got as well. Cambois and Blyth Bays have principally immature dabs, but soles, flounders, and gurnards occur also in this category.

It is quite evident, then, that the restriction is useful in the protection it affords to valuable fish in the immature condition. But there is a curious dissimilarity often in the proportions of young and mature, or, let us say, saleable fish. The latter give us variable returns, sometimes slightly increasing, sometimes slightly decreasing, from year to year. There is no doubt at all that the in-shore trawling of the first few years did make such severe inroads as to be quite apparent. Allowing for seasonal variation in the numbers, there has not been such a return of the mature or large fish as to justify us in saying that the bye-law in that respect was tending to much good. If we now compare the rough statistics we have for Alnmouth Bay in regard to the immature fish with that part of the table referring to 1896, and assuming that the trawl was down five times at each excursion, the immature flounders would have been, say, 100. We only got three saleable. The immature dabs would be, say, 150. We got about half that number large enough to keep. The immature plaice would be 125, which is below the number of matured forms retained, and this in a bay showing an increase in the saleable plaice. I cannot speak as to the immature fish in previous years; but these figures, which could be repeated for the other bays, show only too well that a large destruction of fish occurs somewhere before they become mature. That this occurs when they go out to spawn seems from the collateral evidence of other experiments only too likely. Either this is the case or many of them depart after their in-shore early life and never return. But this does not explain the practical non-increase in these and other similar territorial waters. These facts only add to the evidence in regard to the destruction of the spawners outside the limits.

The plaice last year varied from 12 to 16 or 17 ins. in total length (one example measured 19¾ by 11½ ins., fins included), and were feeding principally on *Donax trunculus*, which is extremely common in these bays. *Tellina tenuis* and *Venus gallina* also occurred in some of the stomachs examined. The dabs measured 9 to 13 ins. in length, and were feeding mainly on *Portunus holsatus*, and sometimes old and fresh shells of various mollusca were found in the stomach as well. The soles were got from 12 to 20 ins., and sandeels were found most often in the stomachs.

Turbots also varied from 12 to 20 ins., and were found to feed on small whitings, the lesser weever, and the sandeel. Brill of 14½ and 20½ ins. were feeding on whitings. Flounders (12 to 18 ins.) had *Donax trunculus*, sandeels, *Mactra stultorum*, *Tellina tenuis*, *Portunus holsatus* as the forms found in the stomachs of a few examples. The common gurnard of 11 to 16 ins. was feeding on sandeels, whitings, *Portunus holsatus*, etc. Other forms were investigated, and full details of measurements and contents of stomachs are given in last year's report. The more important "other fish," etc., are also referred to.

The surface nets gave us two kind of eggs—those of the Lesser Weever (*Trachinus vipera*) and an unknown egg not differing from McIntosh and Prince's "F" form.

Mr. Gregg Wilson, of Edinburgh University, while in the district, made investigations into the condition of the crab, lobster, and mussel fisheries. He found evidence which led him to suppose that crabs spawn during November, December, and January; that females were not less than 6 in. when mature, that males were mature at 5 in. Along with a close time, which is, however, commonly naturally given during these months, he recommended the raising of the size-limit to 5 in. He recommended also a close time for lobsters during June and July, on the assumption that in these months most berried hens were found. The sale of the berried hen, it is expected, will shortly, however, be prohibited in the district.

A member of the Committee, Mr. William King, who has had much experience in mussel cultivation, contributed an interesting paper on that subject. A list of the papers published for the information of the Committee is appended.

We have to remember also the rich inheritance of local zoological work we have from such eminent naturalists as Dr. Johnston, Joshua Alder, Albany Hancock, Dr. G. S. Brady, Dr. H. B. Brady, the Rev. Canon Norman, R. Howse, and others.

List of Papers Published by the Committee.

1. 1891. William King—"Mussels and Mussel Culture."
2. 1893. Gregg Wilson, M.A., B.Sc.—"Report on the Crab, Lobster, and Mussel Fisheries of Northumberland."
3. 1895. C. Williams—"Report of a Visit of the Northumberland Sea Fisheries Committee to the Marine Hatchery at Dunbar."
4. 1895. Gregg Wilson, B.Sc., Ph.D.—"Further Report on the Crab Fishery."
5. 1895. John Dent, J.P.—"Records of Scientific Trawling Operations conducted off the Northumberland Coast (1892–95).
6. 1896. Alexander Meek, B.Sc., F.Z.S.—"Report on the Scientific Results of the Trawling Expeditions carried on by the Northumberland Sea Fisheries Committee during the Summer of 1896."

Tables showing the number of Fish captured in each Bay.

(1) Blyth Bay. 2–5 Fathoms.

Year.	Date.	Turbot.	Brill.	Sole.	Plaice.	Dab.	Flounder.	Haddock.	Whiting.	Gurnard.	Skate.	Midday surface temp., F.	Sea.	Wind.
1892	Aug. 1	—	—	1	88	40	—	—	—	—	—	—	rough	N.E.
	,, 15	—	—	—	20	12	—	—	—	—	—	—	smooth	W.S.W.
	Sept. 20	2	—	3	60	41	—	—	—	—	—	—	rough	E.N.E.
	Average	·5	—	1·5	56	31	—	—	—	—	—	—		
1893	Aug. 2	3	—	56	59	23	—	—	—	—	—	55	smooth	W.N.W.
	Sept. 13	6	—	17	37	19	—	—	—	—	—	56	rough	W.S.W.
	Average	4·5	—	38·5	48	21	—	—	—	—	—	55·5		
1894	July 27	2	—	43	67	23	2	5	—	41	1	52	smooth	N.E.
1895	July 31	1	—	12	64	32	—	4	—	25	—	53·5	smooth	calm.
	Aug. 15	4	—	20	58	95	—	7	—	40	—	54	smooth	calm.
	Average	2·5	—	16	61	63·5	—	5·5	—	32·5	—	53 75		
1896	June 18	7	—	5	85	44	—	—	—	46	—	53	smooth	W.N.W.
	Aug. 26	2	—	36	63	78	2	—	—	20	1	55	smooth	E.
	Average	4·5	—	20·5	74	61	1	—	—	33	·5	54		

(2) Cambois Bay. Depth 3–7 Fathoms.

1892	Aug. 11	—	—	—	80	44	—	—	—	—	—	—	smooth	S.W.
	Sept. 13	3	—	7	120	80	—	—	—	—	—	—	smooth	W.
	,, 15	2	—	8	81	47	—	—	—	—	—	—	smooth	W.S.W.
	Average	1·7	—	5	93·7	57	—	—	—	—	—	—		
1893	July 15	2	—	3	50	12	—	—	—	—	—	54	strong N E sea	calm.
	Aug. 7	4	—	16	60	51	—	—	—	—	—	55	smooth	W.
	Average	3	—	9 5	55	31·5	—	—	—	—	—	54·5		
1894	Aug. 17	1	—	20	18	11	4	20	—	17	—	53	strong	N.
	Sept. 13	1	—	59	30	18	—	22	—	6	—	53	surf	N.E.
	Average	1	—	39·5	24	14·5	2	21	—	11·5	—	53		
1895	July 4	3	—	4	37	13	—	—	—	7	—	52·5	rough	N.E.
	Sept. 5	3	—	4	71	33	—	7	—	85	1	54	smooth	W.
	Average	3	—	4	54	23	—	3·5	—	46	·5	53·25		
1896	Aug. 12	8	—	24	76	81	—	—	—	100	—	55	smooth	W.

(3) Druridge Bay. 2-3 Fathoms.

Year.	Date.	Turbot.	Brill.	Sole.	Plaice.	Dab.	Flounder.	Haddock.	Whiting.	Gurnard.	Skate.	Midday surface temp., F.	Sea.	Wind.
1892	Sept. 16	—	1	13	140	70	—	—	—	—	—	—	smooth	S.W.
1893	Aug. 31	9	—	24	87	67	—	—	—	—	4	56	smooth	N.E.
	Sept. 8	7	—	28	73	39	—	—	—	—	—	56	smooth	N.N.E.
	Average	8	—	26	80	53	—	—	—	—	2	56		
1894	July 4	27	—	5	146	54	3	7	—	—	3	54	smooth	W.
	Aug. 22	7	—	36	50	40	2	24	—	120	—	55	smooth	N.E.
	Average	17	—	20·5	98	47	2·5	15·5	—	60	1·5	54·5		
1895	June 20	5	—	6	120	15	2	—	—	13	2	52	rough	N.E.
	July 11	5	—	12	116	60	—	—	—	35	1	52·5	smooth	W.
	Aug. 22	2	—	11	132	70	—	2	—	120	1	55	smooth	calm.
	Average	4	—	10	123	73	·5	·5	—	63	1·5	53		
1896	July 9	9	—	35	160	68	—	—	—	83	3	54	smooth	S.W.
	,, 29	8	—	8	157	68	1	—	—	143	—	55	rough	E.
	Sept. 8	13	—	26	104	123	1	—	—	124	1	56	smooth	E.
	Average	10	—	23	140·5	86·5	·5	—	—	117	1·5	55		

(4) Alnmouth Bay. Depth 2-3 Fathoms.

Year.	Date.	Turbot.	Brill.	Sole.	Plaice.	Dab.	Flounder.	Haddock.	Whiting.	Gurnard.	Skate.	Midday surface temp., F.	Sea.	Wind.
1893	July 25	9	—	8	116	100	—	—	—	—	4	54	smooth	N.W.
	Aug. 22	3	—	11	75	49	—	—	—	—	1	55	smooth	S.S.W.
	Average	6	—	9·5	95·5	74·5	—	—	—	—	2·5	54·5		
1894	July 11	17	—	5	131	63	14	2	—	49	3	52	smooth	N.E.
	,, 31	8	—	18	60	51	4	12	—	17	3	54	smooth	calm.
	Aug. 29	14	—	8	65	35	7	15	—	85	2	55·5	smooth	W.
	Average	13	—	10·5	85·5	50	8·5	10	—	50·5	3	54		
1895	July 25	7	—	4	118	82	—	10	—	24	—	52	smooth	N.E.
	Aug. 29	3	—	7	101	46	—	103	—	65	1	54	moderate	W.
	Average	5	—	5·5	109·5	64	—	56·5	—	44·5	·5	53		
1896	July 23	13	—	30	202	117	3	2	1	29	1	55	smooth	W.
	Aug. 19	9	1	9	154	44	3	—	—	46	—	55	smooth	N.
	Average	11	·5	19·5	178	80·5	3	1	·5	37·5	·5	55		

(5) SKATE ROADS (BUDLE BAY). 2½–4 FATHOMS.

Year.	Date.	Turbot.	Brill.	Sole.	Plaice.	Dab.	Flounder.	Haddock.	Whiting.	Gurnard.	Skate.	Midday surface temp., F.	Sea.	Wind.
1894	June 27	28	—	1	371	22	19	—	—	—	4	54	smooth	N.E.
	Aug. 6	18	—	1	90	30	9	—	—	81	3	54	smooth	W.S.W.
	Average	23	—	1	230·5	26	14	—	—	40 5	3·5	54		
1895	June 26	4	—	—	120	42	—	6	—	30	—	53	rough	calm.
	Aug. 5	1	—	3	75	13	—	4	—	70	—	53·5	moderate	N.
	Average	2·5	—	1·5	97·5	27·5	—	5	—	50	—	53·25		
1896	June 24	7	—	5	85	44	—	—	—	46	—	53	smooth	W.N.W.
	Aug. 3	50	1	2	155	10	32	—	—	29	—	55	rough	N.E.
	Average	28·5	·5	3 5	120	27	16	—	—	37·5	—	54		

Gadus Esmarkii, Nilsson, the Norway Pout, an addition to the Fish Fauna of the English South-Western District.

By

Matthias Dunn, of Mevagissey, and Ernest W. L. Holt.

In the summer months, for some years prior to 1887, very large quantities of *Hake* (*Merluccius vulgaris*) had been caught by trawlers beyond the entrance of the Bristol Channel, and landed at Plymouth. Knowing that such masses of hungry creatures would not be found continuously in any given locality without a heavy balance of smaller fish being in their neighbourhood as food for these hakes, I became anxious to know what these smaller fish were, and throughout the summer of 1888 I tried more than once to get at them through our fishermen, but failed.

In July, 1889, I desired my son Howard to visit the Plymouth Barbican, and notice the gutting of the hakes there and tell me the result. His report was that they had been feeding on small whiting (*Gadus merlangus*), and that single hakes had as many as ten whiting in their stomachs. I told him that I doubted if these small fish were whiting, and asked him to send the specimens at once, as I expected them to be the poutassou (*Gadus poutassou*) of Couch. I had recently had specimens of this fish brought me from thirty miles west of the Scilly Isles.

About a week afterwards my son sent me seven of these little ones taken from the stomach of a pollack (*Gadus pollachius*) which had been caught in a trawl forty miles north-west of St. Ives. On giving them my attention, I was surprised to find they were not the poutassou nor any other *Gadus* I was acquainted with.

Hence I forwarded these two specimens to the Plymouth Biological Laboratory for further enquiry and research concerning this new species.

M. D.

The credit of the discovery of the Norway pout in the south-western district, and of its recognition as distinct from any *Gadus* previously recorded in the local fauna, is entirely due to Mr. Dunn. My own share in the matter is confined to the specific identification of the material, a matter of small difficulty, owing to an extensive previous acquaintance with the species on the west coast of Ireland and in the North Sea.

Though the species has been discussed at some length as recently as 1895,* a short recapitulation of its history appears convenient.

Originally discovered by Esmark, in 1844, as an inhabitant of the Norwegian coast, its range was subsequently extended by Lütken to the Faröe Islands.

In 1888 it made its first appearance in British records, being found in comparative abundance by Günther among the fishes collected by Murray on the west coast of Scotland.

It was next recorded by myself, in 1890 and 1891, from the west coast of Ireland, where it occurred, during the Royal Dublin Society's survey, in considerable numbers, a great many of my specimens being found, as was the case with Mr. Dunn's, in the stomachs of larger fishes; and in 1892 I was able to extend its range again, from the examination of stomach contents, to the Great Fisher Bank in the North Sea. It is therefore apparent that, in so far as regards the date of capture, Mr. Dunn's specimens actually represent the second occurrence of the species within the British area.

It is not a shallow-water fish, having hitherto been found, or at any rate recorded, only between 26 and 144 fathoms, a fact which may partially account for its having so generally escaped attention at the hands of naturalists. Fishermen would naturally regard it with unconcern, since it never grows to a marketable size, and bears, moreover, a very close resemblance to a common and, from the market point of view, equally worthless form, *Gadus minutus*.

Probably it may prove to be common enough at suitable depths around our coasts, though it may perhaps not extend into the English Channel or further south, since our continental neighbours, who take a gastronomic interest in even smaller fish, would in such case be likely to have noticed it.

The specimens forwarded by Mr. Dunn to the Laboratory are two in number, and, taken as they were from the stomach of a pollack, are naturally not in the most perfect condition, though quite sufficiently so for identification. One, which is complete, measures 7¼ inches in total length, while the original length of the other, which has lost

* HOLT and CALDERWOOD, *Sci. Trans. R. Dub. Soc.*, v. 1895, ix. p. 431.

the caudal peduncle, may safely be estimated as over eight inches. They are thus rather large examples.

Dr. Günther has called attention to the existence of two varieties of the species, of which the typical Norwegian forms were found to differ from the Scottish chiefly in the greater attenuation of the body and the greater size of the eye. The same difference was found to exist between the solitary specimen from below the 100 fathoms line and the smaller ones from lesser depths among the Irish survey collections. Without entering into details, it may suffice for the moment to remark that Mr. Dunn's specimens agree with the larger Norwegian and deep-sea Irish type, and not with the smaller Scottish and Irish variety.

E. W. L. H.

Remarks on Dr. Petersen's Report of the Danish Biological Station for 1895.

By

Ernest W. L. Holt.

It may be predicted of a Report by Dr. Petersen that it is sure to contain matter of great interest, both to the ichthyologist and to the student of fishery questions; and the volume for 1895 is assuredly no exception to the rule.

The subject dealt with is the plaice fishery of the Lim fjord, an arm of the sea which pierces the Danish peninsula from Thyboron, on the west coast, to Hals, on the Cattegat. Such a geographical feature is quite without parallel in our comparatively mountainous countries, and may even be said to present difficulties of comprehension to those who have not had an opportunity of visiting Denmark. Indeed, the physical conditions are so different from our own, that it must be at once acknowledged that the mass of information so carefully collated by Petersen cannot be made of direct use in connection with any of our own fisheries. Indirectly, however, the Danish work will be found to be of the highest importance, and well worth the attention of those concerned with British fisheries.

A glance at Petersen's map shows that the Lim fjord consists of "brednungs," or broads, connected with each other by somewhat narrow channels of various lengths. The westernmost (Nissum) broad communicates with the sea (since the beginning of the present century) by means of an inconsiderable opening in the barrier ridge of Hasboöre, while the Liv broad, the easternmost, and by far the largest of the series, is separated from the Cattegat by a long and, for the most part, narrow sound. Previous to the breakdown of the Hasboöre barrier we learn that plaice were only found in the sound last mentioned, viz., that between Hals and Lögstör, and only then, as now, in quite inconsiderable numbers, even in that part. Consequently the fish, which now form the object of a most important industry, are comparatively new-comers, and belong, not to one of the stunted Baltic races, but, as Petersen incidentally shows, to the largest of the North Sea races, viz., the one familiar to Grimsby fishermen. It is, moreover, most important to note that the plaice of the Lim fjord does not as yet appear to have become a true native, the stock of fish annually taken being merely those which have entered the fjord in the early stages of their career. Petersen evidently holds the conviction that the fish does not breed there at all; but rightly guards himself against an absolute statement to that effect until his evidence shall be more complete. It is equally evident that the contrary opinion is not unknown in the locality; but certainly all that we know in this country about the breeding of the plaice must be taken as evidence of the correctness of Petersen's views on this matter.

To what extent the reproductive activity may be affected by conditions of mere salinity is a question to the solution of which we are not helped by the recorded observations of any writer; and, as it happens, no details of specific gravity, etc., are given in the present Report, though we learn, incidentally, that the salinity, if that be really a desideratum, must be sufficient for the reproduction of the rockling, sprat, and flounder. That these fish will spawn in narrow waters we know from our own experience at home, but except where, as on the west coast of Ireland, the rapid declivity limits the habitable area to a comparatively narrow strip, I cannot call to mind any record of plaice spawning close inshore. In the Lim fjord the fish is limited to an area of 614 square miles, of which only 283 square miles contain three or more fathoms of water; and, as Petersen shows, the Liv and Thisted broads, which comprise about one-half of the whole area, are seldom, if ever, reached at all by plaice under natural conditions.

That a few fish are occasionally found with ripe ovaries is, I think, rightly held by Petersen to be no proof that actual breeding takes place there, since we know, from our experience of aquaria, that fish will yearly develop spawn, but will not shed it until thoroughly acclimatised. Even in the feral condition one occasionally meets with fish in which the ripe ova have remained to decompose within the ovaries, and I can recall at least one instance in which such a condition appeared to be directly due to the creatures having returned too soon, or having never left the estuarine waters.

That the fish are not actually land-locked in the fjord is evident from the fact that they got in there, but very few seem to get out again, for the sufficient reason that the fishermen catch practically all that are marketable; and it is worth while to note that it only takes about twelve days' fishing in each broad to exhaust the annual supply.

Fishing appears to be carried on entirely by means of seines, of a fixed pattern of mesh, and during a season which opens on the 1st September, while a law has for some time been in force whereby the sale of plaice less than 9¾ inches long is prohibited, though there is no means of preventing the use of undersized fish for agricultural purposes. However, it does not appear from anything in the Report that there is any depreciation in the annual take, though the annual drain on the stocking power of the outside fish is so considerable, and to all intents and purposes wholly uncompensated by the return of mature fish to the open sea.*

Human intervention is therefore here required, not to arrest a decrease of the general supply, but to effect an increase in the number of large fish, for of the small there seem to be enough and to spare. The problem is really, as appears from the Report, how to get enough fish into the inner broads, *i.e.*, Liv broad and its subsidiary lagoons, which, forming about one-half of the total area of the fjord, are practically never reached by plaice under natural conditions. Petersen's observations lead him to the knowledge that the young fish move very slowly up the fjord, and reach the inner expanses, if at all, only in very inconsiderable numbers.

The reason is not far to seek, for, in the first place, nearly all the fair-sized individuals find their way into the hands of the fishermen; while if any escape they must, to reach the inner waters, traverse dense grass-fields (zostera), whither the plaice "come but rarely, and where it has no reason at all to go, as it does not know there is plenty of food for it further up." A somewhat extensive experience of fishery literature supplies me with no more striking instance of common-sense expressed in simple language.

But if the fish does not know where he would be well off, the fjord fish merchants seem to have perceived that it is to their interest to help him on, for we learn that since 1892 there has been carried on a system of State-aided transplantation, whereby in 1895 alone more than 80,000 fish were transferred from the North Sea to the inner broads. A proportion of these fish were marked by means of holes in the fins, and it is by ascertaining the proportion of marked fish captured later on that Petersen is able to prove, not less to the satisfaction of his readers than of himself, that the inner waters are populated almost, if not entirely, by transplanted fish; while even the unmarked fish support the same conclusion by bearing traces of confinement in a boat's well.

* There is an exactly parallel condition in the Mediterranean, where Professor Marion has shown that the bands of young sardines, which every year enter some of the shallow lagoons near the mouths of the Rhone, neither return to the sea nor survive to reproduce their species within the inland waters.

It was found by the fishermen, and is proved by Petersen's observations, that plaice grow much more quickly in these inner waters than in the western expansions of the fjord, and, moreover, reach a larger ultimate size, which increases their value, apart from mere question of weight, since very large fish command, from their rarity and excellent condition, an unusual price. It appears, in fact, from the examination of the few sexually mature females available, that the transported fish are similar, in their relations of size and maturity, to the larger of the North Sea races, from which, of course, they are annually bred.*

On the other hand, the plaice in the outer broads show a tendency to become mature at a somewhat smaller size. There is, perhaps, to the biologist nothing in the whole Report of greater interest than this last observation, since we seem to have before us the possibility of the establishment of two *apparent* size-races, derived from common parentage, operating under comparatively slight differences of environment. There is, of course, nothing to show that the differences would be transmitted, even if (1) the fishermen spared any fish to reproduce their race within the fjord, and (2) if reproduction, as seems to be doubted, is possible there at all.

In any case, the study of biological problems is pretty generally known to bring no grist to the mill, and as Petersen's duties are to the fishermen and not to the ichthyologist, he clearly regards the annual fishing-out of the possible breeders with absolute complacency. In his opinion, undoubtedly a sound one, the preservation of breeders might yield unexpected results; and I would venture to go further and predict that, if any result in the way of reproduction were achieved, it would inevitably be in the ultimate peopling of the fjord with one or more stunted races of little commercial value.

Granted that the fish grow more quickly and larger in the inner broads, the question arises, Why is this the case? The fisherman's answer, that the bottom is more suitable than in the outer part, does not appear to be based on a profound study of the benthos, since Petersen is unable to detect any particular difference in this respect. On the other hand, he produces figures to show that there is a very marked difference in the number of fish which are found per acre in the different parts; and as the number is infinitely the greater in the outer broads, he concludes that in the latter the fish are stunted in their growth by "over-population." I have quoted the word used, which is not qualified by any explanation, but is surely intended to be understood as over-competition for a limited available food-supply. Otherwise,

* Since Dr. Petersen is good enough to refer to me in this connection, I must remind him that I proposed 17 inches as the biological limit between mature and immature fish, and not as a size-limit for legislative purposes.

since oxygen may be presumed to be in ample abundance, I do not see that mere crowding need unfavourably react on the growth of the fish. In any case, one may venture to suggest that an attempt to tabulate the stomach contents of fish, and the proportionate quantity of food organisms per acre, would greatly enhance the interest of the statistics given.

Granted that overcrowding means in great part underfeeding, there seems no reason to quarrel with the conclusions which Petersen bases on his statistics; and if I am constrained to criticise the figures themselves, it is chiefly in regard to the manner in which they are set forth.

The statistical work was undertaken, as we have seen, with a view to ascertaining the local population in the different broads, and the fishing was done entirely with seines.

The word seine is capable of rather a wide interpretation in this country, and probably in Denmark also; but as no details are given, one must assume that the nets used, if not of uniform pattern, were at least of approximate efficiency in proportion to their sizes. It appears that the plaice-seines are hauled into boats in about three fathoms of water, and may be supposed to be similar in general make to the "tuck-net" of the Plymouth district, since an ordinary bottom-seine without a central bunt could not easily be raised in so much water without risk of losing the fish. In calculating the results, Petersen shows that a seine shot from a boat covers, theoretically, a triangular area of ground, marked out by the net as base and the two lines as sides. Thus, if twenty fathoms of line are used, and the net is twenty fathoms long, it covers, theoretically, an equilateral triangle, the sides of which are each twenty fathoms. On this basis the area covered by a number of hauls is computed in Danish "Tonder Land," and the population per "T. L." ascertained by proportional assignment of the total catch of fish.

While my own experience leads me to the belief that the seine is the most efficient engine that could be used for the statistical enumeration of bottom fish in shallow waters, it is perhaps my ignorance of the local conditions which leads me to suspect that Petersen, although he acknowledges that his figures are only approximate, hardly lays sufficient stress on the possibilities of error.

In this country the state of the tide has the greatest possible effect on the efficacy of a seine, not only in determining, by its rise and fall, (1) the amount of ground that can be covered, and (2) the movements of the fish, but also in influencing the action of the net. So far as the first question is concerned, we learn that the rise and fall in the fjord is only about a foot in extent, so that it need not be considered;

but nothing is said as to the force of the tide, except that the tides are strong at the Thyboron end. I do not know how far we may be justified in inferring, from the insignificance of the rise and fall, that there are no violent tide currents in the inner broads and channels; but if such really exist, the efficacy of the net must be largely dependent, as here, on the tide period.

It is also recognized that the weather exercises an important influence on seining. Even in waters far narrower than those of the Lim fjord broads, the wind, when not strong enough to stop it altogether, may seriously interfere with its success; while, though fishing operations may not be hampered, it is very generally believed, if not actually known, that conditions of wind and temperature react most powerfully on the distribution of the fish. No detailed information being forthcoming,* we are left to assume that the hauls on which the comparative statistics are based were all made under practically identical conditions of tide, weather, temperature, etc., which is a very large assumption.

I have perhaps laid too much stress on this matter, for there is no reason to doubt the general accuracy of Petersen's conclusions as to the relative numbers of fish in the different areas; and if he thinks that, by converting his actual figures into more or less approximate enumerations of population per acre, the result is more easy of general comprehension, he is more than probably right.

We have now to deal with the recommendations which are suggested by the conditions already ascertained; and it is obvious that only two courses are open, *i.e.*, either (1) to preserve the fish with a view to their reproduction, and to the consequent population of the now comparatively uninhabited inner broads, or (2) to annually stock these broads with the largest number of young fish that can thrive (*i.e.*, grow rapidly) therein.

We have already seen that Petersen is no friend to preservation. He is not sure that it would result in reproduction, while he sees that if reproduction occurred it would have the effect of encumbering the broads with a number of small, hungry fish that would be of no value for some years, besides entailing some hardship by the imposition of a very high size-limit. I cannot controvert his arguments, the more so since, as I have already said, I believe that reproduction would ultimately result in a stunted race.

The Lim fjord men have, as one may say, at their very doors a vast natural and practically inexhaustible hatchery—or rather nursery—to which they may resort in all weathers with the certainty of finding as

* In Appendix III., the diary of professional fishing operations, the weather is noticed, but only when bad enough to entirely suspend fishing operations.

many fish as they have time to transport. Small wonder, therefore, that Petersen inclines to the restocking method, and is only troubled as to the maximum number of fish which may be safely dumped down on the inner broads.

We learn from his previous writings that he is no admirer of the suggestions put forward by myself, in common with some other British naturalists, as to the necessity of preserving small fish; and truly, if we had the same opportunities of replenishing our depleted grounds as present themselves in the fjord, it is little we should reck of the doings of our inshore fishermen or of our trawlers on the eastern grounds. The cases, however, are exactly opposite. Petersen has to deal with too many young fish and not enough accessible ground for them to thrive on; while we are confronted with an unlimited extent of suitable ground and an enormous destruction of the very fish which, if unmolested, would come to populate these grounds. I do not see that there is any necessary want of harmony in these apparently opposite views. Apart from our own coasts, the destruction of which I have seen cause to complain affects the outer fringe of the continental small fish, which would ultimately set offshore; and I think that if the fish were spared to populate the offshore waters in their large condition, our trawlers might be relied on to prevent their having the chance of sending back too many little ones to choke Dr. Petersen's fjords.

With the exception of appendixes giving the figures on which the conclusions are based, the Report ends with the formulation of propositions having in view the regulation and improvement of the fjord plaice fishery. The general object of these propositions we have already seen, viz., the extended transplantation of fish into the inner waters; but there is a rider to the effect that none but the local fishermen should be allowed to participate in the benefits which are expected to accrue. It must be presumed that this is in accordance with the Danish conception of the principles of political economy. In any case, it is the Danish taxpayer's affair, and none of ours.

Incidentally it is proposed that more material and money should be placed at the disposal of the Biological Station, and with all sincerity we may hope that Dr. Petersen will get it, for it is certain to be well used.

Notes and Memoranda.

Aphia pellucida. *Nardo.* This species has been hitherto known in the Plymouth district from a single example taken at the surface, south of the Mewstone (*cf.* Cunningham, vol. iii. p. 166). During the present year it has proved to be rather abundant in the estuarine waters, and has also been taken at sea. The following records may be cited:

Lynher River. 14th April. "Deep water" above Waterlake to Anthony passage. More than twenty specimens altogether; most abundant towards the upper part of the area named, where they occurred in company with young herring of similar size and translucency. No large and fully differentiated males were taken on this occasion.

Tamar River. 18th May. Kiln Bay. Two specimens, large male and half grown.

Cawsand Bay. 9th June. Zostera beds. A large male.—E. W. L. H.

Cantharus lineatus. *Mont.* An example, 6¼ inches long, was taken in the seine on the 2nd July, 1897, at the junction of the Tamar and Lynher rivers, *i.e.*, at the upper end of the Hamoaze. Couch remarks that this fish sometimes enters harbours, but I believe it has not been previously observed to ascend estuaries on our coasts. Small examples, such as the present, seem to be of rare occurrence.

E. W. L. H.

Gobius Jeffreysii. *Günther.* (*G. quadrimaculatus.* Day, *nec auct.*). This goby has been recorded from Norway, the Faröe channel, the Hebrides, the Clyde estuary, and the south-west of Ireland. Its range may now be extended to the English Channel, owing to the capture of six specimens, of adult size, in about nineteen fathoms, south of the Plymouth Mewstone, on 30th March, 1897. It is probably common enough in this district, and may have escaped attention partly by its deep-water habitat, and partly from a certain resemblance which it bears to *G. minutus.*—E. W. L. H.

Arnoglossus Grohmanni. *Bonaparte.* A fine male of this species was trawled south of the Plymouth Mewstone on the 30th March,

1897. Two females were trawled in the "Silver Pit" in Gerrans Bay, Falmouth, on the 8th July, 1897. The latter were both full of spawn, but the ova which were exuded on pressure from one of them proved to be not quite ripe. At least three examples have previously been taken by the Laboratory boats in the neighbourhood of Plymouth, and there can be no doubt that the species is a regular, if somewhat rare, member of the local fauna. One of the specimens, a female, came on board in an unusually perfect condition, and I was able to note that the dark markings on the ocular side exhibited the purplish metallic tinge best described (as by Valenciennes in Pomatomus) as *gorge de pigeon.* Another feature of interest is the excessive development of the membrane of the elongated second dorsal ray in one of the females. This feature is not without importance in a due appreciation of the secondary sexual character, and I hope soon to have an opportunity of discussing it at greater length.—E. W. L. H.

Callionymus maculatus. *Bonaparte.* This dragonet must in future be included in the English fish-fauna, since a fully differentiated male was trawled in Falmouth Bay on the 10th July, 1897, at a depth of 30 to 35 fathoms. In British waters it is already known from the Hebrides and Clyde Estuary (Günther) and from the west coast of Ireland (Holt and Calderwood). Other North Atlantic records are from Scandinavia (Fries and Ekström, Lilljeborg, Smitt) and Denmark (Kröyer). Moreau knew of no instance of its occurrence on the Atlantic coasts of France, but it has long been known as common in the Mediterranean.

It is quite possible that the spotted dragonet is fairly common in our seas. It is a small species, and in the North Atlantic does not come into very shallow water. In consequence it is seldom within the reach of the fishing apparatus at a naturalist's disposal. Professional trawlers may probably see it often enough, but cannot be expected to distinguish it from the common dragonet, and in any case would shovel it overboard as soon as possible, since dragonets are credited with toxic properties, which, as a matter of fact, they do not possess.

In the Mediterranean all fish, however small, appear to be saleable. Hence the fishermen use nets of the finest mesh, and the ichthyologist can acquaint himself with the smallest species by simply overhauling the fishmonger's stores. It is therefore no matter for surprise that species which have only recently been added to our list have long been well known to Mediterranean naturalists.—E. W. L. H.

Muræna helena. *Linn.* A fine specimen was brought to the Laboratory on March 3rd, 1897, with the information that it was trawled off the Eddystone, and was just alive when brought on deck. It measured 44·6 inches, or 113·4 cm., and proved to be a male with ripe testes, the milt readily exuding on pressure. The spermatozoa are rather large, but were not measured.

In view of the known existence of sexual dimorphism in the family, the following measurements may be of interest:—

Total length	113·4 cm.
Snout to anus	54·2 „
„ „ gill opening	14 „
„ „ angle of jaw	6 „
„ „ eye	3 „
Length of „	·8 „
Interorbital space (horizontal)	1·9 „
Greatest girth (at gill opening)	26·8 „
Girth in front of anus	23·6 „

In colour the specimen resembled such Mediterranean forms as I have seen, the orange of the anterior ventral region being much less vivid and less extensive than in Couch's figure. The whole body was very soft and flabby, and appeared distended, as though the tissues were undergoing mucoid or colloid degeneration, but such proved to be not the case. The marginal fins were almost entirely masked by the skin and body tissues, the anal, in particular, so much so as not to reach the general ventral surface level. The skin of the abdomen was exceedingly tough, and about ·5 cm. thick. It consisted of an outer white layer, hard and consistent, and a much thicker inner portion, somewhat gelatinous in character. The testis was long and band-like, somewhat crenulate behind. It terminated a little behind the vent posteriorly, extending forward at least half-way along the abdominal cavity. A round wound, about two inches in diameter, and probably caused by a dog-fish, was present on the left side of the tail, involving the loss of the skin and underlying muscles.

Only two records of the occurrence of this fish in British waters have come under my notice, viz., from Polperro and Fowey (Couch). The only specimen measured was just two inches shorter than the Plymouth example.—E. W. L. H.

Director's Report.

As announced in the Report of the Council for 1896–97 (p. 100), important changes have taken place in the staff of naturalists working for the Association. Mr. Garstang, who now has charge of the fishery investigations, commenced his new duties in June; and Mr. E. W. L. Holt, who has placed his services, for the time being, at the disposal of the Association, has been occupied with researches on food fishes since March last. It is much to be desired that the staff should be maintained at at least its present strength, but unfortunately the conditions of Mr. Holt's appointment, which is purely honorary, preclude the possibility of our hoping that this may be the case, unless funds can be provided to give him a position of a more permanent character. It will be remembered that it was only through private generosity that the Association was able for a number of years to retain the services of two naturalists for fishery investigations, and although we have the good fortune for the present to maintain this condition of things, the possibility of the reduction of the number is a prospect which cannot but be regarded as most serious for the future welfare of the Association. It would be exceedingly unfortunate if from the want of funds to remunerate his services the really valuable work which Mr. Holt is now doing for the Association were to be stopped.

In connection with the investigation into the natural history of the mackerel visiting the Irish coasts, which has been undertaken by the Association at the instance of H.M. Treasury, a report has been prepared on the present state of our knowledge with regard to the habits and migrations of this fish. This report has been forwarded to H.M. Inspectors of Irish Fisheries, and is published in full in the present number of this *Journal*. In order to further elucidate the subject, Mr. Garstang has been devoting his attention to the general question of the movements of the migratory fishes, in connection both with the periodic movements of the floating organisms upon which these fishes, directly or indirectly, depend for their food supply, and also with the changes in the physical conditions of the sea, especially with regard to density and temperature. Much striking and valuable work in this direction has been done in recent years by Swedish, Norwegian, and Scottish investigators, an account of some of which Mr. Garstang gives in the present *Journal* (pp. 56–70). Mr. Garstang is also paying special attention to the mackerel which are being taken in the neighbourhood of Plymouth, with a view to determining whether different races of this fish can be recognized; and at the same time arrangements have been made, through the Inspectors of Irish Fisheries, for samples of mackerel taken off the south-west coast of Ireland to be sent from time to time to Plymouth for examination.

Mr. Holt has been chiefly devoting his attention to the distribution in this neighbourhood of young fishes, more especially of young flat-fishes, and to the study of the eggs and larval stages captured in the tow-net.

The trawling experiments in Teignmouth, Start, and Tor Bays have been continued by Mr. Scott and Mr. Holt. In March the work was done with the hired sailing trawler which had been used in all the previous experiments. In May and June our own steamboat, *Busy Bee*, was used, and with the aid of the steam winch with which she has been fitted, she proved herself satisfactory for the work. A fortnight was spent at Exmouth and Dartmouth, and successful hauls of the trawl were made in each bay.

We have been able to extend our work this year to the Cornish Coast, Fowey and Falmouth being used as centres. At the latter port a fortnight was spent, and with the assistance of Mr. Vallentin the trawling and dredging grounds, both of the harbour and of the neighbouring bays, were examined.

The results of the experiments with floating bottles, described in my last Report, for the purpose of determining the direction of the surface drift, have so far proved interesting. A considerable number of bottles put into the sea in the neighbourhood of the Eddystone in January and February last have now been recovered. These have been found to the eastward of Plymouth, having been carried up Channel. At first we received the post cards from the south coast of England, between the Isle of Wight and Dover, with a few from the north coast of France, in the neighbourhood of Calais. Later cards, from bottles put out about the same time, have been returned in numbers from places in the southern part of the North Sea, the bottles having been washed ashore chiefly on the islands off the Dutch and German coasts (Terschelling, Amiland, Borkum, Langeoog, etc.).

In addition to the members of the Association's staff who have been engaged in these investigations, a number of naturalists have, as heretofore, occupied tables at the Laboratory, in order to carry out their own independent researches. The following is a list of these workers, and of the subjects which have engaged their attention :—

Beaumont, W. I., B.A., June 1st to August 5th (*Faunistic Researches*).
Bedford, Z. P., B.A., August 2nd (*Hydrozoa*).
Bushnell, F., M.D., March 22nd to April 22nd (*Marine Bacteria*).
Church, A. H., B.A., March 29th, April 30th, July 29th (*Marine Algæ*).
Duncker, G., PH.D., August 8th (*Variation of Fishes*).
Harmer, S. F., M.A., March 19th to April 13th (*Polyzoa*).
Hodgson, T. V., June 1st (*Polychætes*).
Parkinson, J., April 21st to May 5th (*Compound Ascidians*).
Scott, S. D., B.A., July 1st to August 7th (*Ascidians*).
Shelford, R., B.A., April 29th to May 11th (*General Zoology*).
Weldon, Professor, F.R.S., July 9th to August 5th (*Variation of Crabs*).

During the Easter vacation Mr. Garstang again conducted at the Laboratory a class in Marine Biology for advanced University students, which was well attended, and for which applications were received from more students than we were able to accommodate.

A collection of specimens of fishes and of marine invertebrates, which serve as food for fishes, or are used as bait, has been arranged and exhibited by the Association at the Yachting and Fisheries Exhibition, held during the present summer at the Imperial Institute. The specimens include a number of fish eggs, larvæ, and young fish, together with examples of the smaller floating organisms which are found in the sea.

It has been found necessary to provide a number of additional shelves for the Library, the present accommodation having grown insufficient for the increasing number of books which is being accumulated. Although every year becoming more useful, owing to the number of periodicals regularly subscribed for, the Library, however, still shows serious deficiencies, from the want of many of the classical monographs dealing with marine biology, and also of the back numbers of Journals. A list of some of the more important publications, which are badly needed, is printed at the end of this Report. The addition to the Library of any of these periodicals and works, or even of reprints of papers which have appeared in the former, would be a boon, not only to those who are regularly working at the Laboratory, but also to the naturalists who visit it from time to time. Plymouth being so far from any of the larger libraries, it is most important that our own should be as complete as possible, and we shall be grateful to anyone who can help us to fill up deficiencies.

E. J. ALLEN.

August, 1897.

LIST OF PERIODICALS AND MONOGRAPHS URGENTLY REQUIRED FOR THE LIBRARY.

Anatomischer Anzeiger.
Annals and Magazine of Natural History.
Annales des Sciences Naturelles. Zoologie et Paléontologie.
Arbeiten aus dem zoologisch-zootomischen Institute zu Würzburg.
Archiv für Anatomie und Entwicklungsgeschichte (His u. Braune).
„ „ Mikroskop. Anatomie—previous to Vol. xlv. 1895.
„ „ Zoologie, niederländ. Selenka u. Hoffmann.
Archives italiennes de Biologie. Emery et Mosso.
Bibliotheca Zoologica. Leuckart u. Chun.
British Association Reports, previous to 1893.
Comptes Rendus Acad. d. Sciences. Paris.
Jenaische Zeitschrift für Medicin u. Naturwissenschaft.
Journal of the Linnean Society.
Journal of Anatomy and Physiology.
La Cellule. Carnoy, Gilson et Denys.
Morphologisches Jahrbuch. Zeitschr. f. Anat. u. Entwickelungsgesch. Gegenbaur.
Proceedings of the Royal Society of London, previous to Vol. xlv. 1888.
Royal Society of Edinburgh. Transactions previous to 1888. Proceedings previous to 1889.
Zeitschr. f. wissensch. Mikroskopie. Behrens.
„ „ „ Zoologie. Kölliker and Ehlers. Previous to Vol. xxv. 1875.
Zoologische Jahrbücher. Spengel. Abth. f. Systematik, etc. Abth. f. Anat. u. Ontogenie.
Zoologischer Jahresbericht. Zool. Stat. Neapel.
Zoological Society of London. Transactions and Proceedings, previous to 1891.

Beneden, P. J. van. Les Poissons des Côtes de Belgique, leurs Parasites et leurs Commensaux. Bruxelles, 1870.
Brooks, W. K. The genus Salpa. 4to. Baltimore, 1893.

Claparède. Les Annélides Chétopodes du Golfe de Naples. Supplément. Genève et Bâle, 1870.

Claparède. Beobact. über Anat. und Entwicklungsgesch wirbelloser Thiere an der Küste von Normandie angestellt. Leipzig, 1863.

Claus, C. Studien über Polypen und Quallen der Adria. 4to. Wien, 1877.

Claus, C. Untersuchungen über die Organisation und Entwicklung der Medusen. 4to. Prag u. Leipzig, 1883.

Claus, C. Grundzüge der Zoologie. Marburg.

Cuvier, G. Le Règne Animal.

Darwin, C. Works of: (excepting monograph of Cirripedia and Voyage Round the World).

Forbes, E. Natural History of European Seas.

Graaf, L. von. Das Genus *Myzostoma*. 4to. Leipzig, 1877.

Grenacher, H. Untersuchungen über das Sehorgan der Arthropoden. 4to. Göttingen, 1879.

Haeckel, E. Die Radiolarien. Berlin, 1862.

„ Zur Entwickelungsgeschichte der Siphonophoren. Utrecht, 1869.

Haeckel, E. Die Kalkschwämme. 3 vols. Berlin, 1872.

Heller, C. Die Zoophyten und Echinodermen des Adriatischen Meeres. Wien, 1868.

Hertwig, O. and R. Der Organismus der Medusen.

„ „ Das Nervensystem und die Sinnesorgane der Medusen.

Hertwig, O. and R. Studien zur Blättertheorie.

Hertwig, R. Der Organismus der Radiolarien.

Hudson and Gosse. The Rotifera.

Huxley, T. H. Works of.

Jeffreys (John Gwyn). British Conchology. 5 vols.

Kent, W. Saville. Manual of the Infusoria.

Kleinenberg, N. Hydra. Eine Anatomisch-Entwicklungsgeschichtliche Untersuchung.

Leidy, J. Fresh-water Rhizopods of North America.

Lilljeborg. Sverig o Norg Fiske. 3 vols.

Linnæus. Systema Naturae.

Middendorff, A. T. Reise in den äussersten Norden und Osten Siberiens während der Jahre 1843–44.

Möbius, K. Fauna der Kieler Bucht.

"Novara." Reise der österreichischen Fregatte *Novara* um die Erde in den Jahren 1857, 1858, and 1859.
Fische. R. Kner. (1865–67.)
Mollusken. G. von Frauenfeld.
Anneliden. E. Grube.

Sars, G. O. On some remarkable forms of Animal Life from the great deeps off the Norwegian coast. 2 parts. Christiania, 1872–75.

Selenka, E. Zoologische Studien. Leipzig, 1878–81.

„ Studien über Entwickelungsgeschichte der Thiere. Hefte I.–IV. Wiesbaden, 1883–86.

Semper, C. Reisen im Archipel der Philippinen. Wissensch. Resultate. 4to. Leipzig, 1868-86. Bände. I.–V.

Sladen and Duncan. Echinodermata of the Arctic Sea to the W. of Greenland.

Smitt. Edition of Fries and Ekström's Skandinavian Fishes.

Thomson, C. Wyville. The Depths of the Sea.

Tizard and Murray. Exploration of the Faröe Channel during the Summer of 1880.

Vogt, C. Crustacés Parasites des Poissons. Genève, 1879.

Webb and Berthelott. Histoire Naturelle des Iles Canaries. Vol. ii. Zoology. Paris, 1836–44.

Inspection of the Laboratory.

The Laboratory was visited and inspected on June 26th and 27th by a Committee appointed by the Council for that purpose, and the following report was submitted to the Council at the meeting held on June 29th :—

"The Committee, consisting of the President and Mr. Beddard, arrived in Plymouth on Saturday, June 26th. They visited the laboratories, engine-rooms, tank-room, library, and museum on both Saturday and Sunday. By the President's invitation, they were joined at Plymouth by Mr. John Enys, of Enys, near Falmouth, a member of the Association.

"The Committee report in the first place that the satisfactory standard of general efficiency noted last year has been fully maintained. The place is in excellent condition, clean and orderly, and the servants are well in hand.

"The large laboratory has been provided with a new flat tank, eight feet by five feet and eight inches deep, by aid of which Mr. Garstang has been carrying on some observations on the habits of Brachyurous Crustacea. The sea-water supplied to the laboratory is still kept distinct from the general circulation in the show tanks, and is never returned to the laboratory tanks after it has passed through them. We are of opinion that this is the only satisfactory system for maintaining marine organisms in a really healthy condition in confinement, the whole theory of 'circulation' being illusory and in practice disastrous.

"The lecture-room is in good order, and has proved to be very useful and well fitted for its purpose.

"The collection of local types in the museum has progressed. Mr. Holt has named and rearranged the collection of fishes, and the Echinoderms and Polyzoa have been completed.

"Smith continues, under Mr. Allen's direction, to carry out the preservation and storage of specimens for sale according to the best methods. There is a marked improvement in this matter as compared with the period preceding 1896.

"The library is in good order. A number of books have been bound, but it would be a great advantage were it possible to spend more money on this department. All the chief zoological periodicals and both British and foreign reports on fishery investigations are on our shelves, besides most of the valuable and costly monographs on marine organisms. The total number of volumes is about 1500. We recommend that the series of *Nature* be bound at once.

"The engines and machinery appear to be in excellent order.

"Since last year a considerable improvement has been obtained in the appearance of the water circulating in the show tanks. This appears to be chiefly due to an ingeniously devised filter fitted by Mr. Allen so as to pass all the water on its return from the tanks to the reservoir. The Committee had an opportunity of observing how large an amount of floating organic matter is thus removed in the space of five hours. No chemical analyses of the water have been made during the past year, and the Committee have directed Mr. Allen to procure such analyses with a view to determining the amount of organic and inorganic nitrogen now present.

"The Committee were pleased to note this year that the tanks were very abundantly stocked with a variety of interesting animals, invertebrates as well as fishes. There is no doubt that there is at Plymouth an abundant supply of forms, which become every year more easily obtained owing to the increased experience of the Director and his fishermen. For instance, the interesting Chaetopod, *Chaetopterus*, is now in the tanks, and is not unfrequently fished. Owing to the use of the large trawl with the steam winch, a larger and more varied supply of animals is obtained.

"Mr. Allen has removed the glass front from one of the tanks in the show-room and converted it into a shallow tank, with the advantage that the animals in it are much more easily observed than when seen through the glass side. This alteration might perhaps be extended with advantage to other tanks.

"The Committee inspected the steam launch *Busy Bee* on the afternoon of the 27th, and especially examined the steam winch. Everything was in excellent order.

(Signed) "E. Ray Lankester, *President*.
"F. E. Beddard."

Report of the Council, 1896–97.

The Council and Officers.

Four ordinary meetings of the Council have been held, at which the average attendance has been eight. The Plymouth Laboratory was visited and inspected by a committee appointed by the Council on June 26th.

The Council has heard with great regret from Mr. E. L. Beckwith that he feels compelled, owing to declining health, to resign the office of Honorary Treasurer, the duties of which he has carried out with such advantage to the Association during the last eight years. The Council is glad to know that it will still have Mr. Beckwith's advice and assistance as a Governor of the Association, representing the Fishmongers' Company.

The Council proposes Mr. John Amory Travers, a Warden of the Fishmongers' Company, for election as Honorary Treasurer in succession to Mr. Beckwith.

The thanks of the Council are again due to the Royal Society for allowing the meetings of the Association to be held in their rooms.

The Plymouth Laboratory.

The buildings, fittings, and machinery of the Laboratory have been maintained in good condition. The only repairs of importance which have been necessary have been in connection with the renewal of a considerable portion of the sea-water supply pipe, which was destroyed by the stranding of the s.s. *Ariel* on the rocks below the Laboratory in December. The expenses of these repairs have been met by the owners of the vessel.

The Boats.

The *Busy Bee* has been working continuously and successfully during the year, and has proved a valuable addition to the equipment of the Laboratory. She has recently been fitted with a strong steam winch, which has greatly added to her efficiency for trawling work.

The sailing boat *Anton Dohrn* has also been used from time to time for collecting-work in Plymouth Sound.

The Staff.

Mr. J. T. Cunningham has left the service of the Association during the year, and has been appointed Lecturer to the Technical Education Committee of the Cornwall County Council.

Mr. F. B. Stead, who had been working at fishery problems at Plymouth, having resigned his position as Assistant Naturalist, Mr. W. Garstang has been appointed Naturalist in charge of the fishery investigations of the Association. Owing to the increased expenditure in connection with our fishery work which is involved in this change, the Council has found it impossible to renew Mr. T. V. Hodgson's appointment as Director's Assistant for the coming year.

Mr. E. W. L. Holt, having offered his services to the Association, has been appointed an Honorary Naturalist on the staff, and will be engaged in investigations connected with the life histories and distribution of fishes.

The Library.

The list of periodicals regularly purchased for the Library has been increased by the addition of the *Journal of Morphology*, the *Archiv für Mikroskopische Anatomie*, and the *Archiv für Entwickelungsmechanik*.

Prof. Gustav Retzius has presented the Association with copies of his valuable publications, *Biologische Untersuchungen*, Neue-Folge, which deal chiefly with the histological structure of the nervous system. The thanks of the Council are also due to the Royal Society, the Zoological Society, the Royal Microscopical Society, the United States Commissioner of Fish and Fisheries, and many other societies and individuals, for copies of their publications.

General Report.

Mr. Cunningham's book on the *Natural History of the Marketable Marine Fishes of the British Islands* was published in the autumn by Messrs. Macmillan and Co. The work has met with a most favourable reception from the press, and appears to meet a popular want.

During the summer and autumn of 1896 Mr. Cunningham continued his researches on the distribution of flat-fishes in the North Sea, paying particular attention to the relations which exist between the physical and biological conditions in that area, and also to the peculiarities of the fish which live upon the different fishing grounds. The results of these observations are contained in two memoirs published in the Journal of the Association. A memoir by Mr. Cunningham dealing with the minute structure and the development of the ovaries of fishes has appeared in the *Quarterly Journal of Microscopical Science.*

The trawling experiments in the bays on the south coast of Devon, which were commenced last year, have been continued and extended by the special request of the Devon Sea Fisheries Committee, who have contributed towards the expenses of this undertaking. At the same time a general study of the distribution of young fish in the neighbourhood has been undertaken, and Mr. Holt has recently been paying particular attention to this enquiry.

Experiments with floating bottles, similar to those carried out by Prof. Herdman in the Irish Sea and by the Scottish Fishery Board in the North Sea, for the purpose of determining the general direction of the surface drift of the water in the English Channel at different times of the year, have been commenced. Bottles put into the sea near the Eddystone during January and February were carried for the most part up Channel, some having passed through the Straits of Dover and been found at Terschelling and Borkum, off the Dutch and German coasts respectively.

The detailed investigation of the grounds between the Eddystone and Start Point, mentioned in last year's Report, was continued during the summer of 1896, and the results are for the most part worked out. It is intended, however, to go over the ground carefully again this year before these results are published.

In promising to place on the estimates for the year 1897–98 the usual grant of £1000 to the Association, the Lords Commissioners of H.M. Treasury have made it a condition that the Association will give all the assistance in its power to the Inspectors of Irish Fisheries in investigations which they desire to be made on the habits and migrations of the mackerel visiting the Irish coast. In connection with this subject a report has been prepared and transmitted to the Inspectors of Irish Fisheries on the present state of knowledge with regard to the natural history of the mackerel, and arrangements are being made for samples of the mackerel taken on the west coast of Ireland to be sent to the Plymouth Laboratory for examination.

Occupation of Tables.

The following naturalists have been engaged in research work at the Plymouth Laboratory during the year:—

J. E. Barnard, British Institute of Preventive Medicine (Phosphorescent Bacteria).
T. Beer, Ph.D., Vienna (Sense Organs of Crustacea).
G. Brebner, University College, Bristol (Marine Algæ).
E. Brumpt, Paris (General Zoology).
A. H. Church, B.A , Oxford (Marine Algæ).
Prof. P. T. Cleve, Ph.D., Upsala (Diatomaceæ).
Miss M. C. Colcutt, University College, London (Hydrozoa).
W. Garstang, M.A., Oxford (Marine Bionomics).
E. S. Goodrich, B.A., Oxford (Holothurians).
S. F. Harmer, M.A., Cambridge (Polyzoa).
E. W. L. Holt (Distribution of Fishes).
C. A. MacMunn, M.D. (Blood of Fishes and Invertebrates).
K. R. Menon, B.A., Cambridge (Nervous System of Mollusca).
J. Parkinson, B.Sc., University College, London (Ascidians).
T. H. Riches, B.A., Cambridge (Nemertines).
S. D. Scott, B.A., Cambridge (Ascidians).
R. Shelford, B.A., Yorkshire College, Leeds (General Zoology).
S. Watasé, Ph.D., Chicago (Phosphorescence).
Prof. Weldon, F.R.S., University College, London (Variation of Crabs).

Vacation classes in Marine Biology for advanced University students have again been conducted by Mr. Garstang, and have been very successful. These classes have been attended by sixteen students.

Published Memoirs.

Amongst the papers, either wholly or in part the outcome of work done at the Laboratory, which have appeared elsewhere than in the Journal of the Association, are the following:—

Allen, E. J.—*Studies on the Nervous System of Crustacea*, IV. *Further Observations on the Nerve Elements of the Embryonic Lobster.* Quart. Journ. Micr. Sci. vol. xxxix. p. 33.

Bassett-Smith, P. W. — *Notes on the Parasitic Copepoda of Fish obtained at Plymouth, with descriptions of New Species.* Ann. and Mag. Nat. Hist. (6) vol. xviii. pp. 8–16.

Bethe, A.—*Ein Carcinus maenas (Taschenkrebs) mit einem rechten Schreitbein an der linken Seite des Abdomens. Ein Beitrag zur Vererbungstheorie.* Arch. Entwick. mech. iii. p. 301.

Browne, E. T.—*On British Hydroids and Medusæ.* Proceed. Zool. Soc. London, 1896, Pt. ii. p. 459.

Cunningham, J. T.—*On the Histology of the Ovary and of the Ovarian Ova in certain Marine Fishes.* Quart. Journ. Micr. Sci. N.S. vol. xl. pp. 101–163.

Garstang, W.—*On the Aplacophorous Amphineura of British Seas.* Proc. Malacol. Soc. ii. Oct. 1896.

Garstang, W.—*On the Function of certain Diagnostic Characters of Decapod Crustacea.* British Association Report, Liverpool, 1896.

Nutting, C. C.—*Notes on Plymouth Hydroids.* Bull. Lab. Nat. Hist. Iowa, vol. iv. No. 1.

Donations and Receipts.

The Receipts for the year include the Annual Grants from H.M. Treasury (£1000) and the Worshipful Company of Fishmongers (£400), Annual Subscriptions (£122), Rent of Tables in the Laboratory (£68), Sale of Specimens (£287), and admission to the Aquarium (£67). Towards the fund for the payment of the purchase money of the *Busy Bee* donations amounting to £213 19s. 0d. have been received during the year, the fund now amounting in all to £537 14s. 0d. In order to meet the deficit due to the purchase and fitting out of the *Busy Bee*, and to the fact that the work in the North Sea was continued for six months after the special donation for that purpose had ceased, £170 Forth Bridge stock held by the Association has been sold, and has realised £251 15s. 3d. The total receipts for the year (exclusive of sale of stock) amount to £2203 6s. 4d.

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1896–97:—

President.

Prof. E. Ray Lankester, LL.D., F.R.S.

Vice-Presidents.

The Duke of Argyll, K.G., K.T., F.R.S.
The Duke of Abercorn, K.G., C.B.
The Earl of St. Germans.
The Earl of Morley.
The Earl of Ducie, F.R.S.
The Right Hon. Lord Tweedmouth.
Lord Walsingham, F.R.S.
The Right Hon. A. J. Balfour, M.P., F.R.S.
The Right Hon. Joseph Chamberlain, M.P.
The Right Hon. Sir John Lubbock, Bart., M.P., F.R.S.
Prof. G. J. Allman, F.R.S.
Sir Edward Birkbeck, Bart.
Sir Wm. Flower, K.C.B., F.R.S.
A. C. L. Günther, Esq., F.R.S.
Prof. Alfred Newton, F.R.S.
Rev. Canon Norman, D.C.L., F.R.S.
Sir Henry Thompson.
Rear-Admiral Sir W. J. L. Wharton, K.C.B., F.R.S.

Elected Members.

F. E. Beddard, Esq., F.R.S.
Prof. F. Jeffrey Bell, F.Z.S.
G. C. Bourne, Esq., F.L.S.
Sir John Evans, K.C.B., Treas. R.S.
G. Herbert Fowler, Esq.
S. F. Harmer, Esq.
Prof. W. A. Herdman, F.R.S.
Prof. S. J. Hickson, F.R.S.
J. J. Lister, Esq.
John Murray, Esq., F.R.S.
P. L. Sclater, Esq., F.R.S., Sec. Z.S.
D. H. Scott, Esq., F.R.S.
Prof. Charles Stewart, F.R.S.
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. Burdon Sanderson, F.R.S. (Oxford University).
Prof. Michael Foster, F.R.S. (Cambridge University).
Sir William Flower, K.C.B., F.R.S. (Brit. Assoc. for Advmnt. of Science).

Dr. *Statement of Receipts and Expenditure for the Year ending 31st May, 1897.* *Cr.*

Receipts.	£	s.	d.	£	s.	d.
To H.M. Treasury				1000	0	0
,, Fishmongers' Company				400	0	0
,, Special Donations—						
Royal Society	100	0	0			
Grocers' Company	50	0	0			
Skinners' Company	21	0	0			
E. L. Beckwith	5	5	0			
E. S. Heywood	5	5	0			
Earl of St. Germans	5	0	0			
G. Fry	5	0	0			
J. Mackrell	5	0	0			
R. Assheton	5	0	0			
E. Grove	3	0	0			
A. O. Walker	2	2	0			
S. F. Harmer	2	2	0			
W. H. St. Quintin	2	2	0			
S. Makovski	2	2	0			
W. I. Beaumont	1	1	0			
				213	19	0
,, Annual Subscriptions				121	16	0
,, Rent of Tables	68	11	0			
,, Sale of Specimens	287	8	6			
,, Sale of *Journal*	18	5	5			
,, Admission to Tank Room	67	8	3			
				441	13	2
,, Interest on Investment				25	18	2
,, Sale of Forth Bridge Stock, £170 4 % Guaranteed Stock				251	15	3
				£2455	1	7

Examined and found correct,
EDWIN WATERHOUSE,
F. E. BEDDARD,
STEPHEN E. SPRING RICE,
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,, Salaries and Wages—									
Director				200	0	0			
,, allowance for Assistance				100	0	0			
Naturalist				169	9	0			
Assistant Naturalist				75	0	0			
Wages				490	12	10			
							1035	1	10
,, Stationery, Office Printing, Postages, &c.							167	16	7
,, Printing and Illustrating *Journal*							81	9	3
,, Purchase of Steam Winch							69	18	6
,, Sundry Expenses—									
Gas, Water, Coal, Oil, &c.				101	4	7			
Coal and Water for Steamer				29	6	6			
Insurance of Steamer				12	7	6			
Stocking Tanks, Feeding, &c.				62	3	6			
Glass, Chemicals, Apparatus, &c.	£137	18	9						
Less Sales of Glass	16	6	5						
				121	12	4			
Maintenance and Renewals of Buildings, Boats, and Nets	£225	8	6						
Less Sales of Nets and Gear	17	5	9						
				208	2	9			
Rates and Taxes				4	6	2			
Boat Hire				18	2	1			
Travelling Expenses				37	8	1			
Expenses of Exhibition of Specimens				25	9	6			
Library				65	1	1			
North Sea Investigation				10	10	0			
							695	14	1
,, Interest on Overdraft							4	19	9
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OBJECTS

OF THE

Marine Biological Association of the United Kingdom.

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

The late Professor HUXLEY, at that time President of the Royal Society, took the chair, and amongst the speakers in support of the project were the Duke of ARGYLL, Sir LYON PLAYFAIR, Sir JOHN LUBBOCK, Sir JOSEPH HOOKER, the late Dr. CARPENTER, Dr. GUNTHER, 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 £29,000, of which £13,000 has been granted by the Treasury. The annual revenue which can be at present counted on is about £1,820, of which £1,000 a year is granted by the Treasury, the remainder being principally made up in Subscriptions.

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

The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

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

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Notes on the Reproduction of Teleostean Fishes in the South-Western District.

By

Ernest W. L. Holt.

THESE notes are intended to be explanatory of the record of tow-net stages of Teleosteans kept by Mr. S. D. Scott and myself. Although my own name appears alone under the title, it must be understood that the observations were in the sole charge of Mr. Scott until the beginning of March. The record of the 5th April is also Mr. Scott's. The rest were kept by myself. The credit of any scientific result that may accrue from the observations previous to the 30th March belongs therefore solely to Mr. Scott, since his notes and figures are so complete as to render my own share of this part of the work a very simple one.

This journal is not designed for the publication of such profusely illustrated papers as are best suited for the explanation of the earliest stages of Teleosteans. It so happens that in the present instance I am able in most cases to refer either to figures already published, or to others now in the press. A series of notes made at Professor Marion's laboratory at Endoûme, Marseilles, was prepared for the press during 1897. Observations made at Plymouth during the same period were found to have an obvious bearing on the subject-matter of my researches at Marseilles, and by the generous permission of Professor Marion I have been allowed to include in a paper shortly to be published in the *Annales du Musée de Marseille** a number of drawings made from Plymouth specimens. I am therefore able in many instances to eke out somewhat inadequate descriptions by references to figures in the *Annales.*

The subjoined notes on the reproduction of different species call for no introductory remarks; but one feature which has not, as I believe, been hitherto noticed, appears to require a little attention. That the largest fish are the earliest spawners is, as I imagine, the general

* "Sur La Reproduction des Poissons osseux, surtout dans le Golfe de Marseille," *loc. cit.*, v., Fasc. II., 1898.

experience of those who have had occasion to examine spawning fish; but that the larger fish of a species lay the larger eggs is a proposition which I have not seen in print, at least as regards marine forms. I am led to believe that this is the case from measurements of the ova of several species during successive months, both at Plymouth and Marseilles. My observations are at present of a sporadic nature, and suggestive rather than conclusive. I hope to continue them during the present year in a more methodical manner. I have previously alluded to the experience of the late Sir J. Gibson-Maitland, to the effect that among the Salmonidæ the larger parents of a species give rise to the larger eggs, from which alone, speaking generally, offspring of large potential size can be procured. If, as my experience leads me to expect, the same relation of size of egg to size of parent holds good for marine fishes or for some of them, it is not unreasonable to suspect that the young derived from the smaller and later spawned eggs are, like their representatives among the Salmonidæ, of little account in the up-keep of specimens of large size. The question has obviously a most important bearing on measures that may be adopted for the preservation of our marine fisheries. I have been myself an enthusiastic advocate of the protection of immature fishes; but if the contention which I now advance holds good, it must be recognised that this measure will not alone secure an abundance of large specimens. It cannot, by itself, go further than to protect fish until the period at which they become capable of producing offspring incapable for the most part of attaining a respectable size. That over-fishing results, whether in a river or at sea, not so much in the reduction of the numbers of a species as in a diminution of fine specimens, if not entirely a matter of common knowledge, has, at any rate, been pointed out by Herdman some years ago (*Trans. Liv. Biol. Assoc.*, vii., 1892, p. 121). Its explanation seems to be that though many fish survive to the first breeding season, comparatively few reach a size at which they are capable of producing vigorous and potentially large offspring. The proposition, if applied to domestic stock, would be by no means startling to breeders. In the case of fish I suspect that there may be found a certain correspondence between the size of the adolescent fish at spawning and the average potential size of its offspring. It may, perhaps, be reasonably suspected that the rate of growth of the offspring of small parents differs considerably from that of the young of large specimens; a condition which, however difficult to tabulate, furnishes some clue to the extraordinary variation in this respect, which must be familiar to everyone who has endeavoured to understand the apparent anomalies of the sizes of young fish taken in company.

I do not propose to discuss, except incidentally, the developmental habitat of the species dealt with, these notes being only designed to assist in the determination of the young stages. A word is necessary with regard to the references given under various species to M'Intosh and Masterman's *Life Histories of British Fishes.* This book conveniently summarises the numerous and important observations of Professor M'Intosh, which appeared originally in a great number of papers in the Scottish Fishery Board reports and elsewhere; it may also be taken as setting forth his most recent opinion on matters of doubt. I have therefore referred to it in preference to the original papers.

Trigla lineata. *Gm. Linn.* Polperro bull-dog, Parrot gurnard.

The Polperro bull-dog, as it is generally called at Plymouth, is one of the commonest gurnards of the district. It frequents the rather deep water from a few miles beyond the Breakwater outwards, though I have known it to be taken on one occasion in Cawsand Bay. The young stages have not been found in the estuary or inshore waters, and I do not think that we have ever taken the ova in tow-nets. It therefore spawns in all probability on off-shore grounds, and apparently towards the end of the summer. A female taken on the 31st July, 1897, proved to be nearly ready to spawn, since the ovaries contained a few translucent eggs. Artificial fertilisation was attempted. After the lapse of an hour and thirty-five minutes three eggs were still floating. One had reached the two-cell stage, the others may or may not have been impregnated.

These eggs measure from 1·29 to 1·33 mm. in diameter. The single dark, but not conspicuously coloured oil-globule measures, in all three cases, ·24 mm. The zona is strongly ridged, but this is probably an ovarian character. The ova were all dead on the following day.

Trigla hirundo. *Bloch.* Tub (Plymouth), Latchett (North Sea).

? Marion, A. F., *Annales Mus. Mars.*, iv., 1891, I., p. 120, Pl. II., Fig. 10. *Early larva.*

Holt, E. W. L., *Ann. Mus. Mars.*, v., Fasc. II., 1898. *Tow-net egg, larva, young pelagic form.*

The Tub is the most economically important gurnard of the Plymouth district; but, although young specimens are common throughout the year, the adults appear to leave the grounds near Plymouth before the breeding season. I have never had an opportunity of submitting ova, obtained directly from the parent, to exact observation. Speaking rather generally, I can say that spawning takes place in the summer or early autumn.

Trigloid ova obtained at Marseilles by Marion, and subsequently by myself, appear, from local considerations, to be referable to this species. The only two which I observed measured 1·25 and 1·36 mm. in diameter, with a single oil-globule of ·26 and ·28 mm. The characters of the larva, according to my notes, cannot be stated in such a way as to clearly distinguish the species from either *T. gurnardus* or *T. pini*, and I suspect that all gurnards are practically identical in conformation and pigment in the vitelligerous condition.

Since the tub attains a large size in the Mediterranean I suppose that the dimensions of ova taken in that district may be of some service in the determination of Plymouth tow-net material. I have therefore assigned with due reserve to this species a Trigloid egg taken between the Eddystone and Hand deeps on the 27th July. It measures 1·35 mm. in diameter, with an oil-globule of ·28 mm. It is chiefly the large size of the globule that inclines me to refer it to the tub rather than to the Polperro bull-dog.

Only two species of gurnard, viz., the tub and the grey gurnard, *T. gurnardus*, appear to make their way into the Plymouth estuary. Neither of them would appear to breed to any great extent in the neighbourhood, yet the young of the season appear in some numbers in the river in the autumn and winter. I do not propose to discuss the matter here, but will merely remark that the *Trigla nigripes* of Malm is certainly the young of *T. hirundo*. Smitt, who gives (*Hist. Scand. Fish.*, Ed. ii., 1895, I) a figure of one of Malm's specimens, seems to incline to the same view; but makes a reservation to the effect that (1) the fin-rays of *T. nigripes* may increase in number in the further development of the individual, so as to bring it in harmony with some species other than *T. hirundo;* (2) the ossicles of the lateral line of *T. nigripes* are not present in the adult.

Malm's specimen is about 20 mm. long. Plymouth examples of about 30 mm. agree equally well in fin-ray formula with *T. hirundo,* so that it seems probable no increase of fin-rays takes place. The double row of lateral-line ossicles is quite distinct from the single row of much stouter bony structures in a *T. gurnardus* which is only a little larger than the young *T. hirundo.*

It appears from Smitt's remarks that the Scandinavian naturalists have found a difficulty in associating *T. nigripes* with *T. hirundo* on account of the rarity of the latter. But the Tub or Latchett is not rare on the Danish coast in summer, and the drift of the surface water has been shown by Fulton to pass, under certain conditions of wind, from the Danish to the Scandinavian coast. The young *T. hirundo* seems to have a longer pelagic existence than other gurnards, since a specimen of about 30 mm. has been taken during 1897 at the surface,* while there is no record, that I know of, of the occurrence of any other species at the surface at such an advanced stage of development.† The Bohüslan examples of *T. nigripes* may therefore be derived, in all probability, from North Sea parents rather than from the few adults of the Norwegian coast.

Callionymus lyra. *Linn.* Dragonet, Skulpin, Sting-fish.

M'Intosh, W. C., *Ann. Nat. Hist.*, 1885, p. 480. *Ovarian egg.*
Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 442, Pl. LI. *Egg and larva of C. lyra or C. maculatus.*
Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., ii., 1891, p. 89, Pl. V. *Egg and larva.*
Prince, E. E., *Ninth Ann. Rep. S.F.B.*, 1891, p. 349, Pl. XIII. *Egg and larva.*
Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., 1893, p. 36, Pl. III. *Egg, larva, metamorphosing stages.*

Mr. Scott's observations show that the dragonet begins to spawn in January. It is one of the commonest fishes in the Plymouth district, and I think that our records show that the eggs are deposited, in some instances, in or near the Sound, as well as out towards the Eddystone, which seems to be one of the chief haunts of the larger members of the species.

The other British member of the genus, *C. maculatus*, has only recently been found on the south-west coast, one specimen having been trawled in Falmouth Bay and another off the Plymouth Mewstone. It is probable that the two species lay eggs which closely resemble each other, but as *C. lyra* is a far larger form than *C. maculatus*, I imagine that a corresponding difference holds good with regard to the ovarian products. I have been able to assign a Mediterranean tow-net egg, with a reasonable degree of probability, to *C. maculatus*. It is ·73 mm. in diameter, and the early larva is quite destitute of black pigment. The zona radiata resembles that of *C. lyra*, but the latter species is extremely rare at Marseilles.

In the first description which I gave of the larva of *C. lyra*, from the Irish coast, I omitted all mention of black chromatophores, having failed to observe any. The correctness of my description in this respect was challenged independently by Cunningham and Prince, while I myself had noticed black pigment in embryos of *C. lyra* before the papers referred to appeared. A re-examination of the only preserved specimen of those on which I had based my first description,

* In July, exact date not recorded: another was seen about the same time.

† I am not speaking of large specimens. I have been credibly informed of instances of a large gurnard pursuing smaller fish at the surface. As a matter of fact the only species identified was *T. hirundo.*

substantially bore out its correctness, and, on making acquaintance with the Mediterranean egg which probably belongs to *C. maculatus*, I concluded that I must really have been dealing with that species. *C. maculatus* is apparently not very rare on the Irish coast, and I had not measured the eggs from which my first Irish larvæ were hatched.

However, it is a fact that black pigment is not invariably present in the early larva of *C. lyra*. In examining a drawing made by Mr. Scott in January from a larva a few hours old, I noticed that no black chromatophores were shown. The specimen was again examined by Mr. Scott and by myself, and the drawing proved to be correct. The egg from which the larva was hatched measured ·90 mm. in diameter, and belonged without any doubt to *C. lyra*. The absence of black pigment must, nevertheless, be regarded as exceptional, since I was careful to examine all subsequent ova of Callionymus, and in all cases the embryo or larva exhibited some black chromatophores.

I think that without much doubt all the ova we obtained are those of *C. lyra*, since the difference in size observed seems to be roughly in accord with the date, though by no means all the eggs obtained were measured. The sizes run as follows:—January, ·90; February, ·83; March, ·91 and ·92; April, no observations; May, ·78 to ·84. I hope that it may be possible during 1898 to pay more continuous attention to the subject.

Scomber scomber. *Linn.* Mackerel.

? Agassiz and Whitman, *Mem. Mus. Comp. Zool. Harv.*, xiv., 1885, p. 36, Pl. XVII. *Unidentified Sp.* 10, *in part.*

Cunningham, J. T., *Journ. M.B. Assoc.*, N.S., i., 1889, p. 25, Pls. III., IV. *Egg.*

Cunningham, J. T., *ibid.*, N.S., ii., 1891, p. 71, Pl. IV. *Vitelligerous larva.*

Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., v., 1893, p. 10, Pl. I. *Egg, vitelligerous stages of larva.*

Holt, E. W. L., *Journ. M.B. Assoc.*, N.S., ii., 1892, p. 396. *Late larval stages.*

Holt, E. W. L., *Ann. Mus. Marseille*, 1898, *Sp.* I., *egg and larva referred to Mediterranean mackerel.*

Young stages of the mackerel are conspicuously absent from our tow-net records for 1897, although the fish was common enough in the neighbourhood in June. The spawning period is protracted at least as late as that month, and the eggs and larvæ are quite familiar to me. I must therefore conclude that little if any spawning took place on the grounds over which the tow-nets were worked, or at any point close to them. It will be observed that our expeditions did not extend beyond four or five miles off the Mewstone in the early part of the month, while during the latter part of May the *Busy Bee* was occupied in the bays east of the Start.

It is a matter of common knowledge that Mediterranean mackerel are much smaller than their Atlantic brethren. I believe that certain pelagic ova which I found at Marseilles in 1895 belong to the local variety of the species. They are smaller than those of mackerel from the British coasts, which is not remarkable. The larva, however, while closely resembling that of an Atlantic mackerel (*vide* Cunningham, Holt, *op. cit.*), differs from it in having an additional patch of yellow pigment in the middle of the tail. So far as my experience goes this patch is always present in the larva, so that, if it is really a mackerel, the Mediterranean race of the species shows a distinctive character at the very earliest stage. I have already noted that the unknown egg, Sp. 10, of Agassiz and Whitman, strongly resembles that of the mackerel. If this egg is rightly associated with the tow-net larvæ figured on the same plate, it would appear that the American race also differs in larval pigment from the British. The authors, however, do not insist upon the identity of the egg and larvæ, and the younger larva figured appears to be distinct. The older larva bears a much closer resemblance to the British form.

Some years ago I gave a brief description of some young mackerel taken in the eastern part of the North Sea (*vide* Journal, N.S., ii., 1892, p. 396). So far as I know they are the only specimens which have come under the notice of a naturalist, and it appears advisable to give a somewhat fuller account of them.

Including all my material, the details of locality and date are as follows:—

9th July, 1892, 20 to 22 mi. N.N.E. of Horn Reef, Denmark.
12 specimens, 6 to 9·5 mm.

23rd July, 1892, 250 mi. E., ½ N. of Spurn Head.
2 specimens, 14 and 19 mm. *ca.*

27th and 28th July, 1892, "Clay Deep," 150 mi. E. by N. of Spurn Head.
3 specimens, 13·5 to 19·25 mm.

The bearings are magnetic, and it will be seen from the map at the end of vol. iii. of this journal that all the specimens were taken between the Dogger Bank and the Danish and German coasts, and at considerable distances from land. The capture was effected by means of a ring tow-net of mosquito mesh, towed at the surface by a steam-trawler while trawling. As the strain was often sufficient to burst the net, it may be imagined that the smaller specimens suffered considerably.

Indeed, with regard to the smallest specimens, it can only be said that they agree in pigmentation with mackerel larvæ reared from the egg. A specimen of 7 mm. is fairly well preserved, at least on one side, and while agreeing in pigment and conformation with the smallest it can clearly be associated with the older forms, which, though incompletely metamorphosed, are quite recognisable by the characters of the adult.

The specimen of 7 mm. (Fig. 1) is in its present state of preservation somewhat laterally compressed; the abdomen projects boldly below the plane of the ventral contour of the caudal part of the trunk. The pre-anal region, exclusive of the lower jaw, occupies two-fifths of the total length. The snout is pointed, the lower jaw the longer, and both jaws bear a single series of large recurved and rather widely set teeth. The eye measures rather more than one-third of the length of the head. The post-anal region is still elongate and rather slender, though markedly deeper than in the vitelligerous stages; its extremity is slightly upturned by a trilobate hypural mass, beset with developing rays, and similar rays are also present dorsally. The marginal fins are mostly frayed away; the pectorals, also in bad condition, seem to have been of moderate size. The eye, noted at the time of capture to be blue, is now a dense black; a patch of black chromatophores is present on the top of the head, probably in the pia mater, and the roof of the peritoneum (and in part its sides) is beset with black chromatophores. From a short distance behind the anal region dorsal and ventral rows of black chromatophores run back as far as the caudal peduncle, and a few small black specks are present hypurally. Yellow pigment was not observed at the time of capture; it would not in any case be visible in the preserved condition, unless very profuse or in large corpuscles.

Allowing for the difference in age, the specimen of 7 mm. agrees in all respects with the late vitelligerous stage shown in Pl. I., Fig. 7, of my Irish paper. This figure was drawn from a larva of nine days, 4·88 mm. in length. With regard to the pigment the two specimens are practically identical.

Another specimen (Fig. 2) in fairly good preservation is 9·5 mm. long. The pre-anal region is still shorter than the post-anal part, but the distance between the anus and the tip of the urochord only exceeds the pre-anal length by less than one-eighth of the latter. The ventral contour of the abdomen is much less abrupt, though its hinder part still projects somewhat from the caudal part of the trunk. The pointed snout is nearly as long as the eye; both jaws have teeth as in the preceding stage, but relatively smaller. The tail of a larval fish of some sort protrudes from the mouth, while the head can be detected far back in the abdomen.

The metamorphosis of the tail (of the mackerel larva) is advanced,

G. 1. Young Mackerel. Specimen 7 mm. long × 8.

Fig. 2. Young Mackerel. Specimen 9·5 mm. long × 8.

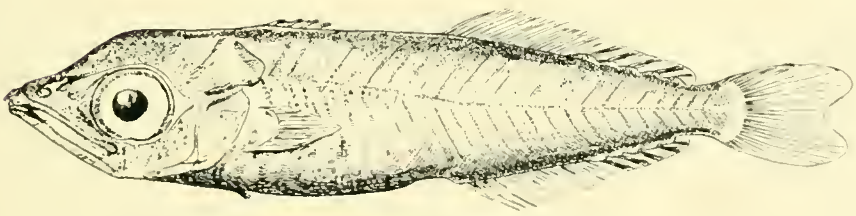

Fig. 3. Young Mackerel. Specimen 14 mm. long × 6.

Fig. 4. Young Mackerel. Specimen 18 mm. long × 6.

the urochord with its embryonic rays being boldly thrust upwards by the hypural mass, the margin of which is still oblique. The caudal part of the trunk is most elevated at about half-way from the anal region to the caudal peduncle; on the slightly salient dorsal and ventral edges appear the interspinous ridges of the future second dorsal and anal fins. Each ridge (dorsal and anal) is continuous, but while the basal lobes of the anterior part are closely crowded together the most posterior of the series appear as rather widely separate nodules, or elevations of the crest of the ridge. Five of these isolated crests, the bases of the future finlets, can be counted on the dorsum. The anal fin region is not so well preserved. The ridges terminate at a point considerably anterior to the caudal fin. The embryonic marginal fin is continuous, but much collapsed in the present state of the specimen. A slight dorsal ridge about half-way from the shoulder to the level of the anus perhaps represents the first dorsal, but is by no means distinct. The black pigment is very similar in distribution to the last stage; but the dorsal post-anal chromatophores are larger and more numerous, forming a practically continuous line on either side of the ridge of the second dorsal and its finlets.

A badly-preserved specimen of about 13 mm. differs from the last chiefly in the greater length and more pointed contour of the snout, and in the elongation of the abdominal region. It forms a transitional stage to the more advanced condition shown in Figures 3 and 4. Fig. 3 is drawn from an example about 14 mm. in length, viewed as an opaque object; it is somewhat shorter and deeper than the specimen of about 18 mm. shown in Fig. 4, but the stage of development seems to be about the same. The bones of the head are well defined. There are no cephalic spines, but a strong longitudinal ridge at the upper extremity of the gill-cover may represent a part of the spinous armature of the young *Naucrates*. The outline of the head in Fig. 3 is probably unnatural, since three out of four specimens at about the same stage have the convex antero-superior profile of Fig. 4. The jaws are sub-equal, but the upper projects slightly, and is furnished with a pair of hooked teeth quite outside the gape. The general conformation can be gathered from the figures, the body being laterally compressed, but not more so than usual in young fish of similar stages. So far as I can gather from the examination of my material, the natural condition of the dorsal and anal fins is shown in Fig. 4. In frayed examples the finlets appear separated, but I am satisfied that the marginal fin really extends without any serious break in its outline from the first dorsal to the end of the dorsal series of finlets, and ventrally from the anus to the end of the anal finlets. It does not appear to be continuous, either dorsally or ventrally, with the caudal fin. I cannot count the rays of the dorsal and anal in any of my specimens; they are not fully developed, but seem in general agreement with the adult formula. As regards the finlets, judging from my best specimens, each isolated basal lobe bears at its apex a single stout somewhat fan-shaped ray, divided distally into numerous fibres. The caudal is injured in most of my specimens. It appears to be slightly forked, as in Fig. 3. Small dark chromatophores are present on nearly all parts of the head and trunk. Larger chromatophores occur on the top of the head and along the dorsum, especially along the base of the second dorsal and dorsal finlets, while there is a corresponding ventral band at the base of the anal fin and finlets. The sides and under-surface of the abdomen are somewhat silvery. On the sides of the trunk the chromatophores are set more thickly at the lines of division of the myomeres than elsewhere. I never saw these large specimens in the fresh condition. As I received them, a few days after they were placed in alcohol, they appeared to have been of a general bluish-grey colour, with silvery eye, gill-cover and abdomen.

Caranx trachurus. *Linn.* Scad, Horse-mackerel.

Holt, E. W. L., *Journ. M. B. Assoc.*, N.S., iii., 1894, p. 190. *Ripe ovarian egg.*
(?) M'Intosh, W. C., *Eleventh Ann. Rep. S. F. B.*, 1893, p. 245, Pl. IX., fig. 8. *Unidentified egg*, 1·2954 *mm. in diameter.*
Holt, E. W. L., *Annales du Musée de Marseille*, 1898. *Egg, larvæ, various stages of metamorphosis.*

My previous communication on the reproduction of this species dealt with ova obtained from dead North Sea specimens. Though milt was added to the water into which the female fish were stripped, I do not think that the eggs were fertilised, since the expansion of the zona and the development of the protoplasmic mound, which I then described, is often if not always achieved by ripe ovarian eggs without any aid from the male product. The observation served to demonstrate the pelagic nature and extreme buoyancy of the egg, and the complete segmentation of the yolk.

At the time of writing I had not access to Agassiz and Whitman's memoir on the "Pelagic stages" (*Mem. Mus. Comp. Zool. Harv.*, xiv., 1885, p. 12, Pls. IV., V.), and erroneously asserted that the scad furnished the only instance of an Acanthopterygian egg with completely segmented yolk. As a matter of fact these authors have given a beautifully illustrated account of the egg of *Temnodon saltator*, a Carangoid allied to Caranx, and their figures showing the gradual phases in the segmentation of the yolk are probably equally applicable to the scad, in which I was able to note that the formation of the yolk spherules is accomplished, at least in part, after the deposition of the egg. The unidentified form doubtfully assigned by Raffaele to Coryphæna furnishes probably another instance of a completely segmented yolk in the Acanthopterygian group.

I have failed to secure any further scad in spawning condition, but have no hesitation in assigning to this species certain tow-net ova obtained first at Marseilles in 1895 and again at Plymouth in 1897. I have described and figured these eggs, with the larvæ hatched from them, and some later stages, in the *Annales du Musée de Marseille*, and must refer to that publication for the illustration of my present remarks.

It will be remembered that the ripe ovarian eggs obtained at Grimsby exhibited an oil-globule, indifferently cupreous, yellow or colourless, and usually divided into several small globules at the time of spawning. The Plymouth eggs are smaller than the Grimsby specimens, but larger than those met with at Marseilles.

	Diameter of egg.		Diameter of oil-globule.
*Grimsby . .	1·03–1·09 mm.	...	·26–·27 mm.
Plymouth . .	·81– ·93 ,,	...	·22–·23 ,,
Marseilles . .	·76– ·78 ,,	...	·19–·20 ,,

I believe that this difference corresponds to the size of the parent fish in the several localities. As between the North Sea and the south-west coast I am not sure that the difference is considerable, but as spawning seems to be at its height in the North Sea in May, and my Plymouth ova were not taken before July, I suppose that the latter were derived from the smallest parents, which seem to spawn as a rule later than the large ones. As to the Mediterranean scad, all that I saw at Marseilles were very much smaller than the large Atlantic variety or race, and I. imagine that in comparative size the scad differs, in the two seas, as the mackerel and pilchard are well known to differ.

Apart from the difference of dimensions the Plymouth and Marseilles ova are identical, and agree in character with the ovarian egg of the scad. The yolk appears to me to be absorbed rather more quickly than in the majority of pelagic eggs, having regard to the degree of development of the embryo, a circumstance which seems to be possibly explained by the greater extent of the protoplasmic element, limited in most ova to the periblast, but here extending inwards as the walls

* An unidentified egg, 1·29 mm. in diameter with an oil-globule of ·19 mm., is described and figured by M'Intosh (*loc. cit.*) from the east coast of Scotland. It may possibly be that of *C. trachurus*, but the nature of the markings shown on the yolk, which rather resemble yolk segments, was not ascertained. As the author observes, they may be simply superficial.

of the yolk segments. Be this as it may, while the egg has but an inconsiderable perivitelline space in its early stages, towards the time of hatching the embryo has ample room within the confines of the zona. A characteristic feature is the transverse elongation of the yolk at this stage. Yellow and black pigment is present when the embryo has acquired a short tail. A few pairs of large yellow patches occur along the head and trunk, accompanied by irregular black chromatophores. Yellow and black pigment is present about the oil-globule.

The early vitelligerous larva bears a close resemblance to that of *Temnodon saltator*, but the oil-globule is always anterior instead of posterior, a feature which also serves, *inter alia*, to distinguish the scad larva from that attributed by Raffaele to Coryphæna. At the stage at which the larva seems to be usually liberated, the anus is about median in position and therefore somewhat widely separated from the hind end of the yolk. The marginal fins are rather wide, but the dorsal does not extend in front of the head. Yellow pigment occurs in variable quantity along the dorsal and ventral region, except on the posterior half of the tail. Submarginal yellow patches, often of conspicuous size, are or may be present on the dorsal and ventral marginal fins, except on the posterior half of the tail. Yellow pigment occurs also about the rectum, the oil-globule, and to a variable extent over the general surface of the yolk. Black chromatophores, nowhere numerous, and variable in number, coexist with the yellow, and extend far back along the tail. The notochord is multicolumnar, the vacuoles being arranged in about two series. Except for the rather reduced condition of the yolk the larva cannot be said to be unusually far advanced at the time of hatching.

A larva, hatched at Marseilles from an egg which I did not measure, was much less advanced than any other which I have seen. The yolk was very large, the larva had only a very short tail, and the gut ended indefinitely a little behind the yolk. A day later the larva had acquired much the same size and conformation as those which hatched at what appears to be the normal stage, but the marginal fins were still devoid of pigment. This, however, judging from the analogy of Temnodon, appears unimportant.

A Plymouth larva, about fifteen hours after hatching, measures 3·03 mm. A Mediterranean specimen, at about the same stage, is 2·47 mm. long. The Mediterranean larva last referred to as exceptional was only 1·71 mm. long when first observed, but had reached a length of 2·63 mm. a day later. I have not succeeded in keeping these larvæ alive for more than a few days. They are exceedingly active, and rapidly injure themselves if confined in small vessels.

I do not imagine that there is any doubt as to the identity of these forms. The characters of the ova correspond to those observed in the ovarian egg of the scad, and that fish is common both at Marseilles and at Plymouth. Its ally, *Capros aper*, is known to possess quite a different egg. The egg of the John dory, *Zeus faber*, is certainly unknown. It is perhaps permissible to suppose that it will be found to resemble that of Capros rather than the form now under discussion.

An advanced larva taken at the surface of Plymouth Sound on the 6th August, 1897, is undoubtedly a scad, as is sufficiently indicated by the fin-ray formula, though the spines of the dorsal are as yet short, and those of the anal are not separated by a notch from the succeeding soft rays. The conformation is of interest.

The head is very large, its length contained about $2\frac{5}{8}$ times in the total length without the caudal fin. The height of the body is a little less than the length of the head. Both head and trunk are laterally compressed, and the general contour bears a resemblance to that of the adult Capros. The total length is 11·5 mm. The colour is olive-green, clouded almost uniformly with large black stellate chromatophores, but the median fins and the caudal peduncle are unpigmented.

The next stages known to me are represented by a number of examples taken by Mr. F. W. Gamble in August, 1896, from under the umbrella of a large Rhizostoma in the Irish Sea. There are seventy-nine little scad altogether, ranging in size, as preserved, from 16 to about 45 mm. The smallest have lost the somewhat abruptly elevated contour of the specimen of 11·5 mm., and the whole series are fusiform in shape, the elevation of the body being naturally greatest in the smaller examples. Of the British Carangoids they may be most readily compared to Lichia. At a length of 31 mm. the transverse keels of the lateral line scales are present on the posterior part of that structure. At 44 mm. the line is keeled throughout its length, but the scales do not appear to acquire the full development of the adult condition until the fish is about 54 mm. in length. Shoals of little scad from about 50 mm. upwards appeared in the estuaries of the Tamar and Plym during the autumn, so that, with the forms already referred to, we have most of the stages in the life-history of the species. Cephalic spines are not represented in any stage which I have examined.

An important gap is left between the vitelligerous larva and the specimen of 11·5 mm. At the latter size we may say that the scad is Capros-like in conformation, passing thence into an intermediate Lichia stage, from which the true Caranx conformation is finally evolved. So far as fishery matters are concerned the scad is important only as a nuisance, but the metamorphosis which we have been able to follow seems to throw an important light on the phylogeny of the whole Scombroid tribe. It appears almost certain that Caranx has been evolved from a somewhat elevated laterally compressed ancestor, bearing in this respect a resemblance to the Capros of the present day. An elevated compressed form may therefore have been a primitive feature in the evolution of a part of the tribe, intensified in the evolution of various genera, such as Zeus and Platax, reduced in others, as certainly in Caranx, and perhaps in Lichia. Scomber has lost in its ontogeny all trace of an elevated ancestry, if it ever possessed one. The importance of a primitive elevated and compressed form may extend far beyond the limits of those fish which are usually associated in the broadest sense as Scombroids. As a matter of pure conjecture it may even be suspected to throw light on the systematic position of the Pleuronectidæ. I have already suggested (*Proc. Zool. Soc.*, 1894, p. 438) that these fish are derived from vertically swimming but elevated and laterally compressed ancestors, and the absence of stout spines in the fin-rays, considering the requirements of the habit evolution, requires no explanation at all.

Capros aper. *Linn.* Cuckoo, Boarfish.

Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., i., 1889, p. 10. *Early stages of egg derived from parent.*

Holt, E. W. L., *ibid.*, v., 1897, p. 41. *Egg and larvæ derived from parent; tow-net egg and larva; late larvæ referred to C. aper.*

Holt, E. W. L., *Ann. Mus. Mars.*, v., 1898, Fasc. II. *As above, illustrated by numerous figures.*

With regard to the ova, I have little to add to the observations published in the last number of the journal. It will be seen from our records that the species must have been spawning in the neighbourhood of Plymouth from the beginning of June to the end of August. Trawlers regard it as a vagabond, here one day and gone the next, but never moving very far as long as it favours the coastal waters with its unwelcome presence. It was noted on the 3rd August that no cuckoos were caught in the trawl, though their ova, in an early stage of development, were fairly numerous on the surface above the ground trawled. So closely do these fish seem to congregate that a large shoal may have been quite near us at the time.

It appears worth while to recapitulate from our records the sizes of the eggs measured on different dates, in order to set forth what evidence we have of the diminution in size towards the end of the season. The notes of interrogation signify a doubt as to the correct determination of the species.

April	27	·98	mm. ?
June	4	·96–1·01	"
"	4	1·04	" ?
"	12	·90	"
"	25	·97– ·99	"
"	29	·99	" ?
July	6	·93– ·99	"
"	23	·96	"
"	27	·93– ·97	"
"	29	·93	"
August	25	·91	"
"	27	·93	"

In describing some late larvæ taken off the Fowey river on the 29th and 30th June, I omitted to point out the close resemblance which they bear, in pigmentation, to young Lepadogaster of about the same size. The arrangement of the black chromatophores is practically identical. The supposed Capros are, however, deeper in the body. I cannot find, examining them either as opaque objects or clarified in xylol, that they have any trace of a sucker, while at 5·5 mm. the development of the tail is much more advanced than in a *Lepadogaster bimaculatus* (with well-developed sucker) of 7·5 mm. The condition of the dorsal and anal fins would refer the supposed Capros larvæ to that species of Lepadogaster, if to any. The differences noted above dispose of such a suggestion, but the resemblance in pigmentation is interesting.

Lophius piscatorius. *Linn.* Monk, &c.

The ripe ovaries of a monk were brought to the Laboratory on the 20th January, 1898. I saw, but did not closely examine, the ovaries of another specimen on the same day; they appeared also to be ripe. Thompson, according to Day, observed a female with advanced ovaries in December, so that the spawning season would appear to commence very early in the year.

The ovaries were placed in sea-water, and as much as possible of the delicate ovarian wall stripped off. The mucous sheet soon swelled to a considerable width, and the spawn-mass floated for an hour or more. The oil-globules imparted to the whole a brilliant orange or salmon-colour. They were found to be divided, in a number of eggs examined, into numerous particles of various sizes. The mucous matter was only slightly adherent externally.

As is well known, the spawn, although a very conspicuous object, is rarely encountered at the surface. Is it possible that the parent manages to hitch it in some way to a submarine object?

Blennius ocellaris. *Linn.* Butterfly blenny.

Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., i., 1891, p. 36, Fig. XXV. *Egg.*
Holt, E. W. L., *Ann. Mus. Marseille*, v., 1898, Fasc. II. *Newly hatched and late pelagic larva.*

This blenny must probably be regarded as difficult to catch rather than as actually rare in the Plymouth district. Two adults, both males, were taken in 1897. Cunningham has already described the ova, which were found in an ox-bone, and identified by the presence of the male parent.

On the 20th June, 1896, Mr. Beaumont dredged a large whelk-shell off the Plymouth Mewstone. In the mouth of the shell was a male Butterfly blenny, guarding a great number of eggs. Higher up in the shell a *Lepadogaster bimaculatus* was similarly occupied. I did not specially examine the eggs of the blenny, but Guitel's researches (*Arch. Zool. Exper.*, S. iii., I., 1893, p. 325) render it very probable that in this species, as in others, the egg adheres by means of a series of long attachment filaments situate around the micropyle. The eggs were in various advanced stages of development, and many had hatched before the *Busy Bee* arrived at the Laboratory, but some had not hatched on the following day. Very probably they had not all been spawned at the same time. All unhatched eggs appeared bright red, the colour being that of the yolk.

A larva, from twelve to twenty-four hours old, measures 6·30 mm., of which the greater part is occupied by the tail. The distance between the snout and the hind end of the yolk is only 1·85 mm., and of this ·95 mm. pertains to the head. The rectum occurs immediately behind the yolk. The head is bluntly rounded in contour, and the edges of the marginal fins show a bold inflection towards the end of the tail, the caudal part being spatulate. The pectoral fin is large, with well-developed rays, the longest of which, when laid parallel to the body, extend ·12 mm. beyond the anus. This fin is yellow, with black chromatophores along the rays. The brain and anterior tissues generally are buff by transmitted light. Black chromatophores occur on the top of the head and about the posterior end of the trunk. The marginal fins are devoid of pigment. The notochord is multicolumnar.

I was unable to study any later stages as an accident to the escape pipe caused the loss of all my material. The larvæ appeared delicate, since many died soon after hatching; but as they were exceedingly active it is quite possible that they injured themselves against the sides of the bell-jar in which they were confined.

A much more advanced larva, taken in the little bay under Professor Marion's laboratory, at Endoûme, appears to belong to the species now under consideration. The total length is 18 mm. The conformation approaches that of the adult, and the fin-ray formula agrees with that of *B. ocellaris;* while local considerations seem to eliminate from the list of probable parents such other blennies as exhibit a practically identical formula. The pectorals, 5 mm. in length, are olive-green, finely dotted with black—a character of *B. ocellaris.* The head and anterior part of the body are pale yellow; several olive-green bands radiate from the large blue eye. There is a patch of olive-green on the top of the head, a band along the middle of the side, and another along the base of the anterior part of the anal. Anteriorly a series of short bars descend from the dorsum. The dorsal and anal fins are colourless, and there is no pigment whatever on the hinder half of the post-anal region. There are no well-developed cephalic tentacles, and the dorsal, though deeply notched, is not conspicuously elevated in front. The little fish, when first observed, was swimming at the surface, the pigmented parts being alone visible. The resemblance to a butterfly was very much more apparent than in the adult condition.

The relatively enormous pectorals of the larva, though vigorously employed, cannot be regarded as very effective organs of locomotion, since the result achieved is by no means remarkable either for pace or staying power. Their significance is, perhaps, ancestral rather than adaptive. The resemblance, not only in the pectoral development but also in the contour of the head, to Dactylopterus, may be, so to speak, accidental. The young blenny is entirely devoid of cephalic armature. Both of the larval stages described above are figured in the *Annales du Musée de Marseille.*

Blennius pholis. *Linn.* Shanny.

M'Intosh and Masterman, *Life-Histories Brit. Food-Fish.*, 1897, p. 206. *Late larval stages.*

Holt, E. W. L., *Ann. Mus. Mars.*, 1898, v., Fasc. II. *Pelagic larval stage, with figure.*

The early development of the shanny seems never to have been the object of exact observation. The later larval stages have been dealt with by M'Intosh and Masterman.

On the 15th July, 1897, a larva of 15·5 mm. was found by Mr. Beaumont and myself in a dahlia flower which was floating under St. Anthony lighthouse, Falmouth. The fin-ray formula is that of the adult; in other respects the specimen is very similar to the young *B. ocellaris* of 18 mm., but the colours are different. The dorsal and anal fins and the hinder half of the post-anal region are entirely devoid of pigment. The ground colour of the anterior parts is canary-yellow, with a deeper patch near the middle of the post-anal region. Several bands of black chromatophores radiate from the eye; there is a black patch on the top of the head and a row of black chromatophores on the cheeks. A band of black, notched at intervals, occurs on the dorsum, a row of black along the base of the anterior part of the anal, and there are some small black chromatophores along the lateral line. The pectorals are reddish brown, with very large transversely elongated black chromatophores, or groups of chromatophores, arranged on the interradial membrane so as to form rows transverse to the long axis of the fin. The pigment differs thus in colour rather than in general distribution from that of *B. ocellaris*. The pigmentation of the pectoral is practically that of the adult *Dactylopterus volitans*. The specimen is figured in the Marseilles paper.

On the same day I saw, but failed to catch, what were probably similar larvæ. They were among the Laminaria at the sides of a tidal pool near the place of capture of the specimen described. A day later we found another—a little larger—in the Helford river zostera bed, at low water. Older specimens, 19·5 and 20 mm. long, were taken at the surface in Plymouth Sound on the 7th September, but I omitted to note the presence or absence of any floating body to which they might have been clinging. A feature of note is the extraordinary activity of the larva when out of its native element. Its leaping powers are most respectable, and no injury seems to ensue from contact with terrestrial matters. I suppose that its locomotion on land is accomplished in the same way as that of Periophthalmus; but my specimens were a great deal too lively to make sure of this. I imagine that the young shanny is not infrequently stranded by the falling tide, in which case its jumping powers may serve it in good stead.

Ctenolabrus rupestris. *Linn.*

Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 465, Pls. XLVIII., XLIX. *Tow-net egg and larva, Sp.* iv.

Pelagic ova taken on the west coast of Ireland were referred to this species on account of the close resemblance they bore to those of the American connor, *C. adspersus*. This identification has never been confirmed by the evidence of ovarian eggs, and perhaps hardly requires such confirmation. A glance at our records will show the frequency with which the egg has been taken in the Plymouth district during 1897. This is by no means surprising, as the parent species is exceedingly abundant on rocky ground both in the Sound and outside the Breakwater. It occurs also, if one may judge from the evidence of tow-net eggs, on the outlying Eddystone rocks. Young examples are common in the zostera beds of Cawsand Bay and the Yealm estuary, but adults are rarely taken, at least by the Laboratory boats, on any ground fit for trawling. It would appear from our records that there is no special migration in connection with the spawning instinct, but that the ova are liberated on the grounds ordinarily inhabited by the species. The breeding season appears to be prolonged from April to August, and such measurements as were made afford evidence of a diminution in the size of the ova as the season advances. The actual numbers will be found in the records, while the subjoined list may be taken as a summary:—

April	·90 to 1·01 mm.
May	·87 „ ·94 „
June	·84 „ ·87 „
July	·78 „ ·82 „
August. . . .	·72

An egg of ·67 mm., taken on the 28th June, can probably be assigned to this species; as it presents certain indications of immaturity, it cannot fairly be utilised as evidence of size variation. Excluding this specimen, the variation is ·29 mm., or more than one-fourth of the size of the largest specimen.

It may be urged that the ova which we have assigned to *C. rupestris* may really have been contributed by more than one species of wrasse, but I do not think that this is the case. The common wrasses of Plymouth are *L. maculatus, L. mixtus, Cr. melops, Ce. exoletus,* and *Ct. rupestris.* The first three may be discarded, since their ova are demersal. Of the ova of *Centrolabrus exoletus* I know nothing, but I found at Marseilles, where *C. exoletus* is not known to exist, a similar variation and seasonal diminution in the size of tow-net ova referable to *Ct. rupestris.*

April	·80, ·83 mm.
May	no observations.
June	·75, ·76 mm.
July	·70 mm.

Moreover the occurrence of young specimens in the Plymouth zostera beds affords evidence that the spawning season is really as prolonged as would appear from the tow-net gatherings. Preliminary experiments indicate that the species can easily be reared from a very small size, and it may be possible to study its development continuously.

Unidentified Labroid, resembling **Coris.**

Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 467, Pls. XLVIII., LI., *Sp.* v., Coris-like.

Holt, E. W. L., *Ann. Mus. Marseille*, v., 1898, Fasc. II. *Egg and larva, with figure.*

An egg which appears to have unquestionable Labroid affinities was taken in the Plymouth district in July and August, 1897. Our records show that it occurred on more or less off-shore grounds. I have no doubt but that it is identical with ova already described from the west coast of Ireland, but the parentage remains in doubt.

The Irish specimens measured from ·80 to ·83 mm. in diameter, the oil-globule measuring ·15 mm. Those taken at Plymouth measure from ·78 to ·81, the oil-globule from ·13 to ·15 mm. The yolk is homogeneous, the oil-globule colourless, but, in the Plymouth examples at all events, very dark. A larva, measured very soon after hatching, is 2·21 mm. long. A somewhat more advanced specimen from Ireland measured 2·44 mm. The conformation of the larva bears a striking resemblance to *Coris julis* (*vide* Raffaele, *Mittheil. Zool. Stat. Neap.*, viii., 1888, Tav. II., Figs. 18, 19). The yolk is pyriform, its narrow end, having the globule at the apex, projecting boldly in front of the head. The rectum is separated by a considerable interval from the hind end of the yolk. The marginal fins are of moderate width, the dorsal arising behind the head. My notes distinctly state that the edges of the marginal fins are not serrated as in Coris. The notochord, in Irish specimens, is of a peculiar type. For the most part arranged in a double series, the vacuoles are occasionally unicolumnar. This appears to me a strong indication of Labroid affinity, since both Coris and Ctenolabrus exhibit a notochord intermediate in character between the unicolumnar and multicolumnar conditions, though the approach to the former condition is much more marked than in the form before us. I must add that I did not find any unicolumnar cells in a Plymouth example which I examined; it is probably a variable feature, but, on account of its rarity, in so far as my knowledge extends, in other groups of fishes, not the less useful.

The pigment is all black, and has the same distribution as in Coris, but resembles perhaps even more closely that of Mullus. Indeed, save for the presence of cortical yolk segments in Mullus and for the separation of the yolk and rectum in our unidentified larva, the two forms are extremely alike.

I believe that the Labroid affinities of the parent are fairly well demonstrated by the characters of the embryo and larva. The difficulty is to find a Labroid parent. Labrus, Crenilabrus, and Ctenolabrus are naturally eliminated. *Centrolabrus exoletus* spawns, at least in great part, at a season earlier than the date of capture of the ova, as is demonstrated by the presence of the young in the zostera beds. It seems also to be a rather littoral fish, and it is quite possible that its ova are demersal. *Acantholabrus Palloni* may exist in the Plymouth district, but is only known to British zoology by a few examples recorded by Couch from the Cornish coast. *Coris julis* has been taken at Plymouth, but not to my knowledge in recent years, while the eggs of Mediterranean specimens, according to Raffaele's observations and my own, measure from ·58 to ·70 mm. in diameter, with an oil-globule of ·12 to ·14 (·18) mm., and, as already noted, the fin-edges of the larva are serrated. The difference is thus not only one of dimensions, though it is possible that I overrate the importance of the fin serration as a constant character.

The Mediterranean *Coris speciosa* of Risso is regarded by Marion (*Annales Mus. Mars.*, i., 1882, Mem. 2, p. 20, foot-note 3) as a deep-water variety of the common littoral *C. julis.* So far as my knowledge of the forms allows me to hold an opinion, it is in agreement with that of Marion. *C. speciosa* is known only from large specimens and may be, as I suppose, simply the ultimate phase of the development of *C. julis;* but, on the other hand, since its anterior dorsal rays are proportionately shorter than those of the fully developed *C. julis* of coastal waters, it may be a true variety. I have not had an opportunity of examining the British Museum specimens of Coris from the S.W. coast, but Day's remarks appear to indicate that at least one specimen is of the *C. speciosa* type.

Since Coris is little liable to capture by ordinary British fishing apparatus, it is quite possible that it really exists in some numbers in our district, and our undetermined ova may be thus accounted for, assuming that the British variety is larger and lays larger eggs than the Mediterranean coastal form, and that the serration of the larval fin is either variable or only present in the offspring of the smaller form or stage.

It is quite possible that our undetermined form is not a Labroid at all, but referable to one of the too numerous common fishes of which the early stages are still unknown to us. I do not think that this is the case, imperfect as is our present knowledge of Teleostean development.

The Topknots. Zeugopterus and Phrynorhombus.

Brook, G., *4th Ann. Rep. S.F.B.*, 1886, p. 226. *Ovarian egg of P. unimaculatus.*

M'Intosh, W. C., M'Intosh and Prince. *See M'Intosh and Masterman.*

Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., ii., 1892, p. 325. *Ovarian egg of Rh. norvegicus.*

Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1893, pp. 96 to 103. Pls. II., VII., VIII. *Sp.* x., xi., *and* xii., *undetermined tow-net eggs, now referred indiscriminately to the topknots.*

Holt, E. W. L., p. 104, Pl. XI., *Sp.* xiii., *Metamorphosing larvæ, now referred to P. unimaculatus.*

Holt, E. W. L., p. 111, Pl. XII. *Sp.* xiv., *Metamorphosing larvæ with periotic spines, now referred to Rh. punctatus.*

Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., iii., 1894, p. 202. *Rh. punctatus, advanced metamorphosing larvæ with periotic spines.*

Petersen, C. G. J., *Rep. Dan. Biol. Stat.*, 1893 (1894), p. 135, Pl. II., Fig. 16. *Late metamorphosing larva of Rh. norvegicus.*

Ehrenbaum, E., *Wiss. Meeresuntersuch, Komm. deutsch. Meer. Biol. Anst. Helgoland, Neue Folge*, ii., 1897, i., p. 317. *Tow-net egg referred to Sp. F. of M'Intosh and Prince.*

M'Intosh and Masterman, *Life-Hist. Brit. Mar. Food-Fish.*, 1897. *Summary of previous observations by M'Intosh and M'Intosh and Prince. Ovarian egg of Rh. punctatus; tow-net eggs referred by authors to same. Metamorphosing larvæ with periotic spines, provisionally referred by authors to Rh. norvegicus. Metamorphosing larvæ without periotic spines, referred by authors to Rh. punctatus.*

Holt, E. W. L., *Journ. M. B. Assoc.*, N.S., v., 1897, p. 45. *Egg and larva of P. unimaculatus.*

Holt, E. W. L., *Annales Mus. Nat. Hist. Marseille*, v., 1898, Fasc. II. *Larva of P. unimaculatus, early larva of Rh. punctatus with periotic spines, figures.*

Under the designation of Topknot, our record includes a number of eggs taken between the 24th February and the 5th April, with, perhaps, another which occurred on the 4th June. It is impossible to decide to how many species these eggs really belong. The three British topknots all occur in the neighbourhood of Plymouth, and one, at least, of them must be very common there, namely *Rhombus norvegicus*. Another, *Rh. punctatus*, is certainly not rare. The third, *Phrynorhombus unimaculatus*, is less often met with, but as these fish by no means lend themselves to capture by the ordinary methods of fishing, it is impossible to make any exact statement as to their comparative abundance.

With regard to the spawning period in this district, Cunningham has recorded a ripe female of *Rh. norvegicus* taken on the 21st March, and I have trawled two *Phr. unimaculatus* in similar condition on the 1st June. I do not know of any record of the spawning of *Rh. punctatus* from the S.W. coast, but M'Intosh and Prince give the 16th May as the date of the capture of a ripe female at St. Andrews. Judging by the analogy of other species, this topknot should spawn on the S.W. coast at least as early as on the N.E. of Great Britain.

Rh norvegicus and *Rh. punctatus* may therefore be safely regarded as early spawners. *P. unimaculatus* may or may not spawn, as a species, a little later than the others. So far as the few recorded observations go, there seems to be no possibility of distinguishing their eggs by dimensions alone. Thus, from a single example of each species, the various authors who have dealt with them give the following sizes:—

Rh. punctatus, unfertilised . .	d. 1·05 *ca.*	o.g. 0·20 mm. *ca.*	
Rh. norvegicus, „ . .	„ ·90	„ ·15 „	
P. unimaculatus, „ . .	·92–·93 „	(·16–·18) mm.	

Fertilised ova from the last specimen measured from ·90 to ·99 mm. in diameter, the oil-globule from ·16 to ·18 mm.

If the fertilised eggs of a single parent show a variation *inter se* of ·09 mm., it is more than probable that the variation of the eggs of the species as a whole is really much greater. For *P. unimaculatus*, Brooks' measurement of the ripe ovarian egg, after preservation, is ·96 mm. Without further words, I think it will be plain that the eggs of the three species overlap each other in so far as dimensions are concerned, although in all probability the egg of *Rh. punctatus* is on an average the largest, that of *Rh. norvegicus* the smallest of the three. Such comparative sizes of the eggs conform to those of the parent species, so far as they are known to me.

The eggs taken in our tow-nets may be recapitulated as follows, the dimensions of each individual egg being given:—

	Diam. of egg.	Diam. of oil-globule.
February 24 . .	1·05	
„ 26 . .	1·02	·19
March 1 . . .	1·04	·21
	·99	·18
	1·05	·17
	1·08	·19
March 30 . . .	·90	·13
	·91	·13
	1·04	·19
	1·07	·21
	1·07	·21
April 5 . . .	1·03	·17
June 4 . . .	1·04	·20

The egg of June 4th, only observed in its early condition, belongs perhaps more probably to *Capros aper* than to a Topknot.

With regard to the rest it appears at first sight possible to select two, measuring ·90 and ·91 mm. in diameter, as differing markedly from the rest; but it is necessary to remember that the difference of ·15 mm. which separates the smallest of these two from the largest of the whole series is no more than is met with in a single species having ova of about the same size. For instance, tow-net ova, which can be referred with reasonable certainty to *Callionymus lyra* and *Ctenolabrus rupestris,* show variations of ·12 and ·29 mm. respectively (*vide* pp. 112 and 125). The discrepancy in size cannot therefore be regarded as of specific moment.

Appeal to the characters of the embryo and larva does not afford much positive assistance, since of the three Topknots but one is certainly known in its early stages, and that only from a few artificially-fertilised eggs and a single newly-hatched larva. This larva has been described in the last number of the journal, and will be figured in the *Annales du Musée de Marseille.* The Plymouth tow-net eggs yield larvæ which do not appear to offer important differences, though in certain characters they are certainly variable. Taking those which have come under my own observation, apparently similar to those studied by Mr. Scott during the earlier part of the season, the larvæ may be said to be identical with some Irish examples which I have described and figured under the title of Sp. xi. Moreover, it now appears to me that my Species x. and xii. were separated from the last on insufficient grounds. I do not wish to assert that all the eggs which I have described under those titles were spawned by one and the same species; but that, in the light of the Plymouth specimens, I now hesitate to rely on the characters which I formerly considered as specific.

Sp. x. is a St. Andrews form, and is no doubt identical with an egg and larva subsequently attributed by M'Intosh (*Twelfth Ann. Rep. S. F. B.*, 1894, p. 222, Pl. IV.), who appears to have overlooked my previous description in this journal of the ova and larvæ of the turbot, to that important food-fish. According to my observations the egg, which occurred at St. Andrews in April, May, and July, and in Clew Bay, Ireland, in April, has a diameter of 1·00 to 1·05, and an oil-globule of ·18 to ·20 mm.

Sp. xi. is from Ireland, March and April; the diameter is from 1·01 to 1·07, that of the oil-globule ·18 mm.

Sp. xii. is a title applied for the sake of continuity to a form already described by M'Intosh and Prince as Sp. F. According to my own measurements in Scotland and Ireland the diameter of the egg is from ·75 to ·85 mm., that of the oil-globule from ·14 to ·15 mm. According to M'Intosh it may reach a diameter of ·9906 mm. The same egg has been found by Ehrenbaum at Heligoland.

Sp. F. or xii. differs from the rest in that the epidermis is beset with small papillæ or tubercles, connected with each other by a network of fine raised lines. I have already explained in the last number of this journal that I can no longer regard this epidermal feature as of specific importance. It is a common, perhaps a normal feature of the embryo of Arnoglossus, but it is not constant, even in the species of that genus. In typical specimens of Sp. F or xii. it is extremely well marked, but the Topknot eggs which I have seen at Plymouth do not lend themselves to discrimination by this character. Two of them, and it is necessary to remark that these two (·90, ·91, 0·9, ·13) are the smallest of the series, have the reticulo-papillate epidermal character most strongly marked, but the rest are variable. Some have the skin practically smooth. In others it is more or less papillate, with an approach in some instances to reticulation. Moreover, the typically reticulo-papillate condition was observed as an exceptional, perhaps a pathological feature in a species which does not appear from the characters of the larva to be a Pleuronectid (*vide* the egg and larva temporarily assigned to a Gadoid, p. 145).

Apart from the papillation of the skin, I now believe that the various early Topknot larvæ, which have been described from tow-net ova, cannot be distinguished by characters of pigment and conformation. Those which have come under my notice at Plymouth seemed to be referable to my Species x., xi., and xii., but, on the other hand, they appeared capable of bridging over the differences which I had supposed sufficient to separate those species. Species x. was originally supposed by myself to have a Trigloid affinity, on account of the rather precocious development of the pectoral fin and a certain Trigloid character of the pigment of the marginal fins. I am now convinced of error in this respect, and it appears reasonably certain that all our British Triglæ have much larger eggs.

An inevitable want of continuity in our tow-netting operations during the period when these eggs occurred, seems to me to greatly prejudice any discussion based on the comparative sizes of the eggs taken. As to the general question of the determination, by the characters of the vitelligerous larva, of the eggs of the several species of Topknot, I do not think it is possible, as yet, to pronounce a definite opinion. The single larva which I was able to rear from artificially fertilised ova of *P. unimaculatus* seems to me to suggest that some of the ova which have been described under Sp. F belong to that form. Further, it would appear that the reticulo-papillate larva is perhaps more commonly hatched from the smaller of the eggs which may safely be assigned to Topknots. M'Intosh and Masterman deal with the egg and larva F under *Rh. punctatus*, but it does not appear that they wish to definitely identify them with that species. It seems at least possible that the reticulo-papillate condition may be more or less pathological; and if, as I suppose to be the case, the smaller spawning members of a species give rise to small and often weakly offspring, it is quite possible that the occurrence of the character rather in small eggs than large may be explained in this way. On such a supposition one must class the smaller ova with reticulo-papillate larvæ merely as the offspring of small individuals, of one or more species, and not as a distinct species. I put forward the suggestion for what it may be worth. A papillate condition of the skin is certainly a pathological condition in the larvæ of many species, but is certainly present in some cases in individuals which appear to be quite healthy.

There is, I imagine, no means of deciding how many Topknots have contributed to the ova taken in our tow-nets this spring, although the apparent lateness of the spawning period and certain characters of my solitary larva of *P. unimaculatus* seem to indicate that the share of that species is, at any rate, unimportant. Failing any observation of larvæ derived from the artificially fertilised eggs of *Rh. punctatus* and *Rh. norvegicus*, it is impossible to say whether one or both of these species are represented.

Some help may perhaps be derived from a consideration of the few metamorphosing larvæ of Topknots which were obtained during the year.

I have described from Ireland, as Sp. xiv., a very conspicuously characterised pleuronectid larva, which can now be referred, without any doubt, to a Topknot. It is most readily recognised by the presence of a pair of relatively enormous spines on each otocyst, and is further characterised by a very distinctly banded black pigmentation. In discussing the affinities of this larva, I at first considered that it must belong either to the Brill (*Rh. lævis*) or to *Rh. norvegicus*. Confirmation of Raffaele's earlier observation of the young stages of the Brill has shown that it is certainly not the parent of the larva with periotic spines. On the other hand, Cunningham seems to me to have proved, by the examination of older stages, that *Rh. punctatus* has a spined larva similar to my Sp. xiv. A specimen examined by this author has D. 90, A. 69, and he rightly contends that, of the possible parents, *Rh. punctatus* is by far the most probable. My largest specimen had D. 80 *ca.*, A. 66 *ca.* It was not possible to count all the rays. Cunningham makes the reservation that there may be more than one species with a spined larval condition.

A larva with periotic spines was formerly considered by M'Intosh to be possibly a young *Rh. punctatus*, representing an older stage of another larval form apparently similar to that which I doubtfully assigned, under Sp. xiii., to *P. unimaculatus*. His latest discussion of the matter (M'Intosh and Masterman) refers the last-named larva, which has no periotic spines, to *Rh. punctatus*, while the former, including my Sp. xiv., is assigned with some reserve to *Rh. norvegicus.* No St. Andrews larva is assigned to *P. unimaculatus,* because that species has never been recorded in the district, but the capture of a single specimen of *Rh. norvegicus* seems to be considered to have afforded sufficient warrant for changing the determination of the spined larva.

The Irish larva without periotic spines, Sp. xiii., is, if one takes into account the stages of the metamorphosis which the two forms exhibit, much smaller than the spined Sp. xiv. Thus at a length of 10·62 mm. the latter is still nearly symmetrical, with a heterocercal tail, while at 9·37 mm. the former has the eye at the ridge, and the tail quite homocercal. I should imagine that the larva which, at any given size, has the metamorphosis most advanced, would be universally held to belong to the smaller species. Yet M'Intosh and Masterman put forward the same comparison as an argument in favour of an exactly converse conclusion.

Cunningham's observation of the later stages of the spined larva seems to me too positive to permit of any doubt as to the spinigerous nature of the larva of *Rh. punctatus,* unless, as is most unlikely, he was dealing with a specimen with an exceptionally large number of fin-rays. The St. Andrews authors, however, refer the larva without spines to that species, with the simple remark that they are unable to concur with Cunningham's opinion.

During the present season we have twice taken a larva with periotic spines, corresponding exactly in this respect, and in the disposition of the pigment, with my Irish series, but less advanced in metamorphosis. They measure respectively 5·11 and 4·5 *ca.* mm., the latter specimen being bent and difficult to measure with accuracy. The body is still elongated, and shows no signs of elevation. The contour of the head is still rounded, although the jaws protrude somewhat, and the general appearance is that of a larva not long after the final absorption of the yolk. Yet the periotic spines are conspicuously developed, the upper one being somewhat the larger, and rather backwardly deflected. The larvæ, which will be figured in the *Annales de Musée de Marseille,* are certainly identical with the Irish forms, and I refer them without hesitation to *Rh. punctatus.*

They occurred on the 8th and 24th of April (*vide* record), that is to say at the end of the period of occurrence of the Topknot ova, while Cunningham's advanced larvæ were taken on the 4th May. Taking into consideration dates and localities, one is led to suppose that these larvæ must be derived from ova similar to those which have been referred to the Topknot generally. In other words the said eggs are in part, at least, those of *Rh. punctatus.*

From the date, locality, and dimensions of the ova, it is obviously probable enough that some of the latter may belong to *Rh. norvegicus*, but I do not think that there is any satisfactory evidence of the nature of the metamorphosing larva of that species. It may, as M'Intosh and Masterman suppose, be characterised by the possession of periotic spines, but I should say that the conformation of the St. Andrews specimen of 11 mm. (if correctly represented by M'Intosh and Masterman), referred to *Rh. norvegicus*, bears certainly a greater resemblance to that of *Rh. punctatus*.

Apart from the spinigerous forms there is another larva or group of larvæ which can be definitely associated with the Topknots.

Under Sp. xiii. a typical series of this form, from the symmetrical condition to an advanced stage of metamorphosis, has been figured and described by myself. It has no spines at all, and at parallel stages of the metamorphosis is very much smaller than the spined form, and shows moreover no trace of the bold pigmentation of the latter. From the conformation at the most advanced stages, and from the fin-ray formula, I considered that this form belonged to *P. unimaculatus*, and so far as is possible, the appearance of the early vitelligerous larva of that species confirms my opinion.

Metamorphosing larvæ, either identical with or at least very similar to the Irish specimens, have been met with at St. Andrews, and are referred, as we have seen, by M'Intosh and Masterman to *Rh. punctatus*. As that species has certainly a spined larva, it appears to me that the spineless forms from St. Andrews must belong either to *P. unimaculatus* or to *Rh. norvegicus*. It is simply a question of whether the larva of the last-named has periotic spines or has none.

The few spineless sinistral larvæ which have been taken at Plymouth in 1897 leave the matter in doubt. One, 8 mm. in length, presents the stage of metamorphosis of an Irish specimen of 8·87 mm. (*op. cit.*, Pl. XI., Fig. 92). The two are very much alike, but the Plymouth example is somewhat more profusely and generally pigmented. Does the difference in size justify us in supposing that the Plymouth larva belongs to a smaller species than *P. unimaculatus?* I should say that it is possible, but not certain, since individual larvæ vary in the size at which they assume the different phases of metamorphosis. Another larva, about 3 mm. long after preservation, connects itself more readily with the younger stages of the St. Andrews spineless larvæ than with any of the Irish series. The head is large, but the trunk is narrow and elongate, without any trace of Pleuronectid metamorphosis, but the abdomen is relatively enormous, a condition apparently due to the viscera being distended with food. Whether naturally or by accident, the abdomen is laterallly compressed. Pigment is present in the form of minute black chromatophores scattered over the general surface, but scarce about the middle of the tail; larger black chromatophores occur along the edges of the dorsal and of the posterior part of the ventral marginal fins.

Seeing that they were taken on the inner Eddystone ground, a haunt of *Rh. norvegicus*, it is not improbable that these larvæ belong to that species, but in view of the resemblance of the larger specimen to the Irish larvæ, which appear to belong to *P. unimaculatus*, I am not inclined to make any positive assertion without further material.

A larger sinistral larva, taken from the stomach of a gurnard (*T. lineata*) on the 10th June, is so macerated that it is only possible to say that it has no spines and bears, in conformation, a fair resemblance to *Rh. norvegicus.* The total length is about 9·5 mm.; the eye is on the ridge.

Arnoglossus laterna. *Günther.* Scaldfish, Scaldback.

Since the last number of this journal was published I have had no further opportunity of measuring ova taken from the parent, but, as may be seen from the records, tow-net specimens, certainly referable to this species, were taken up to the 29th July. They cannot be regarded either as particularly rare or as specially confined to the lower strata of the water. The last egg belonging to the genus was observed on the 3rd August.

The difference already noted as existing between ova taken from the small undifferentiated females and those from large specimens with elongated dorsal rays seems to be accidental. Large females yielded ova of ·75 to ·76 mm., with a globule of ·12 to ·13 mm., while small females gave ova of ·67 to ·69 mm., with a globule of ·14 to ·15 mm. The difference in the size of the egg might be regarded as correlated to the size of the parent, but it was not apparent why the smaller egg should have the larger globule, if the two forms belong to the same species.

Tow-net eggs have since been found measuring ·63 and ·66 mm., in both cases with an oil-globule of ·13 mm. They can be identified from the characters of the larva with *A. laterna.* It follows that the full variation in the dimensions of the ova of this species, and of the proportionate size of the oil-globule, are not represented by the measurements which I took from the spawn of a few specimens.

Regarding *A. conspersus* of the Mediterranean as not entitled to specific distinction from *A. laterna,* my observations suggest that the northern representatives have larger eggs than the southern. Ova measured at Marseilles range from ·61 to ·68 mm., with an oil-globule of ·11 to ·13 mm. The larva is also smaller, but, allowing for variation observed in both localities, identical in pigment and other characters with the northern form. Both British and Mediterranean examples are illustrated in my paper in the *Annales.* So far as I know, large differentiated Scaldfish have never been observed at Marseilles, though they are known from other parts of the Mediterranean.

Arnoglossus Grohmanni. *Bonap.*

Raffaele, F., *Mittheil. Zool. Stat. Neap.*, viii., 1888, p. 49, Tav. iv. *Larva hatched from tow-net eggs resembling those of various species of Arnoglossus, Rhomboidichthys, and Citharus.*

Holt, E. W. L., *Annales Mus. Mars.*, v., 1897, Fasc. I., Note 4., p. 33. *Preliminary notice of egg and larva provisionally referred to A. Grohmanni.*

Holt, E. W. L., *ibid.*, v., 1898, Fasc. II. *Ova and larvæ, Mediterranean and British, referred to A. Grohmanni; with figures.*

In all, eight specimens of *A. Grohmanni* were trawled by the *Busy Bee* in 1897 and in January, 1898, viz., six at Plymouth and two in Falmouth Bay. The latter, taken on the 8th July, were females, very nearly ready to spawn. The species can no longer be regarded as extremely rare on our south-western coast. I have never noticed it among the large numbers of large *A. laterna* which have been brought to me from the off-shore trawling grounds; it seems rather to prefer the neighbourhood of rocks or rough ground nearer the shore, and may perhaps be common in actually rocky places inaccessible to trawling.

I associate with this species ova measuring ·67 to ·68 mm., oil-globule ·12 to ·13 mm., at Marseilles, and ·72 and ·74 mm., oil-globule ·12 mm., at Plymouth. The Plymouth specimens, with another not measured, occurred in July.

The larva, which is certainly that figured by Raffaele (*loc. cit.*), is readily distinguished from *A. laterna* by the presence of two post-anal pigment bars or patches, of which the last is near the caudal extremity. *A. laterna*, apart from some pigment sometimes present about the origin of the tail, has only one, approximately median, post-anal band or patch of pigment.

The pigment is perhaps more vividly red or orange in *A. Grohmanni.* In general conformation, in the unicolumnar character of the notochord, in the presence of digitiform cells along the edge of the marginal fin, and in the frequently reticulo-papillate condition of the skin, the two larvæ are identical. A newly-hatched larva of *A. Grohmanni* (Plymouth) measures 2·32 mm. Allowing for individual variation in the degree of development at which hatching takes place, Mediterranean examples appear to be of about the same size, or a little smaller.

By those who may still regard *A. laterna* and *A. lophotes* (the large form with elongated dorsal rays) as distinct species, it may be suggested that the larva which I refer to *A. Grohmanni* may be really that of

A. lophotes. The latter, however, as has already been noted, seems to be unknown at Marseilles, where *A. Grohmanni* is common. It is not likely that so well-marked a form as *A. lophotes* would have escaped the keen attention of Professor Marion and his subordinates, if it ever ventured into a region whence the very rapidly developing ova could have found their way into our hand-net, never employed far out at sea. The economic value even of such a comparatively small fish as the scaldback in its "Lophotes" form, would certainly ensure its prompt recognition in the Marseilles market; although, as we know, its worthlessness from the point of view of the British consumer long concealed the very same fish from the knowledge of naturalists in this country. I think it is almost certain that the scaldback is only present in the Marseilles grounds in its small undifferentiated form.

On our own coast, when I have trawled large differentiated and small undifferentiated *A. laterna* in company, I have found the ovaries of the first the more advanced, whereas the tow-net eggs of *A. laterna* began to occur before those referred to *A. Grohmanni.* This argument, it must be confessed, would have more weight if the numbers were larger.

Solea variegata. *Donov.* Thick-back.

Cunningham, J. T., *Journ. M. B. Assoc.*, N.S., i., 1889, p. 23, Figs. 14, 15. *Ovarian egg and tow-net egg referred to S. variegata.*

Cunningham, J. T., *Treatise on the Common Sole*, 1890, p. 90, Pls. XVI., XVII. *Egg, vitelligerous larva.*

Only one egg of this species was taken during 1897. It occurred on the 27th July between the Eddystone and Hand deeps. The adult seems to be oftener found outside the Eddystone than on the grounds nearer shore. The egg was first examined by Mr. Beaumont, and had died before I looked at it on the following day; there was, however, but little evidence of decomposition. The embryo, devoid of a caudal rudiment, showed only yellow pigment. The cortical vesicles of the yolk were quite apparent. I counted in all thirty-seven yellow oil-globules ranging in diameter from ·03 to ·11 mm., but for the most part exceeding ·05 mm. Mr. Beaumont observed no material change in this respect since the egg was examined on the previous day. The diameter of the whole egg was 1·11 mm.

I have made no effort to ascertain the duration of the spawning season, but as Cunningham records the occurrence of a ripe female on the 30th May, it is evident that our specimen belongs to a late clutch. The diameter is ·20 less than that of the tow-net egg recorded by Cunningham as having occurred on the 17th July.

Solea lascaris. *Risso.* Sand sole.

(?) Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 457, Pls. XLIX., L., *Solea, Sp.* i. *Advanced egg and larva.*

(?) Holt, E. W. L., *Ann. Mus. Mars.*, v., 1898, Fasc. II. *Early and advanced egg referred, with above, to S. lascaris.*

S. lascaris was common enough in the Plymouth market in the early part of 1897, but could not be found during the spawning season, which, as I computed, would occur a little later than that of *S. vulgaris.* The ovarian egg remains unknown, and I have no reason to think that *S. lascaris* is represented among the few eggs of Solea entered in our records.

I have described and figured in the *Annales* two stages of a sole egg taken at Marseilles. At an early stage of development the egg does not essentially differ in the character and arrangement of its globules from that of *S. vulgaris,* but as development proceeds the originally minute globules tend to coalesce so as to form larger ones. In this condition the egg appears identical with the Irish Solea Sp. i. The dimensions agree closely. I have set forth in my Marseilles paper the considerations which suggest that *S. lascaris* is probably the parent of both forms. Other tow-net ova are provisionally referred, in the same paper, to *S. Kleinii* and *S. hispida.*

Gadus.

The most abundant Gadus in the inshore waters of this district is the pollack, *G. pollachius.* The bib or blind and the pout (the names have no constancy of specific application), *G. luscus* and *G. minutus,* are commonest outside the Sound—the former about outlying rocks, the latter on the Eddystone trawling grounds. The whiting, *G. merlangus,* is at times abundant, but erratic in its distribution. The cod, *G. morrhua,* is not very plentiful, while the haddock, *G. æglefinus,* and the coal-fish or "roamer," *G. virens,* are decidedly exceptional.

In spite of much that has been written about them, the young stages, especially of those with which we are here concerned, are very difficult to distinguish one from the other. The ova approach each other closely in dimensions, and the variations in this respect have not hitherto been studied in a methodic manner. It is only possible, therefore, to identify the ova mentioned in our records in a provisional manner.

Gadus luscus. *Will.* Bib, Blind, Pout, Brassie.

Cunningham, J. T., *Journal M. B. Assoc.*, N.S., i., p. 46, Fig. 35: *Tow-net egg and larva.* P. 375: *Dimensions of ripe egg.*

Cunningham provisionally identified with this fish tow-net ova, 1·13 mm. in diameter, taken on January 20th, 1888. Ripe ova taken from a female in the Aquarium in March, were found by the same author to measure 1·05 to 1·15 mm. The larva, hatched from a tow-net egg, is figured. It has an irregular series of dorsal and ventral black chromatophores from the head to near the extremity of the tail.

Observations in January, 1898, show that large examples of *G. luscus* contained ripe ova, of which the largest measured 1·13 mm. one hour after extrusion into sea-water, on the 10th of the month. This dimension would be subject to further increase, but the eggs were not fertilised and died. Ova of corresponding dimensions, giving rise to larvæ resembling Cunningham's figure, first appeared on the 4th January, 1898, from grounds known to be frequented by *G. luscus.* It is therefore reasonably certain that Cunningham's identification is correct, and we have therefore associated with *G. luscus* those forms which in date, dimensions, and larval characters appear to sufficiently fulfil the required conditions. It will be seen that these ova, observed by Mr. Scott, occurred from the 28th January to the 6th February. The diameter ranges from ·90 to 1·10 mm., so that the eggs are rather small as compared with those obtained from parents in January of the present year. The smallest ova I have as yet found are derived from a female twelve inches long (20th Jan., 1898), and measure ·98 mm. after twenty-two hours' immersion in sea-water. If I am right in supposing that the smaller members of the species spawn later and have smaller eggs than their larger sisters, the small size of some of the 1897 tow-net ova is accounted for. The dimensions do not serve to distinguish them from eggs of *G. minutus*, but such evidence as I have points to a rather later spawning season for that species. Ten females, examined on the 12th January, 1898, were still far from ripe.

In every case when the development of the embryo was followed, the ova entered as *G. luscus* can be associated with the larva that appears to belong to this form. It is characterised by a *rather regular double series of dorsal and ventral black chromatophores*, extending from the head to the neighbourhood of the caudal extremity. In larvæ of a few days old the supra-cephalic ampullation, common to several if not to all Gadus larvæ, is well developed. *Only black pigment is usually visible*, but I am able to affirm the presence of yellow chromatophores also, an observation which explains existing discrepancies in the descriptions of various authors of other Gadus larvæ.

In the larvæ (of *G. luscus*) which I have observed no coloured chromatophores can be made out as long as the specimen is in full health and vigour; but a greenish or yellowish refraction is noticeable, often very faintly, on the salient parts, such as the front end of the yolk or the head. I have not succeeded by any manipulation of the light in detecting the presence of coloured chromatophores, and as a similar tinge is often visible in the blastodermic mound of a fish-egg, and certainly is not due in that case to pigment, I concluded that only black pigment was present. However, it so happened that a larva injured itself on the stage of my microscope, and during the development of the usual morbid symptoms I became aware of the presence of minute yellow chromatophores, rather closely set over the greater part of the skin.

It appears therefore that yellow chromatophores, though present in large numbers, cannot (in all cases, if at all) be detected in healthy larvæ. So far as my experience goes, a larva of *G. luscus* with conspicuous (*i.e.* contracted) yellow chromatophores would be exceptional.

In the case of *G. minutus*, I have seen and described Irish tow-net specimens, almost certainly belonging to the species, in which no yellow chromatophores were visible. The larva of this form was first described from the Mediterranean by Raffaele, its correct identification being beyond doubt. Only black pigment was observed; and larvæ observed by myself at Marseilles agree in this respect with Raffaele's description and figure; while, though only tow-net material was studied, the identification was, from the known fauna of the district, beyond doubt. I have seen similar larvæ at St. Andrews, yet M'Intosh's, the only British specimens hatched from artificially fertilised ova, are very conspicuously decorated with yellow chromatophores. (M'Intosh and Masterman. Pl. X., Figs. 1–3.) The absence of yellow pigment from Mediterranean larvæ may be actual as well as apparent, since a regional variation may very well exist in this particular. As to British forms, the figures (1 and 2) of M'Intosh's youngest larvæ appear to have been drawn from unhealthy specimens, and the yellow chromatophores appear to be contracted. It is possible, though I do not insist on the suggestion, that in perfectly normal British larvæ of *G. minutus* the yellow chromatophores may be too diffusely expanded to be conspicuous.

The larvæ of the cod and haddock have been so extensively studied that I do not think that yellow chromatophores, if present, could have failed to attract observation, for the other characters of these two species are sufficient to ensure their distinction (if occasionally coloured). Larvæ of the whiting have been described by M'Intosh and Prince, from artificially fertilised eggs, and by myself, from tow-net material, as profusely adorned with yellow. On the other hand Cunningham (*Journal*, N.S., i., p. 46, Fig. 34) makes no mention of yellow pigment in a larva which he refers to the whiting. It is possible that the yellow pigment, which seems to be usually conspicuous in this species, may be occasionally invisible as in *G. luscus*. Cunningham's ova, from which the supposed whiting larva was derived, measured 1·23 mm. in diameter, and were taken on the 6th February, 1888. I should myself regard this date as rather early for the species, but as my observations are far from complete, I am not inclined to set my own opinion against Cunningham's.

To return to *Gadus luscus*, the smallest Gadoid fish which can with certainty be referred to this species is 18 mm. long. The depth of the body is quite characteristic. Rows of dark chromatophores extend at the bases of the dorsal and anal fins to the first third of the posterior fin: each series is connected by a more or less continuous sheet of chromatophores which extends forwards, supra-abdominally to the top of the head. Dark patches are present on the distal part of the first and second dorsal and first anal fin. As this and a few other specimens of only a slightly larger size occurred at the end of May and beginning of June, it would appear that the rate of growth is slow, unless, as is probable enough, these examples were derived from late-spawned ova of small parents.

Gadus pollachius. *Linn.* Pollack, lythe.

M'Intosh, W. C. *11th Ann. Rep.*, *S. F. B.*, 1893, p. 246: *Dimensions of egg.*
14th Ann. Rep., 1896, p. 171, Pl. V.: *Egg, larva.*
Holt, E. W. L. *Sci. Trans. R. Dub. Soc.*, S. II., v., 1893, p. 55. *Egg.*

So far as they have been observed from material directly derived from the parent the egg measures, after fertilisation, from 1·10 to 1·14 mm., but as there is a large range of size among female pollack which have attained to sexual maturity, it is probable that the eggs show a more extensive variation than has been noted. The larva is only known from a prematurely hatched and obviously abnormal specimen figured by M'Intosh. It is impossible to say how far the pigmentation is characteristic of the normal condition, but Mr. Scott's notes deal with a larva which closely corresponds in this respect to M'Intosh's figure, and which appears to be perfectly healthy. It was hatched from ova of 1·40 to 1·45 mm. in diameter, taken a mile outside the Breakwater, on the 5th February. The larva measures 4·2 mm. in length, and has a single lateral row of stellate black chromatophores extending from the head to about midway along the tail. No other pigment was observed. The conformation, being that common to the genus, calls for no special remark. Mr. Scott has noted the resemblance, in character of egg and larva, to the haddock, *G. æglefinus.* The pigment, however, is more regular than in the haddock, which, in any case, is on account of its rarity practically eliminated from consideration. I believe that we have to do with the offspring of a large pollack, and that Mr. Scott has been the first to observe a normal larva of that species. I have no exact knowledge of the spawning season of the pollack on this coast, but the first young Gadus to appear in the tow-nets seem to connect themselves with older forms, having the specific characters of *G. pollachius*, so that this fish would appear to be one of the earliest spawners of the genus.

A smaller larva, 3 mm. in length, hatched from ova taken on the 15th February, is described by Mr. Scott as having no pigment at all. The eggs were not measured. I have seen a similar larva, hatched in transmission from the west coast of Ireland, but a yellowish tinge in this specimen may have been due to the presence of yellow chromatophores. It is possible that both these forms may be somewhat abnormal pollack, since the species seems to have but little black pigment as compared with others, although *G. minutus* has certainly not very much.

With regard to other ova of Gadus entered in our records I have only to say that they have been provisionally named in accordance with their apparent relationships. The dimensions, where noted, are given; the same remarks apply to the later stages, with which it is proposed to deal more fully when sufficient material has been accumulated.

Motella.—The Rocklings.

Our records comprise a great number of eggs which can be referred with certainty to the genus Motella. I do not think it is at present possible to identify them, in all cases, with any particular species. Ova directly derived from *M. mustela* and *M. tricirrata* have been described by Brook and M'Intosh and Prince (*M. mustela*) and by Raffaele (*M. tricirrata*). The descriptions do not, however, materially assist us to distinguish tow-net specimens, since the observed differences of dimensions might easily be obscured by variation in this respect. It is well-known that the newly extruded egg has usually a number of oil-globules which subsequently fuse into one. In the case of both the species mentioned the ova hitherto described as directly derived from the parent showed no colouration of the oil-globule. Raffaele, nevertheless, identifies with *M. tricirrata* a tow-net egg, having an oil-globule the colour of olive-oil. It is quite possible that this identification is correct, since the oil-globules of Solea (and Trachinus?) do not acquire their characteristic colouration until some time after extrusion. Other forms, which need not be recapitulated, give rise to ova in which the globules are coloured even before the egg is ripe, but this is not necessarily a constant feature. Thus from different females of *Trigla cuculus* and *Caranx trachurus* I have pressed ova of which the globules showed various phases of colouration, from a well-marked cupreous tint through paler shades to a practical absence of any distinct colour at all. The variation, in so far as I have observed it, usually affects individual parents and not individual ova from the same parent, but, while preparing these notes for press, I find among the ova just liberated by a large *Motella mustela* some few with distinctly cupreous globules, while those of the majority are colourless or only very faintly tinted. Its explanation probably involves a physiological and chemical discussion, which I am not qualified to enter upon. For my present purpose it suffices to point out that the known existence of such a variation renders it very unsafe to rely on resemblances or differences in colouration of the oil-globule for purposes of specific determination. I must plead guilty to having done so myself, since the Motella Sp. iii. of my Irish series (*Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 464, Pl. XLVII.; and v., 1893, p. 95, Pl. VI.) is chiefly based on the greenish colour of the oil-globule. I must add that I have since found that this greenish colour is identical with the olive-oil yellow of Raffaele, the former being converted into the latter by the use of a condenser. I am therefore of opinion that my Species iii. can no longer be regarded as sufficiently characterised.

M'Intosh and Masterman (*Life-Hist. Brit. Fish.*, 1897, p. 284) consider that they can distinguish three species of rockling eggs in the tow-net material of their district. I am in a less fortunate position here, for I cannot find among the large number collected any distinctive character which I consider absolutely reliable. Two rocklings, *M. mustela* and *M. tricirrata*, are certainly common here, and no doubt the eggs of both species have frequently come under the observation of Mr. Scott and myself, but it has not so far been possible to check the tow-net material by observation of the spawning of both species. I know that *M. mustela* was spawning in March, 1897, while it has been taken full of roe in January, 1898.*

Of the spawning of *M. tricirrata* in this district I know nothing definite; and the question is further complicated by the undoubted existence in the district of *M. cimbria* and *M. maculata*, and possibly of other forms which may require specific distinction. I do not suppose that the ova of *M. maculata* are small enough to be readily mistaken for

* During the months mentioned females full of roe were seined in the estuary, at the mouth of the Lynher in March, at the same place and also a little higher up the river in January. A specimen transferred to the Laboratory, on the 12th January, spawned at least as early as the 19th, since great numbers of eggs were found in the tank on that date. On the same day rockling eggs were found in Plymouth Sound in water which Mr. Garstang pronounced to be estuarine in character, so that it is practically certain that *M. mustela* spawns to some extent in the estuary. Rockling are known from Petersen's observations to spawn in the Limfjord.

those of other British species, but *M. cimbria* does not seem to be a very large form. The pelagic larval rockling, commonly known as "Mackerel midges," would afford more assistance to a knowledge of the spawning season if it were possible to identify them with absolute certainty, but it seems quite possible that those usually associated with *M. tricirrata* may not all belong to that species.

On the whole I do not think it would be profitable to enter at present upon a detailed discussion of the probable parentage to the tow-net ova. It may be noted that the eggs with colourless globules correspond in character with the descriptions of *M. mustela,* and in date with the known spawning period of that species at Plymouth. The cupreous colour of the globule, noted in several ova by Mr. Scott in January, is the same as has been referred to above as observed in newly extruded ova of the same species. The yellow, which under different conditions of illumination is either the "olive-oil" of Raffaele or the green of my Irish notes, has not been noted in ova directly derived from the female of any species. The ova with yellow globules, first observed in January, continued to occur until the middle of September, and after April were much commoner than those with colourless globules, of which the last was observed in June. If the yellow colour is really a constant character and occurs only in one species, then that species must have a spawning season of nine months. I have failed to recognise any differences in the pigmentation of larvæ with colourless and yellow globules respectively. In our records the colour of the oil-globule is stated whenever it was noted. The record of dimensions was very insufficiently kept by myself during the later months of the year, and it is partly on this account that I defer a discussion of this part of the question. It appears, however, sufficiently plain that there is considerable variation, not only in the diameter of the egg, but in that of the oil-globule, proportionally as well as actual, in ova which are similar in colouration of the globule and in embryonic and larval characters.

Mr. Scott's notes contain references to, and a drawing of, an egg with very numerous oil-globules. It is identical with a form described by M'Intosh and Masterman (p. 396, Pl. IV., Fig. 13) as closely allied to *Solea lutea*, and is in reality the egg of a rockling, probably liberated before it was perfectly ripe. I have seen very similar ova at St. Andrews, which ultimately, by coalescence of the oil-globules, assumed the ordinary appearance, and have also obtained them at Plymouth directly from a female of *M. mustela.* I do not think that any of the tow-net specimens were fertilised.

A "definite pale area, slightly refractive and apparently differentiated from the yolk," noticed by M'Intosh and Masterman (p. 296) in the egg of a rockling, is a common feature in unfertilised eggs of *G. luscus.* It is there associated evidently with imperfect maturation of the vitellus, and has probably no taxonomic value. If my recollection serves me, it occurs not infrequently in eggs other than those of the Gadidæ.

Unidentified egg, with apparently Gadoid characters.

Holt, E. W. L., *Sci. Trans. R. Dub. Soc.*, S. II., iv., 1891, p. 471, Pls. XLIX., L. *Unidentified egg and larva, Sp.* viii.
Holt, E. W. L., *Ann. Mus. Mars.*, v., 1898, Fasc. II. *Egg and larva.*

This species, the "unidentified Gadoid (?)" of our record, is certainly identical with the species of my Irish paper. I am able to add some details omitted in my former description, and have given more detailed figures in my paper in the *Annales du Musée de Marseille.*

The Irish specimens, taken in June, measured ·775 mm. with an oil-globule of ·14 mm. Examples taken at Plymouth in June and July are from ·84 to ·91 mm., the oil-globule from ·16 to ·17 mm.; in August from ·78 to ·84 mm., the oil-globule ·15 to ·17 mm. Two out of eleven eggs examined had two oil-globules in the early stages of development.

The yolk is homogeneous, the oil-globule dark but colourless, the perivitelline space small. The zona is devoid of any distinctive characteristics.

At about the epoch of the appearance of the caudal rudiment numerous minute black chromatophores appear on the trunk of the embryo and about the posterior hemisphere of the yolk. Very soon afterwards small yellow chromatophores are seen in company with the black. They are of a canary-yellow by reflected, golden-brown by transmitted light. Usually they rapidly assume a dendritic form, imparting to the region affected a diffuse yellow colouration, and practically masking the black chromatophores. In some cases, however, they remain simple, and the appearance of the embryo is greatly affected by their condition. Individuals showing the extremes of expansion and contraction of the chromatophores might readily be referred to separate species.

As is shown in my figures in the *Sci. Trans. R. Dub. Soc.*, Pl. X., Fig. 54, the larva appears to be Gadoid in character, that is to say the intestine terminates below the trunk, and does not extend to the edge of the ventral marginal fin-fold. This condition is well known to occur, exceptionally, in larvæ in no way related to the Gadoids, but its occurrence as a constant feature has only been observed within the limits of that group. Our knowledge of the Teleostean larvæ generally is not such as to justify us in saying that a larva of this character is necessarily Gadoid, although the presumption, whatever it may be worth, points in that direction.

I have examined at Plymouth five larvæ. All are recently hatched, and all have dendritic yellow pigment, so that it is probable that the chromatophores always assume this form before hatching takes place. The pigment has much the distribution shown in the figure of the Irish larva, but in the most recently hatched specimens there is none on the dorsal fin, which has no elevation anteriorly. Black chromatophores are present, but are almost entirely masked by the yellow. I suspect that they occurred also in the Irish specimen, but escaped my observation owing to the cabin of the S. S. *Fingal* being very badly lighted. In one Plymouth specimen there is no post-anal pigment except a single patch near the middle of the tail. The larvæ were exceedingly delicate, and only one survived even to the early stage of the Irish figure. It had acquired the same elevation of the anterior part of the dorsal marginal fin, accompanied, as in the Irish larva, by pigment. A Plymouth larva, apparently newly hatched, measures 2·02 mm. The Irish specimen, about twelve hours old, measured 2·68 mm.

I imagine that the normal larva exhibits no epidermal peculiarity. None was present in the Irish specimen, nor in one of the Plymouth examples. In others the skin was tuberculated, while in one I observed a reticulo-papillate condition exactly similar to that met with in Arnoglossus and in Sp. F of M'Intosh and Prince. The absence of submarginal pigment patches from the dorsal fin, coupled with the anterior elevation of that fin, sufficiently distinguishes the form before us from Sp. F, but otherwise a papillate specimen in which the connecting ridges are also developed comes very near to that supposed species; a fact which illustrates the danger of relying on the reticulo-papillate epidermal character for purposes of specific determination. The Laboratory was often very hot during the months in which these larvæ were obtained. My specimens, necessarily confined in small vessels for periodic observation, suffered great mortality, and I have no doubt that the tuberculation of the skin was simply pathological.

The question of the parent species must remain for the present quite uncertain. I am not at all satisfied that we are dealing with a Gadoid, but as the characters appear to connect the larva with that group rather than any other, it may be as well to consider whether any local Gadoid species can be reasonably regarded as the parent. It is unnecessary to recapitulate the forms of which the young stages are known, since their larvæ cannot possibly be confused with the one before us. There remain but a few species worthy of serious consideration. These include some of the rarer rocklings, Motella. *M. mustela* and *M. tricirrata* need not be considered. Their ova and larvæ, however difficult to distinguish from each other, are well known. *M. cimbria* exists, and may be common in the district, though rarely observed. *M. maculata* is known to me from a single specimen taken in Start

Bay. As it is not a shore species, it is quite impossible to say whether it is common or rare, since rockling can keep out of the way of ordinary fishing gear. I do not know to what extent we are justified in supposing that the ova and larvæ of the rocklings resemble each other. I certainly imagine that *M. cimbria* in its young stages resembles *M. mustela* and *M. tricirrata*, but *M. maculata* is a much larger and more brilliantly coloured fish. It is possibly, though not, as I think, very probably, the parent of the larva before us.

Phycis blennioides is regarded by the local fishermen as rare. I do not know any reason why it should not be often caught, if common. It is a deep-water fish on our coasts, but I have known one taken in Kenmare Bay in Ireland, and another was trawled here in Cawsand Bay some years ago, so that the species cannot be exclusively confined to deep water. Nothing is known of its ova and larvæ. The larva with which we are dealing shows an elevation of the dorsal fin, accompanied by pigment; a condition sometimes associated with the development of a filamentous ray, such as Phycis possesses in front of the first dorsal. Most of our ova were taken some way outside the Breakwater, though one occurred, on the ebb, in Cawsand Bay. I do not think that the balance of the evidence points very strongly to Phycis as the parent.

It must, in any case, be borne in mind that our records cover only a single year, and that, in certain features, an exceptional one. Mackerel were present in the inshore waters of Plymouth in the summer and autumn in very unusual quantity. "Mackerel Britt," that is to say young sprats and probably other young Clupeoids also, and scad old and young were also exceedingly abundant. Whether the young sprats were more abundant than usual I have no means of knowing, but whatever cause induced the influx of mackerel may have influenced other fish as well, while predaceous forms may have followed the mackerel. It is therefore quite possible that our ova and larvæ may belong to some species which does not usually occur, at any rate in the spawning season, in the neighbourhood of Plymouth. Their occurrence or absence in succeeding years may throw some light on this point.

Atherina presbyter. *Linn.* Sand smelt.

I believe that the young stages of the sand smelt are for the first time described and figured by myself in the *Annales du Musée de Marseille*, 1898. Agassiz, however, long ago figured the larvæ of the American *Atherinichthys notata* (*Proc. Amer. Acad.*, xvii., 1882, p. 277, Pls. X., XI.), which are very similar. The ova and larvæ of the Mediterranean *A. hepsetus* have been described by Raffaele (*Mittheil. Zool. Stat. Neap.*, ix., 1889, p. 306), and of this species a description, with figures, of the egg and early larva has been given by Marion (*Ann. Mus. Mars.*, iv., 1891, Fasc. I., VIII., p. 93, Pl. I.). Various larval stages of *A. Boyeri*, which is said to have occurred in British waters, are figured and described by myself in the paper alluded to.

It is rather remarkable that the presumably conspicuous eggs of the sand smelt have never come under the notice of naturalists. Such Atherine ova as are known are of large size, and furnished with long attachment filaments arising from all parts of the zona. In this character they are indistinguishable from the ova of the Scombresocidæ. In both families, as far as one can judge from limited material, the yolk appears to be translucent and practically homogeneous. One or more species of Atherina exhibit a number of small oil-globules, while in one species of Belone there are none. It is impossible to say to what extent the members of the respective families adhere to this distinction, which is, after all, of little importance. The fact remains that in the general characters of the egg the Atherinidæ and Scombresocidæ, though not apparently very closely related, are practically identical.

The larvæ of all Atherines seem to be very much alike. I found no difficulty in identifying those of *A. presbyter* from their resemblance to Agassiz's figures of *A. notata*. My specimens were found swimming at the surface in rock pools at Penzance on the 22nd June, 1891. They were in two shoals, each occupying about the space of the palm of a hand, the individuals very closely packed and hardly visible but for the large blue eyes and the black patch on the pia mater of the mid-brain. Each shoal consisted, as I suppose, of the hatch of a single clutch of eggs; in any case, the individuals were all of about the same size. A specimen from the younger shoal measured 9 mm., one from the older shoal 11·5 mm. The figures of Agassiz, Raffaele, Marion, and my own illustrate equally well the general conformation. The main features are the rounded head, large eye, very short abdomen, and very long tail. In the specimens of 9 mm. the pre-anal length is only 2·09 mm. In those of 11·5 mm. the same region measures 3·15 mm.

The smaller specimens, judging by Marion's figures of *A. hepsetus*, are probably, at most, a few days old, but the organs of the head are well developed, although the large otocyst shows but little internal complication. The yolk appears to have been entirely absorbed; an air-bladder is present, though not clearly visible on account of the dense black pigmentation of the abdominal roof. In serial transverse sections I failed to find any connection between the bladder and the alimentary canal. The large fan-shaped pectorals extend some way beyond the anus; they are entirely devoid of pigment. In this respect, therefore, the young Atherine offers a marked contrast to the young Blenny, which it otherwise resembles rather closely. The end of the multicolumnar notochord is not yet upturned, but there is a slight opacity of the sub-notochordal region, marked by a black chromatophore and by a number of embryonic caudal rays. The marginal fins are of moderate width. The dorsal arises a little behind the level of the anus: both dorsal and anal are constricted in the peduncular region, expanding again to form the spatulate caudal. The notochord is multicolumnar. The brain-tissues are of a bright yellow colour, not apparently due to pigment. Very large black chromatophores occur in the pia mater of the mid-brain in variable number. The roof of the peritoneal cavity is densely coated with black, intermingled with yellow pigment. Elongated black chromatophores occur at intervals along the lateral line. Black chromatophores occur variably along the dorsal and ventral margin of the post-anal region. The marginal fins are devoid of pigment.

In the specimens of 11·5 mm. the trunk is deeper, the snout longer and more pointed. The abdomen is, proportionally as well as actually, somewhat elongated. The gills have become pectinate. The notochord shows signs of segmentation, and its extremity is upturned by the development of a tri-lobed hypural mass. Embryonic fin-rays mark the sites of the second dorsal and anal fins. The axis of the pectoral is obliquely rotated. Pigment changes are chiefly confined to a backward extension of the dorsal cephalic chromatophores.

I did not again meet with the young sand smelt until the 14th July, 1897, when I caught several at low water in Falmouth Harbour, above St. Mawes. They were swimming in a small shoal near the surface at the point of a projecting rock, a habit I have noticed in similar stages of the Mediterranean *A. Boyeri*. The specimens caught were of various sizes. Apart from the fact that *A. presbyter* is practically the only British Atherine, the larger specimens can readily be identified with that species by the fin-ray formula.

A specimen of 12 mm. has the abdomen relatively short, the anus still remote from the anal fin. The pelvics are in the form of small flaps on either side of, and a little above, the anus. A conspicuous fold of embryonic fin is present in front of the true anal, and, in fact, the embryonic marginal fin is still continuous. The tail is in the heterocercal condition, the urochord projecting freely. At 18 mm. the pelvics, with well-developed rays, have united on the ventral surface, the anus having migrated in a posterior direction. The caudal fin is homocercal. An isolated fragment of the embryonic marginal fin persists between the anus and the anal fin.

At 22 mm. the fragment of embryonic fin is still present. The anus has nearly, but not quite, reached the limit of its posterior migration. Even in the adult condition there is between the anus and the anal fin a greater interval than in most Teleosteans, and I imagine that this may be due to the rather recent suppression of an anterior part of the anal, now represented only by the vestige of the embryonic fin fold. The second dorsal and the anal fins have the adult formula, viz., 1/14, 1/16. The first dorsal is still but little developed. No scales are as yet visible.

Compared with similar stages of *A. Boyeri* the larva of *A. presbyter* can be distinguished by the smaller eye, and by the greater length in relation to the degree of development. A young *A. Boyeri* of 32·5 mm. exhibits a stumpy fin-ray midway between the first and second dorsal fins, and in front of and behind this ray are a series of tubercles which are evidently of a similar nature.* These structures represent, I imagine, the vestiges of a continuous dorsal fin, and afford support to the supposition that the restriction of the dorsal and anal fins is of comparatively recent date.

The larval *A. presbyter* of 22 mm., though presenting the broad features of adult Atherine conformation, is still far from exhibiting the adult pigmentation. The lateral "stole" in particular is very imperfectly represented. Young *A. Boyeri* of the same size are much more advanced in this respect as in others.

I suppose that sand smelts, on account of the robust character of the larva, and its capability of assimilating comparatively large organisms, could be artificially reared with much less trouble than most other marine food-fishes, but their economical value is hardly sufficient to encourage the attempt. The larval stages appear to me to be chiefly interesting from the taxonomic point of view. It is generally conceded that the Atherines and the Grey Mullets are closely allied, yet in their ontogeny they differ most widely. The eggs of the former are, as we have seen, large, demersal, and furnished with long attachment processes. Some, at least, of the Grey Mullets have

* Vestigial fin-rays have been observed in the larvæ of another fish; but I cannot recall either the species or the name of the observer.

small pelagic eggs, and none, I believe, are known to have eggs furnished with attachment processes. It is true that Ryder at one time supposed that the ova of *Mugil albula* resembled those of the Atherines;* but as no observations have been brought forward in proof it may be supposed that this view was subsequently abandoned. *M. albula*, a species of which Günther could find no description (Cat. iii., p. 410), has been subsequently identified by naturalists of the U.S. Fish Commission with *M. cephalus*.

It has recently been stated by Sir James Hector (*Protection of Mullet*, Parliamentary paper, New Zealand, Sess. II., 1897, H.–17) that the eggs of the New Zealand *M. Perusii* are demersal, the proof being that ova described as ripe sank in sea-water. Further observations, especially with material the ripeness of which can be demonstrated by its impregnation, are certainly desirable, since the controversy as to the pelagic or demersal nature of the pilchard's egg furnishes ample proof that naturalists of considerable experience may sometimes be mistaken on this point. The matter is, however, of no great importance in connection with my present remarks, for the marked difference which exists between the ova of Atherines and Grey Mullets is not materially lessened by some of the latter being demersal.

The difference in the larvæ of the two families is at least as striking. One naturally expects that the larva newly hatched from a large demersal egg will be larger and more advanced in development than a larva from a small pelagic egg, and this holds good in most respects in the case before us. But in one particular, viz., the elongation of the abdominal region, the larva of the Grey Mullet is, at hatching, very far in advance of the young Atherine. In fact a glance at Raffaele's figure (*op. cit.*, Pl. II., Fig. 17) shows that an extensive elongation of the abdominal region has no part in the metamorphosis of the larva. The much more advanced larva referred by Cunningham (*Journ. M. B. Assoc.*, N.S., ii., 1891, p. 73, Pl. IV.) to *M. chelo* confirms this, while the larvæ entered in our records illustrate a further point. These larvæ are similar in size and conformation to Cunningham's, and require no separate description beyond the remark that the positions of the second dorsal and of the anal fin are clearly indicated by the developing fin-rays. The anus is just in front of the anal fin, a position never attained in the backward migration of the anus in the Atherine larva.

In comparing the Atherine with the Grey Mullet larva it therefore

* *Bull. U.S. Fish Comm.*, i., 1881, p. 283.

appears that the former passes through a long-tailed phase, which is not at all represented in the latter. The question is, Has this phase been suppressed in the ontogeny of the Grey Mullet, or has it been evolved as a specialised feature in the phylogeny of the Atherine? since the adult resemblances probably justify us in regarding both as derived from a common stock. I do not think that the knowledge which we at present possess of the systematic relations of individual groups of Teleostean fishes furnishes us with any answer. I believe it is generally held that the forms with elongated abdominal cavities are the more primitive, or it may rather be said that an elongated abdomen is most commonly met with in what appear to be the more primitive members of the Teleostomi. So far as concerns the families with which we are now dealing, the elongated abdomen appears less primitive, since the arrest in this elongation in Atherina would seem, from the evidence of the persistent ventral embryonic fin and of the vestigial dorsal rays, to result from the more recent restriction of the permanent dorsal and anal fins in that genus to the proportions which are now common to the adults of both families. The force of this evidence depends of course on the assumption that a continuously rayed fin-fold is a primitive condition, and is never achieved by a reversion from an intermediate detached-finned condition.

I am not acquainted with any British larvæ of Mugil except those already alluded to; but a Mediterranean specimen of 14 mm. (figured in my paper in *Ann. Mus. Mars.*, and referred from local considerations to *M. auratus*), appears to afford some evidence of the relative antiquity of the Atherines and the Grey Mullets. In essential features of conformation it is a true Mugil, but it exhibits a most distinct black "stole" or lateral pigment band. This is a feature of the adult Atherine, but not of the adult of any Grey Mullet with which the specimen can be associated; nor, as far as I know, of any Mugil at all. The appearance of this "stole" as a transitional larval pigment-phase of Mugil and its retention in Atherina must be regarded, if of any value as evidence of phylogeny, as indicating that the latter is the more primitive form. The resemblance, however, may be merely superficial, since I cannot say that the pigment stripe of the young Mugil is ever associated with the peculiar characters of the "stole" of the adult Atherine.

Coming to the characters of the ova, the large demersal type appears, *prima facie*, to be that most suitable to the requirements of the presumably fluviatile ancestors of modern Teleostei, which is perhaps the most conclusive argument forthcoming. The attachment process of the zona of the Atherine egg certainly indicates a high degree of specialisation; but, as such would presumably be lost in the evolution of the pelagic from the demersal type, they are not necessarily important in this connection. It may be noted, however, that the ova of all the Blennies studied by Guitel have precisely similar filaments for attachment, only they are confined to the neighbourhood of the micropyle. It has already been remarked that the early Atherine larva closely resembles that of the Blenny, a form in which the ontogeny is marked by no material change of conformation and by hardly any reduction of the embryonic fin area. It is chiefly by the absence of marked Acanthopterygian characters that the Mugiliformes and Blenniiformes are placed close together in modern classifications, and the larval resemblances are perhaps evidence of the correctness of their proximity.

So far as I can see, the points noted above certainly appear to suggest that the Mugilidæ have been evolved from an Atherine-like type, the long-tailed larval phase being suppressed in the ontogeny, while there is a further suggestion that both Atherines and Blennies are derived from a common ancestor resembling the latter in general characters.

I am, however, far from seeking to imply that all Teleosteans with elongated abdomen are similarly derived. In fact it can hardly be doubted that the Blenny-like form is, in respect to the abbreviation of the abdomen, already far from primitive. This is the conclusion arrived at by Raffaele, who has discussed in beautifully illustrated detail the migration of the anus in *A. hepsetus*. He regards as primitive the condition in such fish as the Clupeoids and Salmonoids. The secondary condition is retained throughout life in the Blennies, while a tertiary condition is attained by such an ontogenetic migration as takes place in Atherina. My own contention is that Mugil, which Raffaele does not seem to have had an opportunity of studying, belongs also to this tertiary group, an ancestral secondary phase being suppressed in its ontogeny.

Unidentified larva.

I am unable to identify a vitelligerous larva found by Mr. E. T. Browne in tow-net material from near the merchant moorings in Plymouth Sound on the 22nd September. I did not see it until after it had been preserved in formol.

The total length is 2·09 mm., of which the pre-anal part occupies ·90 mm. The rectum is separated from the yolk by an interval of ·21 mm. The yolk is still fairly large, there is no oil-globule; and I cannot make out any cortical segments, though such may have been present at an earlier stage. The marginal fins are broad, the dorsal commencing in front of the head. Black chromatophores are present on the head, along the dorsum in a continuous row as far as the middle of the tail. A few occur on the ventral part of the trunk and on the rectum. There are several large dendritic black chromatophores on the dorsal near its margin, while two are seen on the post-anal part of the ventral. A patch of pigment occurs above and below the caudal extremity. In all cases the black pigment of the marginal fins is accompanied by paler chromatophores, the colour of which has been destroyed by the reagent. I cannot speak definitely as to the nature of the notochord. The stage of development suggests most strongly that the larva is derived from a pelagic egg. It may possibly be a belated specimen of *Callionymus lyra*, but it does not closely agree with any example of that species which I have seen.

Clupea harengus.—*Linn.* Herring.

The young stages of the herring may be most conveniently reserved for consideration in connection with the distribution of young fishes in the Plymouth district. I only purpose at present to call attention to the occasional occurrence of an abnormal feature in the egg. It is well known that the ova of the pilchard and sardine and of the shads are characterised by the formation, after immersion in sea water, of a very large perivitelline space. The sprat ovum has only a very small perivitelline space, while that of the herring ovum is normally of moderate proportions. It is difficult to take accurate measurements if the spawn is allowed to adhere together, since the zona is then apt to assume a polyhedral form, but this can be obviated by the use of starch as recommended in the United States *Manual of Fish Culture.* I find among the spawn of three fish treated in this way, that the largest normal eggs measure 1·76 mm. in total diameter, the yolk mass measuring 1·25 mm., 24 hours after fertilisation. There are, however, several eggs of a much larger size. One slightly elliptical, but not at all flattened, has the greatest diameter 2·42 mm., the least 2·34 mm.; it appears to be as large as any. It must be remarked that these specimens are all dead, as in all previous instances of abnormally large herring eggs which have come under my notice. So far as I can judge, the excess in size is confined to the perivitelline space, but it is not the case that dead herring ova have usually a larger space, that is to say a more inflated zona, than living specimens. The latter are usually the larger, at least when death takes place at an early stage.

I do not suppose that this observation is new to those who have had to deal with herring spawn, but I do not remember to have seen it recorded. It shows that the perivitelline space may exhibit exceptionally an approach to the dimensions normal in the shads and pilchard. It may also help us to an appreciation of the due value of the perivitelline space as a character in the determination of undescribed ova. Cunningham has made known the occurrence in the egg of the pilchard of an exactly converse variation (*Journal*, N.S., iii., p. 150).

A Record of the Teleostean Eggs and Larvæ observed at Plymouth in 1897.

By

Ernest W. L. Holt and S. D. Scott, B.A.

Abbreviations employed: sev. = several; m. = many; v.m. = very many; o.g. = oil globule.

For convenience of tabulation the different stages of development have been divided into three groups: Stage I. = if fertilised, stages up to the outgrowth of the eyes; II. = from I. up to the appearance of the caudal rudiment; III. = from II. up to hatching.

Since the ova were not always examined immediately after their capture, it has been necessary in many cases to compute the stage exhibited at that time. The divisions indicated above being fairly broad, the results set forth below are probably near the mark. Confusion is most liable to have occurred between Stages II. and III.

All dimensions are given in millimetres.

Date.	Locality.	Position of Net.	EGGS.					LARVÆ.		
			No.	Species.	Diam. of Egg.	Diam. of oil globule.	Stage of Development.	No.	Species.	Length.
					mm.	mm.				mm.
Jan. 18.	1 to 3 miles off	...	m.	*Clupea sprattus.*	1·00					
	Mewstone.	...	1	Motella, o.g. colourless.	·70	...	I.	sev.	Clupea harengus.	
	...	...	2 or 3	Motella, o.g. colourless.	·78–·80					
	...	...	2	*Pleuronectes platessa.*						
,, 27.	2 mls. S. of Break-	...	...	C. sprattus.	...	...	...	1	Motella.	7·
	water Fort.	...	1	Motella, o.g. ∞	·66					
	...	...	...	Motella, o.g. colourless.						
,, 28.	Off Mewstone.	...	1 or 2	C. sprattus.						
	...	...	1	Motella, o.g. yellow.	·75					
	...	...	4	Motella, o.g. cupreous.	·675	...	I.			
	...	...	m.	Motella, o.g. colourless.	·75	...	I.			
	...	...	2	*Gadus luscus.*	1·1	...	III.			

					mm.	mm.				mm.
Jan. 29.	1 mile S.W. of Eddystone.	...	v.m.	C. sprattus.	·97–1·1	...	I., II., III.			
		...	3	Pl. platessa.	1·75–1·80					
	...	...	2	*Pl. microcephalus.*	1·3–1·5	...	II., III.			
	...	...	sev.	G. luscus.	·96	...	III.			
	...	...	6	*Callionymus lyra.*	·90	...	III.			
Feb. 1.	1 mile S. of Breakwater Fort.	...	m.	C. sprattus (mostly 1·00 mm.).	·95–1·05	...	...	1	Agonus cataphractus.	8·
	...	...	3	G. luscus.	·97, 1·, 1·05					
	...	...	sev.	Motella, o.g. colourless.	·75 (·70–·78)	...	I.			
	...	...	3	Motella, o.g. colourless.	·75	...	II.			
	...	...	1	Motella, o.g. colourless.	·82	...	III.			
,, 4.	W. Channel, 1 mile from Breakwater.	Surface.	nil.	...	...	...	...	nil.		
		Midwater.	70–80	Motella, o.g. colourless.	(mean) ·75	...	I.	1	Centronotus gunnellus.	7·
	...	Bottom.	3	G. luscus.	·93–·95					
,, 5.	1 mile S. of E. end of Breakwater.	...	v.m.	C. sprattus.						
		...	m.	G. luscus.	·93 (·9–·99)	...	III.			
	...	...	4	*Gadus pollachius.*	1·4–1·45	...	III.			
	...	...	3	C. lyra.	·83					
	...	Surface.	...	...	...	...	...	m.	C. harengus.	
	...	Bottom.	...	...	...	...	...	m.	C. harengus.	
,, 6.	½ mile S. of Breakwater Fort.	...	1	C. sprattus.	1·00					
		...	4	G. luscus.	·90, ·95, ·97, ·97					
	...	...	2	Gadus sp.	1·19, 1·20					
	...	...	2	Motella, o.g. colourless.	·75					
	...	...	2	Motella, o.g. colourless.	·73					
,, 8.	Off Mewstone.	Bottom.	∞	C. sprattus.	·98–1·30	...	I.	m.	C. harengus.	
	...	Surface.	m.	C. sprattus.	...	...	I., III.	sev.	C. harengus.	
	...	...	2	Pl. platessa.	1·85, 1·93	...	III.			
	...	...	2	Pl. microcephalus.	1·40, 1·43	...	III.			
	...	...	2	G. pollachius (?).	1·23	...	II.			
	...	...	...	G. luscus.	·95–1·00	...	I., II., III.			
	...	...	v.m.	Motella, o.g. colourless.	·75	...	I., II., III.			

Date.	Locality.	Position of Net.	EGGS.					LARVÆ.		
			No.	Species.	Diam. of Egg.	Diam. of oil globule.	Stage of Development.	No.	Species.	Length.
					mm.	mm.				mm.
Feb. 9.	West Channel.	Surface.	f.	Motella, o.g. colourless?	...	...	...	f.	C. harengus.	
	...	Midwater.	nil.	...	...					
	...	Bottom.	nil.	...	...					
,, 10.	West Channel.	...	nil.	...	...	...	...	2	A. cataphractus.	7·, 9·
,, 11.	West Channel.	...	nil.	...	...	...	...	1	A. cataphractus.	6·5
,, 12.	½ mile S.W. of Yealm Head.	...	v.m.	Motella.	·70–·83					
		...	...	C. sprattus.	...					
	...	Bottom.	...	Gadus sp.	·95–1·00					
,, 15.	1 mile S. of Mewstone.	Surface.	600	Motella, o.g. colourless?	...	...	I.			
		...	1	Motella, o.g. ∞	·76	...	I.			
	...	...	20	C. sprattus.	...	...	I.			
	...	...	6	G. pollachius?	...					
	...	...	1	*Topknot.*	1·06					
	...	Bottom.	3	Motella.						
	...	...	3	C. sprattus.						
	...	...	1	G. pollachius.						
,, 19.	West Channel.	Surface.	50	Motella, o.g. colourless	...	...	...	1	Cottus bubalis.	7·3
	...	...	1	C. sprattus.	...	...	...	1	Gobius minutus?	3·4
	...	...	1	Gadus sp.						
	...	Bottom.	50	Motella.						
	...	...	2	C. sprattus.						
	...	...	5	Gadus sp.						
	...	...	1	Pl. microcephalus.	...	...	III.			
,, 23.	½ m. S. of Breakwater Fort. (2 hauls.)	Surface.	23	Motella, o.g. colourless?						
		...	18	C. sprattus.						

					mm.	mm.				mm.
Feb. 23.	½ mile S. of Breakwater Fort.	Surface.	7	Gadus sp.		...				
	(2 hauls.)	...	2	G. pollachius.	1·14, 1·15		III.			
		...	1	C. lyra.						
	...	Bottom.	7	Motella, o.g. colourless ?	...	..	...	1	Unidentified.	8·6
	...	...	2	C. sprattus.						
	...	...	7	Gadus sp.	·92					
	...	...	2	G. pollachius ?	1·13, 1·22					
	...	...	1	C. lyra.						
,, 24.	3 miles S.W. of Breakwater Light.	Surface.	150 ca.	Motella, o.g. colourless ?	...	...	Most I.			
		...	1	C. sprattus.						
		...	1	Gadus sp.						
	(2 hauls.)	...	1	Pl. microcephalus ?	1·25					
	...	...	1	Topknot.	1·05					
	...	Bottom.	240	Motella, o.g. colourless ?						
	...	...	3	C. sprattus.						
	...	...	9	Gadus sp.						
	...	...	1	G. pollachius ?	1·26					
	...	...	1	Pl. microcephalus.	1.46					
	...	...	1	Pl. platessa.	1·85					
,, 25.	Plymouth Sound.	...	240 ca.	Motella, o.g. colourless ?						
	...	...	1	Pl. microcephalus.	1·40					
,, 26.	½ mile S. of Breakwater Fort.	Surface.	37	Motella, o.g. colourless ?						
		Midwater.	60	Motella, o.g. colourless ?						
	...	...	1	G. pollachius ?						
	...	...	1	Topknot.	1·02	·19				
	...	Bottom.	17	Motella.						
	...	...	1	Gadus sp.						
Mar. 1.	½ mile S. of Breakwater Light.	Surface.	120	Motella, o.g. colourless ?						
		(2)	2	Motella, o.g. ∞	...	∞	I.			
	...	...	3	C. sprattus.						
	...	...	1	Topknot.	1·04	·21	II.			
	...	...	3	Topknot.	·99, 1·05, 1·08	{·18, ·17, ·19}	I.			
	...	...	7	Gadus sp.						

Date.	Locality.	Position of Net.	EGGS. No.	EGGS. Species.	EGGS. Diam. of Egg.	EGGS. Diam. of oil globule.	EGGS. Stage of Development.	LARVÆ. No.	LARVÆ. Species.	LARVÆ. Length.
					mm.	mm.				mm.
Mar. 1.	½ mile S. of Breakwater Light.	Surface.	1	G. pollachius ?	1·2	...	I.			
		Bottom.	20	Motella, o.g. colourless?						
	...	...	1	C. sprattus.						
,, 30.	Off Mewstone.	...	54	C. sprattus.	·87–·96	...	I., II., III.	1	G. pollachius ?	3·93
	...	...	1	Motella, o.g. colourless?	·80	·12				
	...	...	8	Pl. flesus.	·96–1·13	...	I., II.			
	...	...	1	Pleuronectes sp.	1·23	...	I.			
	...	...	1	*Gadus merlangus.*	1·21	...	II.			
	...	...	1	G. pollachius ?	1·19	...	II.			
	...	...	1	C. lyra.	·91	...	III.			
	...	...	1	*Trigla gurnardus ?*	1·53	·30	III.			
	...	...	2	Topknot.	·90–·91	·13	III.			
	...	...	3	Topknot.	1·04–1·07	·19–·21	III.			
April 5.	Cawsand Bay.	Surface.	1	G. merlangus.	1·20	...	II.			
	...	...	1	Not identified.	·954					
	...	...	1	C. lyra.						
	...	...	1	Topknot.	1·033	·173				
	...	...	5	Motella, o.g. colourless?	·73–·87					
,, 8.	Off Mewstone.	...	...	Eggs not recorded.	...	...	...	1	Rhombus punctatus (periotic spines).	5·11
	...	...	...	...	...	...	...	sev.	Rh. punctatus ? (vitelligerous).	
	...	...	...	...	...	...	...	1	Solea vulgaris.	
	...	...	...	...	...	...	...	sev.	Unidentified.	
,, 22.	Jennicliff Bay.	Surface.	2	*Solea vulgaris.*	...	...	III.	2	G. pollachius ?	7·
	Plymouth Sound.	...	1	C. lyra.	...	...	II.	3	Pl. flesus.	9·–9·75
	...	...	...	...	...	...	...	2	C. sprattus.	9·, 10·

					mm.	mm.				mm.
Ap. 24.	Jennicliff Bay.	Surface.	...	Eggs not observed.	...	...	...	1	G. pollachius.	10·
	...	...	...	...	...	...	...	1	Agonus cataphractus.	16·25
	...	...	...	...	...	...	...	1	Rh. punctatus (periotic spines).	4·5 ca.
,, 27.	Outermost Buoy of West Channel.	Surface.	4 +	Motella, o.g. colourless.	·75	·14	I.	3	G. pollachius ?	11·–14·
		...	4	Motella, o.g. yellow.	·69–·81	·15–·17	I.	6	Pl. platessa ?	10·5–12·
	...	...	8	*Ctenolabrus rupestris.*	·90–1 01	...	I.			
	...	...	2	C. sprattus.	·96	...	I.			
	...	...	15 +	Topknot.	·98–1·04	·16–·18	I.			
	...	...	1	Topknot.	1·02	·21	I.			
,, 29.	Jennicliff Bay.	Surface.	1	G. merlangus ?	1·15	...	I.			
	...	...	m.	Motella, o.g. colourless.	...	...	I.	2	G. pollachius ?	6·5, 10·
	...	...	5 ca.	Motella, o.g. yellow.	·69, ·72	·15, ·16	I., III.	5	C. sprattus	8·–13·
	...	...	...	...	...	...	...	9	Pl. flesus.	9·–11·5
May 3.	W. Channel, outer Knap Buoy.	Surface.	1	C. sprattus.	·96	...	III.	3	G. pollachius.	4·75–9·5
		...	2	*Gadus minutus* ?	·94, ·96	...	I., III.			
	...	...	2	C. lyra.	·85, ·87					
	...	...	6	Motella, o.g. yellow.	·70–·74	·15–·18	I.			
	...	...	1	Motella, o.g. yellow.	·80	·15	I.			
,, 5.	1 mile S.S.W. of Breakwater Light.	Surface.	...	C. lyra.	...	...	...	1	G. pollachius ?	
		...	1	G. merlangus.	1·2 ca.	...	...	6	G. pollachius.	5·–9·
	...	...	...	...	...	...	...	1	Liparis.	4·25
	...	...	...	...	...	...	..	1	C. lyra.	3·5
	...	...	...	...	...	...	...	2	Gobius minutus ?	4·5, 6·5
,, 7.	Off Mewstone.	Surface.	1	C. lyra.	...	...	II.			
	...	...	2	C. sprattus.						
	...	...	4	Motella, o.g. yellow.	·67–·72	·16–·17	III.			
	...	...	2	Motella, o.g. colourless.	·68, ·70	·14	I.			
	...	Bottom.	...	Eggs not recorded.	...	...	...	5	Gadus minutus ?	5·–9·
	...	Bottom.	2	Motella, o.g. yellow.	·72, ·75	·15, ·16	I.			
	...	...	1	Motella.	...	...	III.			
	...	..	1	C. lyra.	·80	...	I.			

Date.	Locality.	Position of Net.	EGGS.					LARVÆ.		
			No.	Species.	Diam. of Egg.	Diam. of oil globule.	Stage of Development.	No.	Species.	Length.
					mm.	mm.				mm.
May 8.	1 mile N.E. of Eddystone.	Surface.	1	C. lyra.	·85	...	II.	10	G. pollachius.	7·–20·75
	...	...	3	C. rupestris.	·90–·92	...	I.	1	Motella.	6·
	...	...	...	...	...	...	...	1	Motella.	18·
	...	...	...	...	...	...	...	1	Aphia.	
	...	Bottom.	...	Eggs, if present, not examined.	...	...	...	9	Gadus minutus?	5·–6·5
	...	...	...		...	...	...	1	Motella.	5·
	...	...	...	...	...	...	...	1	Motelloid? (very long pelvics).	6·5
	...	...	...	...	...	...	...	3	Pl. limanda.	9·
	...	...	...	...	...	...	...	1	C. lyra.	3·5
	...	...	...	...	...	...	...	2	Belone vulgaris.	10·, 14·
	...	...	...	...	...	...	...	2	Topknot (no cephalic spines).	3·, 5·, 8·
	...	...	...	...	...	...	...	2	Pl. microcephalus.	6·5, 10·25
	...	...	...	...	...	...	...	2	Solea vulgaris.	7·5, 8·
,, 13.	Inner part of Whitsand Bay.	Surface.	sev.	C. lyra.	...	...	...	1	G. pollachius.	10·
		...	1	G. merlangus.	1·27					
	...	Bottom.	...	...	...	...	...	2	G. pollachius.	8·, 10·
	...	...	...	...	...	...	...	9	Pl. limanda.	11·–19·
	...	...	...	...	...	...	...	1	Liparis.	9·
,, 15.	Tamar River above Saltash.	Bottom.	nil.	...	...	...	...	2	G. pollachius.	11·, 14·5
		...	...	...	...	...	...	1	Pl. limanda.	14·
	...	...	...	...	...	...	...	1	Mugil chelo.	11·5
	...	...	...	...	...	...	...	4	C. harengus.	20·–30·
	...	...	...	...	...	...	...	2	Gobius minutus.	15·, 15·5
,, 17.	Yealm Zostera Bed.	Bottom.	...	...	...	...	...	1	G. pollachius.	23·5
		...	...	...	...	...	...	1	Pl. limanda.	14·
	...	...	...	...	...	...	...	1	M. chelo.	11·5

					mm.	mm.				mm.
May 18.	Tamar River, below	Bottom.	...	...	...	...	...	5	Gobius minutus ?	5·9, 15–5
	Saltash.	...	...	...	...	...	...	1	M. chelo.	9·
		...	...	...	...	...	...	2	C. harengus.	24·, 29.
,, 19.	Cawsand Bay.	Bottom.	...	...	...	...	...	1	Gadus minutus.	18·5
	...	...	...	...	...	...	...	30 +	G. pollachius.	19·–24·
	Jennicliff Bay.	Bottom.	...	...	...	...	...	2	Gadus minutus.	18·, 34·
,, 20.	1½ mile S. by E.	Midwater.	nil.	...	...	...	...	nil.		
	of Mewstone.	Surface.	4	C. rupestris.	...	...	I.	1	G. pollachius.	24·
	...	...	...	...	...	...	...	2	G. pollachius.	12, 14·5
,, 21.	Jennicliff Bay.	Surface.	3	C. rupestris.	·87	...	I.	4	Gadus minutus ?	9·–11.
	...	...	2	Motella, o.g. yellow.	...	...	...	4	Motella.	3·25–7·
	...	...	...	...	...	...	...	1	Motella.	19·
	...	...	...	...	...	...	...	1	Ammodytes sp.	6·5
	...	Bottom.	...	...	...	...	...	5	G. pollachius.	14·5–20·
	...	...	...	...	...	...	...	3	Pl. limanda.	13·–14·5
,, 22.	Jennicliff Bay.	Surface.	...	...	...	...	...	1	C. lyra.	8·
	...	...	...	...	...	...	...	2	Gadus minutus ?	9·, 11·
	...	Bottom.	...	...	...	..	...	1	Gobius minutus ?	8 ca.
	...	...	...	...	...	...	...	7	Aphia pellucida.	8·–10·5
,, 25.	400 yards off the	Surface.	1	Motella, o g. yellow.	...	...	I.	1	Solea vulgaris.	11·
	Start.	...	...	...	...	...	...	1	Gadus minutus ?	10·5
	Start Bay, 150 yds.	Bottom.	...	...	...	...	...	2	Gadus luscus.	18·, 20·5
	off Slapton Sands.	...	...	...	...	...	...	21	Gadus minutus.	16·5–28·5
	Start Bay, 100 yds.	Bottom.	...	...	...	...	...	10	Gadus minutus.	17·5–25·
	off Slapton Sands.									
	Start Bay, off N. end	Bottom.	...	...	...	...	...	1	Solea vulgaris.	10·5
	of Slapton Sands.	...	...	...	...	...	...	...	Pl. limanda.	
,, 26.	Start Bay, trawling	Surface.	1	*Solea lutea.*						
	ground.	Bottom.	...	...	...	...	...	1	Pl. limanda.	17·75
	Start Bay, Black-	Bottom.	...	...	...	...	...	2	Pl. limanda ?	10·
	pool.	...	...	...	...	...	...	17	Pl. limanda.	14·5–18·*
	...	...	...	...	...	...	...	1	Solea vulgaris.	11·5

* Including several from 25th.

Date.	Locality.	Position of Net.	EGGS.					LARVÆ.		
			No.	Species.	Diam. of Egg.	Diam. of oil globule.	Stage of Development.	No.	Species.	Length.
					mm.	mm.				mm.
May 27.	Start Bay, trawling ground.	Surface.	5 ca.	C. rupestris.	...	...	I.			
		...	m.	S. lutea.						
	...	...	1	C. aper ?	·98	·17				
	..	...	1	Motella, o.g. colourless.						
	...	...	1	Motella, o.g. yellow.						
	...	Bottom.	...	...	...	...	...	1	C. lyra.	10·
	...	...	...	...	...	...	...	1	S. vulgaris.	10·5
	...	...	...	...	...	...	...	2	Pl. limanda.	17 5, 18·
	Start Bay, outer ground.	Bottom.	...	...	...	...	...	1	Gobius sp. ?	8· ca.
		...	...	...	...	...	...	1	Gadus minutus.	12· ca
June 1.	Teignmouth Bay, trawling ground.	Surface.	3	C. lyra.	·84, ·87	...	2 II., III.			
		...	1	C. sprattus.	...	...	I.			
	...	...	1	T. vipera.	1·16	...	I.			
	...	...	4	S. lutea.	...	...	III.			
	...	...	1	*Arnoglossus laterna ?*	·66	.14	I.			
	...	Bottom.	...	...	...	...	...	1	G. luscus.	20·5
,, 2.	Off Paignton Ness.	Bottom.	...	...	...	...	...	5	Gobius minutus.	10·–19·
	Torbay, trawling ground.	Surface.	1	Motella.	...	...				
		...	...	Other eggs, not identified						
,, 3.	Start Bay, trawling ground.	Surface.	1	*Trachinus vipera.*	..	...	I.			
		...	7	S. lutea.						
	...	...	1	Motella.						
	...	...	1	C. rupestris ?	·87	...	I.			
	...	Bottom.	...	...	...	...	...	1	Gadus ?	
	Start Bay, off Street Road.	Bottom.	...	...	...	...	...	1	Gobius sp.	10· ca.
	1 mile off the Start.	Surface.	nil.	...	...	...	...	1	Gadus minutus ?	10
	...	...	...	...	...	...	...	5	Motella tricirrata.	13·–18·
	...	...	...	...	...	...	...	1	Motella tricirrata.	31·

					mm.	mm.				mm.
June 4.	4–5 miles S. of Mewstone.	Surface.	6	*Clupea pilchardus.*	(yolk) ·96 (one) 2·38	·16	I.			
	...	...	7	*Capros aper.*	·96–1·01	·14–·16	I.			
	...	...	1	*Capros aper?*	1·04	·20	I.			
	...	...	4	C. rupestris.	...	...	I.			
	...	...	1	*Trigla pini?* (rugose zona).	1·49	·28	I.			
	...	...	2	*Arnoglossus laterna.*	...	...	III.			
,, 8.	Off Rame Head.	Surface.	...	...	...	...	...	1	Motella.	22·
	...	...	...	...	..	...	...	2	G. pollachius.	19·
	Jennicliff Bay	Surface.	...	...	...	...	...	2	G. pollachius.	21·, 22·
	Inner part of Whitsand Bay.	Surface.	2	Motella, o.g. yellow.	...	...	I.			
		...	3	C. rupestris.	...	...	I.			
	...	Bottom.	...	...	...	...	...	1	P. limanda.	·18
,, 9.	Cawsand Bay.	Surface.	1	Motella.	...	...	III.			
	...	...	1	Motella, o.g. yellow.	...	...	I.			
	...	...	14	C. rupestris.	(one) ·87					
	...	Bottom.	...	...	...	...	...	3	P. limanda.	20·–24·
	...	...	...	...	...	...	...	m.	G. pollachius.	26·–42·
	...	...	...	...	...	...	..	1	Agonus cataphractus.	36·
	...	...	...	...	...	...	...	m.	Gobius minutus.	12·–17·
,, 10.	2½ miles S. of Mewstone.	Surface.	1	C. rupestris.	...	...	II.			
		Bottom.	...	...	...	...	...	1	Phrynorhombus?	9·5
,, 11.	1 mile S. of Mewstone.	Surface?	sev.	Not identified.	...	...	...	20-30	Motella.	17·5–28·
		...	...	...	...	...	...	1	G. pollachius.	18·
,, 12.	Jennicliff Bay.	Surface.	...	...	...	...	...	1	C. sprattus.	34·
	Off Mewstone.	Surface.	1	C. aper?	·90	·18	I.			
	...	...	4	C. rupestris.						
	...	Bottom.	nil.							
,, 14.	Drake's Island, pools.	Surface.	...	...	...	...	...	1	P. limanda.	18·5
	1 m. off Breakwater.	Surface.	5+	Motella, o.g. yellow.	...	...	III.	2	Rhombus maximus.	15·, 22·

Date.	Locality.	Position of Net.	EGGS.					LARVÆ.		
			No.	Species.	Diam. of Egg.	Diam. of oil globule.	Stage of Development.	No.	Species.	Length.
					mm.	mm.				mm.
June 14.	1 m off Breakwater.	Surface.	8 +	C. rupestris.	(two) ·84					
,, 15.	1 mile S. of Mewstone.	Surface.	2	C. rupestris.	...	...	I., III.			
		Midwater.	2	C. rupestris.	...	...	I., III.			
,, 16.	Cawsand Bay.	Surface.	nil.	...	...	...	...	2	Rhombus maximus.	15·, 22·
,, 17.	200 yds. S. of Drake's Island, ebb.	Surface.	1	C. rupestris.	...	...	...	1	C. sprattus.	16·
		...	...	...	...	...	...	m.	C. sprattus.	21·–26·5
	...	...	...	...	...	...	...	4	C. sprattus.	31
	...	...	...	...	...	...	...	15	Gadus minutus ?	10·–15·
	...	...	...	...	...	...	...	1	G. pollachius.	23·
,, 19.	Hamoaze.	Surface.	...	...	...	...	...	1	Motella mustela.	27·
,, 23.	1 mile S. of Mewstone, early ebb.	Surface.	1	Unidentified (asperous zona).	1·06	...	I.			
	...	...	1	T. vipera.	...	...	III.			
	...	...	6	C rupestris.	...	...	I., II., III.			
	...	...	...	Motella, o.g. yellow.						
	...	Bottom.	12	C. rupestris.						
	...	...	1	Motella, o.g. yellow.						
,, 25.	2 miles N.E. ¼ E. of Eddystone.	Surface.	17	C. aper.	·97–·99	·15–·16	I., II.			
		...	...	No record of other species						
,, 26.	Outer Knap Buoy.	Surface.	...	...	...	...	...	1	Motella ?	4·5
,, 28.	¼ mile S. by E. of Mewstone Buoy.	Surface.	20 ca.	C. rupestris.	...	...	I., II., III.			
		...	2	Motella, o.g. yellow.	...	...	III.			
	¼ to ½ mile off Breakwater.	Surface.	4	C. rupestris.						
		...	1	C. rupestris ?	...	·67	I.			

					mm.	mm.				mm.
June 28.	¼ to ½ mile off Breakwater.	½ to 1 fath. down.	12	C. rupestris.	...	...	I., II., III.			
	...	...	3	Motella, o.g. yellow.	...	...	I., II.			
	..	...	1	T. vipera.						
,, 29.	2 miles off Fowey River.	Surface.	nil.	...		...	...	nil.		
		Bottom.	m.	C. rupestris.	(one) ·84	...	...	2	Ammodytes sp.	6·5, 7·5
	...	...	...	Motella, o.g. yellow.		...	...	1	Motella.	9·5
	...	...	...	C. aper ?	·99	·15	I.	1	Gobius sp.	4·
	...	...	...	...	...	...	...	4	C. aper ?	4·5–6·
,, 30.	2 miles off Fowey River.	1 fathom down.	nil.							
	...	...	1	T. pini ?	1·43	·23	I.			
	...	Bottom.	3	*Unidentified Gadoid (?).*	·86–·91	·16	II.			
	...	...	1	?	·96	·17	II.			
	...	...	1	A. laterna.	·66	·13	III.	1	Ammodytes sp.	9·5 ca.
	...	...	2	C. rupestris.	...	...	...	9	C. aper ?	4·–6·5
	...	...	1	Motella, o.g. yellow.						
July 6.	2 miles S.W. by S. of Mewstone.	Surface.	nil.							
		Bottom.	4	C. aper.	·93–·99	·16–·17	I., II.			
,, 7.	Gerrans Bay.	..	1	C. rupestris.						
	...	...	4	Motella, o.g. yellow.						
				Other eggs not recorded.						
,, 20.	4 miles off Mewstone.	Midwater.	2	Unidentified Gadoid (?).						
		...	2	C. rupestris.						
,, 23.	2 to 3 miles S. of Breakwater.	Surface.	2	*Coris-like Labroid.*	·78–·80	·14	I.			
		...	1	C. aper.	·96	·16				
	...	...	4	C. rupestris.	·78–·82					
	...	...	1	Motella, o.g. yellow.						
	...	4 fathoms down.	1	Unidentified Gadoid (?).	·84	·16	III.			
	...	...	1	*Caranx trachurus.*	·91	·22	II.			
	...	...	1	A. laterna.	·63	·12	II.			

Date.	Locality.	Position of Net.	EGGS. No.	EGGS. Species.	EGGS. Diam. of Egg.	EGGS. Diam. of oil globule.	EGGS. Stage of Development.	LARVÆ. No.	LARVÆ. Species.	LARVÆ. Length.
					mm.	mm.				mm.
July 23.	2 to 3 miles S. of Breakwater.	4 fathoms down.	1	C. rupestris.	·81	...	III.			
			1	Motella o.g. yellow.						
,, 26.	Jennicliff Bay.	Bottom.	...	...	...	...	...	1	Trigla gurnardus.	38· ca.
	...	...	...	...	...	...	...	1	Trigla hirundo.	30· ca.
,, 27.	Between Eddystone and Hand deeps.	Surface.	v.m.	C. aper.	...	...	I., II., III.			
		...	2	C. trachurus.	·81–·93	·22–·23	II.			
	...	...	2	*Arnoglossus Grohmanni*	·72, ·74	·12, ·12	II.			
	...	...	1	*Trigla hirundo?*	1·35	·28	II.			
	...	...	1	Coris-like Labroid.	·82	·14				
	...	Midwater.	...	Eggs less plentiful than at surface, but more plentiful than at bottom.						
	...	Bottom.	3	C. aper.	·93–·97	·15–·17	I.			
	...	...	1	*Solea variegata.*	1·16	·03–11	II.			
	...	...	1	C. rupestris.						
	...	...	1	Motella, o.g. colourless.						
,, 29.	2 miles S.W. of Mewstone.	Surface.	1	C. aper.	·93	·15	I.			
		...	2	Coris-like labroid.	·81	·13	III.			
	...	...	17	C. rupestris.	...	...	III.			
	...	...	5	Motella, o.g. yellow.	...	...	I., III.			
	...	...	8	A. laterna.	...	...	III.			
	...	...	1	A. Grohmanni.	...	...	III.			
	4 miles S. by W. of Mewstone.	Surface to midwater.	1	C. trachurus.	...	...	III.			
			6	C. aper.	...	...	III.			
	...	...	1	C. rupestris.	...	...	III.			
	...	...	1	Motella, o.g. yellow.	...	...	III.			
	...	Midwater to bottom.	2	C. aper?	·96	·14	I.			

					mm.	mm.				mm.
July 30.	Off Mewstone.	Surface.	...	Eggs rather abundant, not examined.						
,, 31.	4 miles S.W. by S. of Mewstone.	Surface.	12	C. aper.	...	...	III.			
		...	2	C. pilchardus.	...	...	III.			
Aug. 3.	3 to 4 miles W.S.W. of Rame Head.	Surface.	17	C. aper.	...	...	I.			
		...	1	Arnoglossus sp.	...	...	I.			
	...	...	1	Coris-like labroid.	·78	·15				
,, 4.	Bigbury Bay.	Surface.	...	Few eggs, not identified.	...	...	...	2	Blennius pholis.	19·5, 20·
	...	...	...	...	...	...	...	1	Trachinus vipera.	13·
,, 6.	Jennicliff Bay.	Surface.	...	...	...	...	...	1	Caranx trachurus.	11·5
	...	...	...	...	...	...	...	m.	C. sprattus (pilchardus?)	21·–27·5
,, 19.	Cawsand Bay.	Surface.	nil.							
	...	...	nil.							
,, 23.	4 miles off Breakwater.	Surface.	nil.							
		Midwater.	nil.							
	...	Bottom.	nil.							
,, 24.	Cawsand Bay.	Surface.	nil.							
	...	Midwater.	nil.							
,, 25.	1 mile S.W. of Breakwater Fort.	Surface.	1	C. aper.	·91	·15	II.			
		...	1	Unidentified Gadoid (?).	·80	·16	II.			
	...	...	8	Motella, o.g. yellow.	·65–·68	·12–·17	Var.			
	...	Midwater.	1	Unidentified Gadoid (?).	·78	·15				
	...	Bottom.	2	Motella, o.g. yellow.	...	...	I.			
,, 27.	1 mile off Breakwater Light.	Surface.	1	C. aper.	·93	·15	II.			
		...	1	Unidentified Gadoid (?).	·84					
	...	...	1	C. rupestris.	·72	...	I.			
	...	...	5	Motella, o.g. yellow.						
	...	Midwater.	nil.							
	...	Bottom.	1	Motella, o.g. yellow.						

Date.	Locality.	Position of Net.	EGGS.					LARVÆ.		
			No.	Species.	Diam. of Egg.	Diam of oil globule.	Stage of Development.	No.	Species.	Length.
					mm.	mm.				mm.
Aug. 28.	Cawsand Bay.	Surface.	1	Unidentified Gadoid (?).	·83	·17	III.			
,, 30.	200 yards inside Breakwater.	Midwater.	3	Motella, o.g. yellow.						
	Jennicliff Bay.	Bottom.	1	Motella, o g. yellow.						
		Surface.	nil.	...						
	...	1 fathom down.	2	Motella, o.g. yellow.						
Sept. 1.	Inside Breakwater.	Bottom.	nil.							
,, 3.	Cawsand Bay.	Bottom.	nil.							
	...	Bottom ?	...	...	...	...	...	4	Lepadogaster bimaculatus.	3·–4·5
	1 mile off Breakwater.	Bottom.	...	...	...	...	...	1	Lepadogaster bimaculatus.	7·5
,, 6.	Cawsand Bay.	Bottom.	nil.							
,, 7.	4 miles off Breakwater.	Surface.	nil.							
		Midwater.	nil.							
	...	Bottom.	nil.							
,, 8.	2–3 miles S.W. of Mewstone.	Surface.	nil.							
		Midwater.	nil.							
	Plymouth Sound.	...	1	Motella, o.g. yellow.						
,, 10.	3 miles N.E. to N. of Eddystone.	Surface.	nil.							
,, 13.	Off Mewstone.	...	nil.							
,, 14.	¼ mile off Penlee.	Bottom.	1	Motella, o.g. yellow.						

						mm.	mm.				mm.
Sept.	14.	Cawsand Bay.	Surface.	1	Motella.						
,,	16.	Cawsand Bay.	Bottom.	...	...	...	...	...	1	Lepadogaster bimaculatus.	15·5
,,	21.	Plymouth Sound.	...	...	...	...	...	...	...	Early larva, sp. ?	2·09
Oct.		No records of tow-nets.	...	...							
Nov.		No records of tow-nets.	...	...							
Dec.	2.	2 miles S. of Mewstone.	Bottom.	nil.							
,,	3.	Whitsand Bay.	Surface.	nil.							
		...	Bottom.	nil.							
,,	11.	Off Breakwater.	...	nil.							
,,	14.	West Channel.	Surface.	nil.							
		...	Bottom.	nil.							
,,	20.	Between Mewstone and Shagstone.	2 fathoms down.	nil.							
		...	Bottom.	nil.							
,,	21.	Between Mewstone and Shagstone.	Midwater.	nil.							
,,	22.	¼ mile off Breakwater.	Bottom.	nil							

Preliminary Report on the Results of Statistical and Ichthyological Investigations made at the Plymouth Laboratory.

By

Georg Duncker, Ph. D.

During my stay, from August to October, 1897, at the Laboratory of the Marine Biological Association of the United Kingdom, I was especially engaged in investigating the variability of *Pleuronectes flesus*, Linn., and *Siphonostoma typhle*, Linn. Of the results so obtained, some of more local faunistic importance are briefly reported here.

I take this opportunity of expressing my hearty thanks to the officers of the Laboratory, especially to the Director, Mr. E. J. Allen, for their help and kind interest in my researches. A paper containing a full statement of the statistical results has been prepared, and will be published shortly.

1. Pleuronectes flesus, *Linn.*

The flounders of Plymouth, when compared with those of the Baltic and the south-eastern parts of the North Sea, form a distinct race. The characteristics of this race are:

1. A high number of fin-rays in the dorsal and anal fin (average, dorsal 61–62, anal 43–44).

2. Almost entirely smooth squamation on the blind side. In both respects it is similar to the variety *Pleuronectes italicus*, Günther, of the Mediterranean.

The variation in the number of fin-rays has been studied in 1120 individuals, of which 602 (= 53·75 per cent.) were males, and 518 (= 46·25 per cent.) were females. Of the males 40 (= 6·6 per cent.) had the eyes on the left side of the head, of the females only 20 (= 3·8 per cent.). On drawing the curves representing the observed total lengths for each sex separately, a distinct size group, similar to those suggested by Petersen,* was found only for the small individuals from 7 to 14 cm. In other portions of the curve no distinct humps were observed.

The males proved more variable than the females in the number of fin-rays. Table I. gives the indices of variability (Airy's error of mean square $\sqrt{\frac{\Sigma(x^2)}{n}}$) for each fin in both male and female.

TABLE I., *showing the Indices of variability of the number of fin-rays.*

	Males.			Females.		
	Index.		Number of Individuals.	Index.		Number of Individuals.
Dorsal fin *	2·4445	...	602	2·3118	...	518
Anal fin *	1·6521	...	602	1·5397	...	518
Left Pectoral fin †	0·7454	...	562	0·6978	...	498
Right Pectoral fin †	0·7152	...	562	0·6993	...	498
Left Ventral fin †	0·3318	...	562	0·3483	...	498
Right Ventral fin †	0·3147	...	562	0·2225	...	498

* Right- and left-eyed individuals.
† Right-eyed individuals only.

Differences of age or sex corresponding to differences in the number of fin-rays were not distinctly shown in the dorsal, anal, and ventral fins. In both pectoral fins a slight increase of the numbers of rays seems to occur with age (*i.e.* with increase of total length).

Table II. gives the arithmetical mean values of the number of fin-rays in six size groups of both sexes. Group I. contains individuals below 10 cm. in total length; group II., from 10 to 14·9 cm., etc.; group VI., above 30 cm. (See page 174.)

The variation is normal in three cases; in three (dorsal and both ventral fins) it is skew, according to Pearson's Type IV. (*Phil. Trans. Roy. Soc.*, Vol. 186 A.); in the dorsal, however, this skewness is only slight. The correlation (according to Pearson's† formula) between the numbers of fin-rays of the dorsal and anal fin is very high, r = 0·672.‡ This is higher even than that of the pectoral fins, r = 0·588. The latter I find to be less than in the symmetrical species mentioned below, in which r = 0·700 and 0·720 respectively. The correlation of the ventral fins is only 0·2085.

* *Report of the Danish Biol. Station*, IV., 1893, "The Biology of our Flatfishes."

† *Phil. Trans. Roy. Soc.*, Vol. 187 A, p. 265.

‡ Compare this with the corresponding values of the Acanthopterygians *Acerina cernua*, Linn., r = 0·238, and *Cottus gobio*, Linn., r = 0·300.

TABLE II., *showing the size-differences in the average number of fin-rays (right-eyed individuals only).*

Size.	Dorsal Fin.		Anal Fin.		Left Pectoral.		Right Pectoral		Left Ventral.		Right Ventral.		Number of Individuals.	
	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female	Male.	Female.	Male.	Female.
I.	61·52	61·95	43·80	43·75	9·96	10·05	10·44	10·75	6·00	5·75	6·00	6·05	25	20
II.	61·27	61·25	43·68	43·28	9·86	9·74	10·60	10·56	5·96	5·95	6·01	5·99	113	115
III.	61·74	61·91	43·84	43·56	10·22	10·02	10·88	10·63	5·93	5·96	5·95	5·95	148	116
IV.	61·76	62·11	43·46	44·03	10·26	10·31	10·93	10·93	5·97	5·95	5·99	5·96	170	127
V.	61·59	61·72	43·43	43·78	10·34	10·40	11·03	10·93	5·94	5·95	5·93	5·98	100	82
VI.	62·17	61·95	43·50	43·87	10·00	10·29	11·33	10·71	6·00	5·95	6·00	6·00	6	38
TOTAL (average)	61·7214		43·6098		10·1425		10·8036		5·9500		5·9745		1060	

2. Syngnathus rostellatus, *Nilss.*

The reasons for separating this common and widely-distributed species from *S. acus*, Linn., are the following:—

1. The differences between the two forms are so distinct and of such a degree that they are not likely to be due to differences of age.

A comparison between twenty-two individuals of the former species and forty-seven of the latter, gives the following ranges of variation :—

	S. rostellatus, Nilss.	*S. acus.*
Ann. corp.	13–15	19–20
Ann. caud.	39–41	43–46
Summa ann.	52–56	62–66
Ann. p. dors.	10–12	8–11
Rad. p. dors.	36–44	36–45
Ann. burs. gen.	20–25	25–28
Observed Total Length	7·7–16·4 cm.	16·0–44·8 cm.

2. The individual variation in the number of body rings in the *Syngnathidae* (corresponding to the individual variation of abdominal vertebræ in other fishes) is a very low one. (*Siphonostoma typhle*, Linn. *Syngnathus pelagicus.*)

3. The fully-developed young in the brood-pouches of the males of both forms differ by the same number of rings as the adult, as well as differing in their total lengths. (They are about 1·5 cm. and 2·5 cm. respectively.)

4. Sexual maturity has been observed in individuals of *S. rostellatus*, Nilss., above 11 cm. long, in *S. acus* not below 30 cm.

5. Cross-breeding between the two forms seems unlikely, in consequence of the difference of the sizes of the eggs and brood-pouches in the two cases.

At Plymouth I obtained *S. rostellatus*, Nilss., from Cawsand Bay and from the Yealm River; *S. acus* from the same places and from the Hamoaze. I also possess specimens of *S. rostellatus*, Nilss., from the western Baltic, the North Sea, and the Mediterranean. Through the kindness of Mr. E. W. L. Holt I was also able to compare some specimens from the River Humber.

On Keeping Medusae Alive in an Aquarium.

By

Edward T. Browne,

University College, London.

I HAVE made several attempts to keep medusae alive in an aquarium, but have only recently been successful. A medusa when first placed in an aquarium swims actively about, but in a few hours it sinks to the bottom apparently tired out. After an interval of rest it takes another swim and again sinks to the bottom. This is repeated until the medusa becomes completely exhausted; then it stays at the bottom and slowly dies. In spite of every attention, plenty of clean sea-water, plenty of copepods, and a suitable temperature, I found that my medusae often used to die within a day of their capture.

When I have been watching medusae at the surface of the sea, I have noticed that they simply float along with the tide without often pulsating the umbrella. In my bell-jars the water was perfectly motionless, so that a medusa had to pulsate its umbrella in order to keep afloat, and as soon as the pulsations stopped it began to sink. There are some species, like those belonging to the *Bougainvillidae*, which live longer in confinement, as they are able to poise themselves in the water by the extension of their tentacles and remain motionless for long periods, but even these finally reach the bottom of the bell-jar, and a long period at the bottom ends in death.

It appeared to me that to keep medusae alive in an aquarium it was necessary to have the water in motion so that a medusa could float about just as it does in the sea, without having constantly to pulsate its umbrella. The intervals of floating are periods of rest.

I pass over the early experiments and describe a simple method for keeping water in motion in a bell-jar, which has given excellent results and has enabled me to keep medusae alive for many weeks in perfect condition. The current in the water is obtained by simply moving up and down, fairly slowly, a glass plate inside a bell-jar. Owing to the downward plunge the plate made in the early experiments it was called a "plunger," and this name I have retained for the want of a simpler one. (Fig. 1.)

The plunger consists of a flat glass plate with a small hole in the centre; through the hole passes a glass rod which is suspended to one end of a long wooden rod, the "beam." The glass rod has a knob at the bottom upon which the plate rests, and it is slightly bent so as to give a slope to the plate. The sloping of the plate prevents the medusae

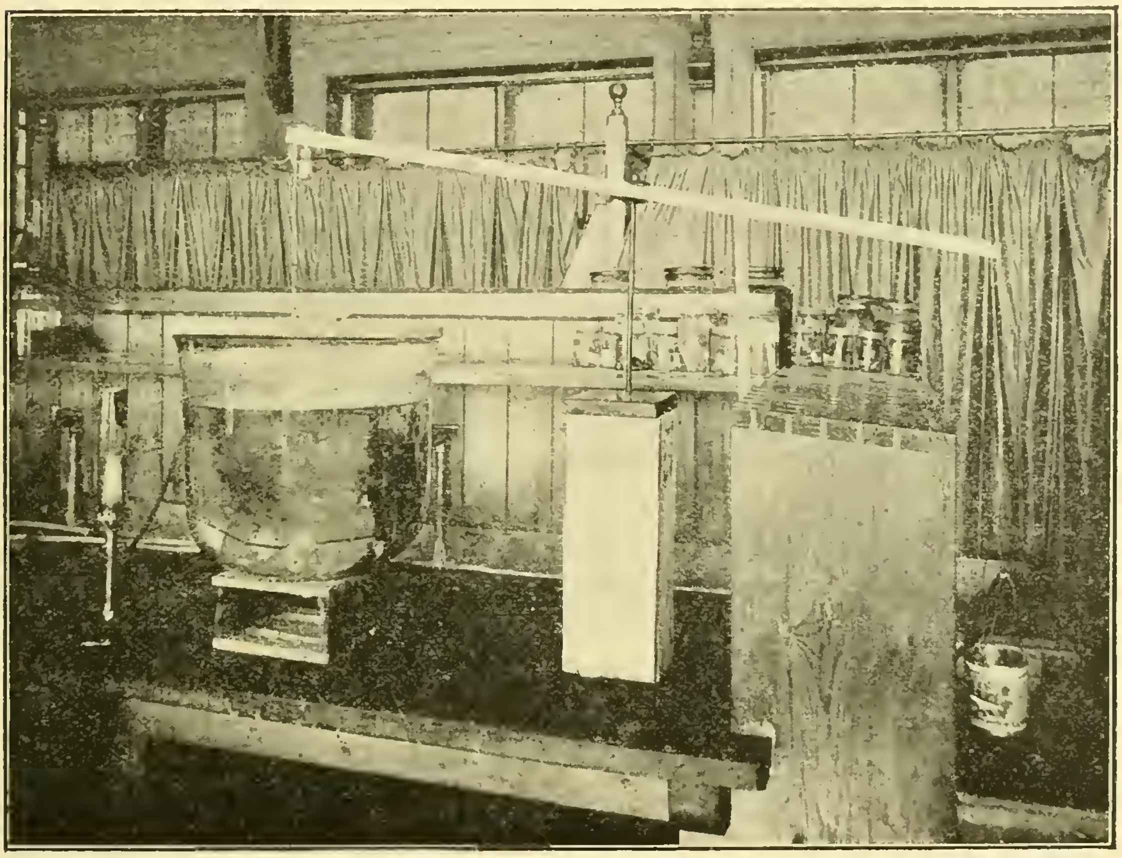

Fig. 1. Bell-jar with Glass Plunger.

being caught between the plate and the surface-film when the plunger moves up.

The beam rests near its centre on a pivot, like the beam of a balance. and at one end is suspended the plunger, and at the other end a small bucket made of tin, fitted with a large siphon. A rubber-tube conveys a constant flow of water (from the fresh-water supply) into the bucket which, when full, quickly empties itself through the siphon. When the bucket has been emptied by the siphon, the plunger is at the bottom of the bell-jar, as the plunger end of the beam is heavier than the bucket end. The plunger need only be a little heavier than the bucket; and the weight can be easily regulated by means of a bottle containing shot, attached to the beam.

The siphon to empty the bucket must be of large bore, so as to carry away the water faster than it comes in. As soon as the siphon has stopped running the bucket begins to fill, and when the weight of the bucket exceeds that of the plunger, the bucket slowly goes down, and the plunger comes up to the surface. The length of the stroke is regulated by two stops, which prevent the beam moving too far up or down. The plunger remains at the surface until the water has reached the top of the siphon, and directly the siphon begins to act the bucket is quickly emptied, and the plunger goes down nearly to the bottom. I found that one down-stroke in eighty seconds was sufficient, and regulated the apparatus so that the down-stroke was a little faster than the up-stroke.

The top of the bell-jar has a wooden cover with a narrow slit cut in the centre to act as a guide to the plunger-rod, and to prevent the plate knocking against the bell-jar on the downward plunge.

The movement of the plunger produces numerous eddies in the water, which are rendered visible by the movements of the copepods and the medusae. The medusae are carried from one side of the bell-jar to the other, or from the bottom to the top. This movement the medusae appear thoroughly to enjoy, and during the intervals in which the plunger is at rest they may be seen either taking a swim or floating with their tentacles expanded, or else playing an active copepod, caught on the end of a tentacle, as skilfully as an expert angler plays a large fish.

The first plunger bell-jar was started in the Plymouth Laboratory on 4th of September. (Fig. 1.) The bell-jar contained about ten gallons of water, which had been in it about three months, and the glass was well coated with algae. In this bell-jar were placed at intervals different species of medusae, and a good food-supply consisting of copepods, crustacean larvae, &c. I kept this bell-jar under close observation until the 9th of October, when my visit to Plymouth terminated. The temperature of the water was often taken, especially on hot days, and occasionally the specific gravity. The temperature varied from 14·75° C. to 17·5° C., and it was kept down on hot days by placing round the outside of the bell-jar a strip of flannel, upon which played a jet of fresh water. This acted very well, for when the temperature of the room was about 21° C., the water in the bell-jar remained about 16° C.

All the species of medusae placed in this bell-jar not only lived longer, but were in a better condition than if kept in still water. Some species lived longer than others, which tends to show that much has yet to be learnt on keeping medusae. Perhaps for some species a slow revolving current would be better; it could easily be obtained by turning a screw-propeller in the water.

The following notes on the inhabitants of the bell-jar may be of interest: About eighty specimens of *Obelia* lived very well for about ten days, and then began to die off. For the first week they kept in splendid condition, and were very active, but were not seen catching copepods. *Obelia* in an aquarium with still water usually lives about twenty-four hours.

Phialidium generally lives about three days in still water, but in the "plunger" bell-jar one specimen (*P. buskianum*) lived six weeks, increased in size, and developed more tentacles. Its umbrella was as transparent as the clearest glass, and its tentacles were often seen stretched out, when fishing for copepods, to the fineness of a spider's web.

Another old inhabitant of the bell-jar was *Phialidium cymbaloideum*. In twenty-five days it added five new tentacles and five marginal bulbs.

The medusa of *Lar sabellarum* (*Willsia stellata*, Forbes) died suddenly after five weeks' captivity. It also added new tentacles, and increased the size of its umbrella. A specimen of *Margelis* lived seventeen days, and during this period added two new tentacles in each of the four marginal groups, and the oral tentacles twice dichotomously divided.

A single specimen of *Sarsia gemmifera* was placed in on the 16th of September. It started with six medusa-buds upon the manubrium; three of these developed into medusae which were liberated, and the others had nearly completed their development by the 9th of October.

These experiments I think show that it is possible to keep medusae alive in confinement for several weeks without any change of water, and that they increase in size and develop more tentacles.

In this bell-jar I placed copepods and crustacean and worm larvae as a food supply for the medusae. Whatever I placed in the bell-jar I examined with a microscope, to see that the specimens were in good condition. This applies not only to the medusae (it is useless to place them in if at all damaged or about half dead), but also to the copepods, &c.

Fresh copepods were added when the stock became low; some died a natural death, and many others were captured by the medusae. I did not try to keep alive the various pelagic larvae that were placed in the bell-jar, but I noticed that they throve wonderfully well. The larval form of *Magelona* was alive when I left Plymouth. It had been several weeks in the bell-jar, and was often seen floating with its two long tentacles stretched out to a considerable length. One worm safely passed through its larval stages, and built a tube on the bottom of the bell-jar. Mr. Garstang identified the adult form as *Capitella capitata*. Several of the crustacean larvae passed through their larval stages. I saw an adult form of a shrimp, and Mr. Hodgson identified another crustacean for me as the adult of *Nika edulis*.

In another plunger bell-jar I placed a colony of *Syncoryne.* It soon sent out long stolons attached to the glass. I measured and made drawings, at intervals, of the new growth of the colony. In thirteen days the total length of the new stolons and branches amounted to 773 mm., and ninety-nine new hydranths appeared. In this bell-jar I also kept some medusae liberated from hydroid colonies of *Perigonimus.* When the medusa leaves the colony it has two long perradial tentacles. In twelve days one specimen possessed four long perradial tentacles, four interradial bulbs, and one adradial bulb. The other specimens were not quite so far advanced.

I tried the experiment of starting with a perfectly clean bell-jar and using filtered sea-water, in which a plunger worked. Into this bell-jar, holding about two gallons, I placed about three dozen medusae and a good supply of copepods. The medusae were not specially selected, but taken as a sample of a day's tow-netting. I did not interfere with them for ten days, but only added copepods when the supply became low, when I found thirty-one specimens alive, and more than half of them were in excellent condition.

I must express my sincere thanks to my friend Mr. E. J. Allen for the great amount of trouble and the many useful suggestions which he made when we fitted up the apparatus for working the first plunger bell-jar. It was his suggestions which led to the plunger being worked by such a simple method.

The "Bottle-nose Ray" (*? R. alba,* Lacép.) and its Egg-purse.

By

Ernest W. L. Holt.

For a number of years our tanks have from time to time contained a very large and easily-recognised Skate-purse, but its specific identity has remained a matter of uncertainty. Fishermen attributed it to the "Bottle-nose ray," a species not to be found, so far as I am aware, in ichthyological works.

In the spring of 1897 I happened to be on the Plymouth fish-quay, when a large ray was landed from the Bay of Biscay. It was pronounced by the universal consensus of piscatorial opinion to be the "Bottle-nose." I have since seen several other specimens, and, by extracting the purses, have ascertained that the opinion of fishermen respecting their origin was perfectly correct.

With regard to the fish itself, it is a well-marked species, but its correct nomenclature is involved in considerable confusion. It is the "Burton Skate" of Couch, the *R. alba* of Day, though I am far from certain that all the records compiled by the last-named author really refer to the fish with which we are dealing. Smitt concludes that it is identical with the ray known to him as *R. lintea,* but this seems also uncertain.

Possibly *R. marginata,* which almost certainly applies to the young of the "Bottle-nose," may prove to be the name which has given rise to least confusion, but as I have not at present access to the older literature of the subject, I do not propose to deal seriously with the synonymy.

Calderwood has given in this Journal (N.S., ii., 1892, p. 283) a description of a female specimen, which is probably sufficient to ensure its recognition. To define it very roughly, the "Bottle-nose" may be said to be a very large, thick ray, with a moderately long and very sharply-pointed snout. Apart from the male sexual spines, which include not only the alar series but also a group at the margin opposite the eyes, the dorsal surface is generally destitute of large spines. Some are present on the snout and on the supra-orbital ridges. On the tail is a single median series, extending some way on to the back, and a lateral sub-marginal series, which, if sometimes single, may frequently be complex. *The ventral surface is generally smooth, except along the anterior margin of the disk, which is occupied by a very distinct border of asperities and spines. There are no black or grey markings of any sort on the ventral surface, which in large examples is dead white, without any pigment whatever.* Young examples have a border of dark pigment on the ventral surface of the wings; the under side of the tail is also dark. The teeth are pointed in both sexes.

The egg-purse does not greatly differ, in so far as concerns the shape of its body, from that of the common grey skate, *R. batis*. Using the topographical terms which are applicable while the purse remains in the ovary, the body is roughly oblong, but slightly constricted posteriorly. The anterior margin is truncate, the posterior margin broadly concave. Its greatest length in the middle line is 17·4 cm. ($6\frac{7}{8}$ inches), and its greatest width 13·8 cm. ($5\frac{7}{16}$ inches); but the actual cavity is only about 13·3 by 10·5 cm. ($5\frac{1}{4}$ by $4\frac{1}{8}$ inches).

The purse is thus of a very large size, apart from the attachment processes. Dorsally and ventrally the surface of the egg-cavity is somewhat inflated, but the convexity is greatest dorsally, and the lateral edges of the purse are rolled up in a ventral direction.

The attachment processes are characteristic. The posterior processes, about 8·7 cm. ($3\frac{7}{16}$ inches) in length, as measured from the level of the anterior edge of the body, are stout, but flattened, tapering to a width of ·9 cm. ($\frac{3}{8}$ in.) at the roughly truncate extremity. They are strongly bent in a ventral direction, and incline somewhat towards each other. The anterior processes are long and ribbon-like. Tapering from a width of 2·2 cm. ($\frac{7}{8}$ in.) at their origin to one of about ·6 cm. ($\frac{1}{4}$ in.) at the extremity,* they measure about 24·5 cm. ($9\frac{5}{8}$ inches) in total length. They are very thin, but supported by a thickened longitudinal ridge. Each process is inwardly curved so as to meet and cross its fellow at about two-thirds of its length, the curve being thereafter continued in a backward direction. The axis is gradually rotated so that the outer edge of the distal part of each filament is ventral in position.

In texture the purse is opaque, and, after exposure to sea water, of a dark olive-brown colour, as is the case with the purses of most rays. The fine longitudinal ridges are most distinctly beaded: each

* The process terminates, in some specimens, in an indefinite gelatinous tissue, which is probably produced in others as a filament.

is, in fact, beset by minute transverse crests. So far as I know this beaded appearance is quite characteristic. At all events, in combination with the peculiar character of the processes, it should ensure the recognition of the purse.

Mr. Allen has drawn my attention to Couch's description of a purse attributed by that author to the Eagle-ray, *Myliobatis aquila* (*British Fishes*, i., p. 137). A similar purse is mentioned by Day (*Fish. Gt. Brit.*, ii., p. 353) on the authority of Buckland; but reference is also made to Moreau's assertion of the viviparous condition of the Eagle-ray. The descriptions given by the authors named leave no doubt as to the identity of the purses, which are certainly those of the "Bottle-nose ray."

On the Occurrence of large Numbers of Larval Herring at the Surface.

A Letter from

Mr. Matthias Dunn.

"MEVAGISSEY, *26th January*, 1898.

"IT may interest you to know that on Friday, 14th January, the weather being very fine, and the wind from the S.E., as the fishing-boat *Sea Belle* (Mr. Blamey, master), was proceeding to the pilchard ground some four or five miles south of the Deadman headland, when about two miles from land they fell in with masses of muddy brown matter in strings, some of which were three or four hundred yards long and from two to seven feet wide, floating quite on the surface. They had not proceeded far along these lanes or path-like forms on the sea before they observed that pilchards were feeding on them ravenously; so they tacked their boat among them for a mile or more, and the further they went the more abundant were the pilchards. About four miles from land and in thirty fathoms of water the anxious gulls indicated the outmost limit of these strangely coloured bands, and here the pilchards were the most plentiful, almost rabid in their mad rush on the lessening streaks, causing the water to boil and whirl violently. Certainly some of the shoals of pilchards could not have had less than thirty to sixty thousand fish in them, for they coloured the water a dark red when concentrated on the brown matter.

"Of course our fishermen expected a more than ordinary catch of pilchards when setting their nets; but, strange to tell, with the decline of the light, having fed to repletion, they sank down below the nets, and the catch was a small one, amounting to some two or three thousand fish.

"Mr. Blamey, being anxious to know what the pilchards had been so fond of, brought me in a quantity of this floating matter, which proved to be young herrings in their first stage, with the yolk still large. In the bucket they were quite transparent, although, as already stated, of a decided brown colour when packed together in millions, and crowding in long lanes. Several other of our fishermen, although some miles from the *Sea Belle*, saw these young herrings with pilchards feeding on them under like conditions.

"MATTHIAS DUNN."

Mr. Dunn's letter requires no introduction ; I have merely to say that some well-preserved material forwarded to me proves the correctness of his identification. The larval herring are at most a few days old, some appearing to be quite recently hatched. Mr. Dunn also sent, at my request, some pilchards taken about the same place a few days later. This fish decomposes very rapidly, and in any case larval herring would be hardly recognisable after being subjected a few hours to the action of the gastric secretions. Though I found no larvæ, the stomach of one pilchard contained unmistakable herring ova, some of which contained far advanced embryos. The fish must therefore have been feeding on the herring spawn at the bottom, a habit of the pilchard previously unknown, at any rate to myself. I do not know of any previous record of the presence of such enormous numbers of very early herring larvæ at the surface, nor of their serving as food to the pilchard. Considering the importance of both species, Mr. Dunn's evidence is most valuable.

E. W. L. H.

On the Pelagic Fauna of Plymouth for September, 1897.

By

Edward T. Browne,
University College, London.

In the Journal of this Association for 1896 (Vol. IV., No. 2, p. 168) I published a few notes on the Pelagic Fauna of Plymouth for September, 1893 and 1895. This year (1897) I again occupied a table in the Laboratory during September for the study of medusae, and also made a few entries in my notebook on the occurrence of certain animals belonging to other groups, and kept a special look-out for the animals which I noted in previous years. Unfortunately I was not able to visit Plymouth during September in 1894 and 1896, consequently the record is broken by two blank years, and spoilt for an accurate comparison of one year with another, but it shows that more Atlantic forms were present in 1895 than in 1893 or 1897.

The pelagic animals of the Plymouth district may be conveniently divided into two sets:—

1. Local forms, to which belong the larval stages of animals living on the bottom, and the medusae liberated from Hydroids.
2. Atlantic forms, which come up the Channel.

It is the latter set which produces the great yearly changes in the fauna, and which gives the greatest interest to pelagic work.

The Atlantic forms often arrive suddenly, occasionally in great shoals, like *Thalia* in June, 1893, and *Doliolum* in 1895, but usually they are rather scarce in numbers.

It is in the neighbourhood of the Eddystone, where the main Channel tide runs, that the richest tow-nettings are taken, and I have noticed that there is a difference between the fauna off the Eddystone and in the Sound. On certain days I was able to obtain tow-nettings from the Sound in the morning and from the Eddystone in the afternoon; the results were in favour of the Eddystone tow-nettings, both in quality and quantity.

As a rule three nets were used, attached to a single rope and placed at different depths, the coarsest mesh near the bottom and the finest close to the surface.

I have drawn up two lists of medusae for September, one to show simply the presence or absence of a species for the three different years, the other to convey an idea of the abundance of medusae during September, 1897. In the latter table I have given in some cases the actual number of specimens taken, and in other cases have conveyed a general idea of the abundance of a species by using Roman numerals as symbols.

Most of the species given in the lists have been described and figured in the *Proc. Zool. Soc.*, 1895, and another contribution to that journal is in preparation.

The table for September, 1897, shows clearly that medusae were by no means plentiful, except two species—*Obelia lucifera* and *Phialidium buskianum*—and on certain days were very scarce. Most of the species taken are liberated from hydroids, so that their appearance and their quantity in September depend upon the breeding-time and breeding-capacity of the hydroids, which are usually conspicuous by their absence or scarcity.

During my stay at Plymouth a considerable amount of dredging was done in various localities, extending from the Sound to the Eddystone. I examined the material carefully for hydroids, especially for the minute forms, and preserved a large number of specimens for further examination. The great bulk of the hydroids taken belonged to genera which do not liberate medusae, such as *Halecium*, *Sertularella*, *Plumularia*, etc., and the hydroids which do liberate medusae were, with a few exceptions, *Clytia*, *Obelia*, and *Perigonimus*, scarce or absent. I have noticed this scarcity of the hydroids with medusae in other localities, and am not able at present to account for it. The medusae of *Lar sabellarum* are by no means uncommon at Plymouth and other places, yet the hydroid has only been taken once at Ilfracombe, over twenty years ago. The medusae of *Hybocodon prolifer* have been recorded from many parts of the British seas, including Plymouth. They sometimes occur in vast numbers, yet the hydroid has never been recorded on this side of the Atlantic, and I believe has only been taken in Massachusetts Bay. The hydroid form must be somewhere in the neighbourhood, as the medusa carries the ova upon the manubrium until the actinula stage is reached, and this stage I have taken in the tow-net.

It is quite possible that the hydroids with medusae are really scarce. A single colony is capable of liberating a vast number of medusae. A colony of *Bougainvillia ramosa* was dredged off the Eddystone in

October and placed in an aquarium. In three days it liberated not less than 4450 medusae, and when the colony was preserved there was still left a good stock of young medusa buds upon the branches. (See page 189.)

NOTES ON MEDUSAE. (September, 1897.)

Obelia lucifera.—This was by far the most abundant medusa during September. On some days thousands were taken in the tow-nets.

Phialidium buskianum.—Specimens of this species were nearly always present, from the earliest to the adult stage.

Phialidium cymbaloideum.—Most of the specimens belonged to the earliest stage, with four tentacles; a few belonged to the second stage, with eight tentacles. The adult was not taken.

Lar sabellarum.—The earlier and intermediate stages were usually taken. The adult form was very scarce.

Amphinema dinema.—Nearly all belonged to early stages.

Cytæandra areolata.—Only the intermediate stages present. (For description and figures of this species see *Proc. Zool. Soc.*, part iv., 1897.)

Lizzia blondina.—This medusa begins its free-swimming existence with four single perradial tentacles and four single interradial tentacles, and as it grows the perradial tentacles only increase in number until there are three tentacles in each of the perradial groups. The early stages have been described as distinct species, and are recorded in Haeckel's *System der Medusen* under the following names:—

First stage: Eight single tentacles = *Dysmorphosa minima.*

Second stage: Four perradial groups with two tentacles and four single interradial tentacles = *Lizzia claparedei.*

Third stage: Four perradial groups with three tentacles and four single interradial tentacles = *Lizzia blondina.*

In the first and second stages the medusa usually buds off medusae from the wall of the stomach, and in the third stage the generative cells make their appearance. The first and second stages have also been described with ripe generative cells, and consequently regarded as adult medusae and distinct species.

During my visit to Plymouth in 1895, and also at Port Erin and Valencia Island, I have always taken the first and second stages with medusa-buds and the third stage with generative cells. This year at Plymouth I obtained specimens of the first and second stages in the same tow-netting, some with medusa-buds and others with genera-

A TABLE *showing the Distribution of Medusae during September*, 1897.

1897.—SEPTEMBER	1	3	6	7	7	8	8	10	13	15	15	16	17	17	18	21	22	23	24	28	30	30
LOCALITY	The Sound.	1 mile S. of Breakwater.	The Sound.	The Sound.	4 miles S. of Breakwater.	The Sound.	3 miles S.W. of Mewstone.	5 miles E of Eddystone.	¼ mile off Mewstone.	The Sound.	2 miles S.W. of Eddystone.	Cawsand Bay.	The Sound. E. entrance.	Cawsand Bay.	The Sound.	The Sound.	The Sound.	The Sound.	The Sound.	Near the Mewstone.	The Sound.	Near the Eddystone.
Obelia lucifera	V.	IV.	VII.	V.	VII.	III.	VII.	IV.	IV.	II.	III.	—	I.	II.	II.	I.	II.	II.	IV.	V.	V.	IV.
Phialidium buskianum	II.	6	4	I.	6	I.	II.	I.	II.	4	III.	II.	—	2	2	I.	1	2	1	V.	IV.	III.
Phialidium cymbaloideum	1	—	1	—	1	—	2	—	2	2	—	—	—	2	—	—	3	1	1	3	1	—
Lar sabellarum	2	2	—	—	1	—	III.	—	1	—	—	—	—	4	—	—	—	—	2	1	—	—
Amphinema dinema	3	—	—	—	5	—	4	8	1	—	—	1	—	—	—	—	—	—	—	—	1	—
Cytæandra areolata	1	—	—	—	1	1	1	—	1	2	—	—	—	1	—	—	—	—	—	1	—	—
Lizzia blondina	4	1	—	—	1	—	2	III.	—	6	VII.	—	1	V.	1	—	—	1	1	I.	—	1
Eutima insignis	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cytæis sp?	—	—	—	2	—	5	—	—	—	4	—	3	2	10	4	—	2	—	3	—	—	—
Tiara pileata	—	—	—	—	2	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphysa aurata	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Irene pellucida	—	—	—	—	—	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Saphenia mirabilis	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Margelis sp?	—	—	—	—	—	—	1	—	—	—	1	—	—	2	—	1	—	—	—	—	—	—
Mitrocomium sp?	—	—	—	—	—	—	1	—	II.	—	I.	—	—	—	—	—	—	1	—	—	—	—
Sarsia sp?.	—	—	—	—	—	—	1	—	—	1	—	—	2	1	1	—	—	—	—	—	—	—
Liriantha appendiculata	—	—	—	—	—	—	—	3	1	1	III.	—	—	—	—	—	—	—	3	III.	1	II.
Sarsia gemmifera	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Gemmaria implexa	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
Ectopleura dumortieri	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—

I. Very scarce. II. Scarce. III. Few. IV. Fairly common. V. Common. VI. Abundant. VII. Very abundant.

tive cells. The third stage was not seen this year. I have noticed in other species of medusae that the gonads may become mature in a medusa which has not reached its maximum growth. The generative cells sometimes develop and ripen faster than the medusa grows, and consequently the ova or spermatozoa are shed earlier. It is possible that a medusa may sometimes begin to shed ova at an intermediate stage of growth and continue to shed them at intervals, until it reaches its maximum growth. All the ova are not usually ripe at one time.

The early ripening of the generative cells has led to many medusae being described as distinct species. It has given me considerable trouble in tracing the life-history of a species, as it is difficult without a large number of specimens to trace and connect the different stages.

Margellium octopunctatum has often ripe gonads in the later stages, and the specimens which show the maximum growth are scarce. I have only taken them in Valencia Harbour. The maximum growth of a medusa is apparently only reached under very favourable conditions. *Hybocodon prolifer* when fully grown has three tentacles, but ripe generative cells are often present in forms with two tentacles. Medusae belonging to the genus *Phialidium* show often the early ripening of the generative cells in the intermediate stages, which has led to the description of a large number of spurious species. I believe that *Saphenia mirabilis* will ultimately be shown to be a stage in the development of *Eutima insignis*, yet both forms are frequently taken with ripe generative cells. In the present list of species both names are given, as my observations require further proof.

Cytaeis sp. (?).—This medusa is not described in Haeckel's *Monograph.* I have only found it in Plymouth Sound—a few specimens in 1893 and many in 1897. A description of the medusa, with figures, is now in preparation.

Tiara pileata.—Only young stages seen.

Euphysa aurata.—A single specimen taken. This species is new to the fauna of Plymouth.

Irene pellucida.—Only young stages seen.

Mitrocomium sp. (?).—This medusa is not described in Haeckel's *Monograph.* A description of the species is in preparation, as enough specimens have now been collected to connect the different stages. I obtained few specimens in 1893 and 1895.

Liriantha appendiculata.—All the specimens belonged to early stages.

Sarsia gemmifera.—A young stage with medusa-buds.

Gemmaria implexa.—An early stage. The hydroid form has not been recorded for Plymouth.

Ectopleura dumortieri.—An early stage. This is an addition to the fauna of Plymouth. The hydroid form has not yet been recorded for Plymouth.

Agastra mira, Hartlaub.—A single specimen taken in the Sound on 31st of August. It is an addition to the Plymouth fauna. (For a description of the medusa see *Proc. Zool. Soc.*, pt. iv., 1897.)

A List of Medusae for September only.

	1893.	1895.	1897.
Obelia lucifera	P.	P.	P.
Phialidium buskianum	P.	P.	P.
Lar sabellarum	P.	P.	P.
Amphinema dinema	P.	P.	P.
Eutima insignis	P.	P.	P.
Saphenia mirabilis	P.	P.	P.
Irene pellucida	P.	P.	P.
Mitrocomium sp?	P.	P.	P.
Lirianthia appendiculata	P.	P.	P.
Phialidium cymbaloideum	P.	A.	P.
Cytæandra areolata	P.	A.	P.
Cytæis sp?	P.	A.	P.
Dipurena halterata	P.	A.	A.
Lizzia blondina	A.	P.	P.
Gemmaria implexa	A.	P.	P.
Solmaris sp?	A.	P.	A.
Octorchis gegenbauri	A.	P.	A.
Tiara pileata	A.	A.	P.
Euphysa aurata	A.	A.	P.
Sarsia gemmifera	A.	A.	P.
Ectopleura dumortieri	A.	A.	P.

P. = Present. A. = Absent.

An Incomplete List of Animals found in the Tow-nets during September only.

	1893.	1895.	1897.
Muggiæa atlantica	P.	P.	P.
Terebella larvae	P.	P.	P.
Magelona larvae	P.	P.	P.
Doliolum tritonis	P.	P.	A.
Noctiluca miliaris	P.	A.	P.
Chætopterus larvae	P.	A.	P.
Actinotrocha	A.	P.	P.
Tornaria	A.	P.	P.
Beroe	A.	P.	A.
Pilidium	A.	P.	A.
Mitraria	A.	P.	A.
Bipinnaria	A.	P.	A.
Thalia democratica	A.	P.	A.
Amphioxus (larva)	A.	P.	A.

P. = Present. A. = Absent.

Noctiluca miliaris.—Specimens were first taken on 7th of September, about four miles outside the Breakwater. It was abundant on the 8th, three miles S.W. of the Mewstone, and on the 10th, five miles East of the Eddystone. Tow-nettings taken close to the Mewstone on the 13th did not contain any specimens. On the 15th, specimens were first taken inside the Breakwater. From the 15th to the end of the month, *Noctiluca* was usually present in the tow-nets. The quantity varied considerably, but it was more abundant outside than inside the Breakwater.

Cydippe.—One or two specimens were usually found in the tow-nets. They all belonged to very early stages, about 2 to 3 mm. in diameter.

Magelona.—The larval stages of this worm were fairly common throughout the month.

Chætopterus.—Five larval stages were taken on the 7th of September, four miles south of the Breakwater, and single specimens on the 13th, 21st, and 30th. Only once taken inside the Breakwater.

Terebella.—The larval stage, living in a little tube, was fairly common until the 8th September, but very scarce during the latter half of the month. Only four specimens taken after the 19th.

Tomopteris onisciformis.—Only four specimens seen. Three taken outside and one inside the Breakwater. About 3 mm. in length.

Actinotrocha.—Single specimens taken on the 10th, 15th, 18th, 28th, and 30th of September. Only once taken inside the Breakwater.

Tornaria.—Single specimens taken on the 10th and 15th of September, off the Eddystone.

Notes and Memoranda.

An Observation of the Colour-changes of a Wrasse. *Labrus maculatus.* Donovan.

The common wrasse of our coasts is well known to exhibit, as a species, an almost endless variation of colour. To what extent the different colour-patterns are individual or congenital, and to what extent they may be produced in the same individual by different stimuli, appears to be a question worthy of careful examination. We propose at present to deal chiefly with the observation of a single specimen.

On the 4th October, 1897, trawling among the red-weed and zostera beds at the mouth of the Yealm, we took a wrasse 16 inches in total length. Captured most probably in the zostera, it exhibited a uniform green colour, without any markings except the inevitable indistinct dark spot at the base of the last dorsal rays.

Confined for a few hours in a tub on board the launch, it underwent no colour-change. It was then placed in a shallow, open tank, with black walls, under an iron shed at the back (N.) of the Laboratory. The next morning, while retaining the general green colour, it showed also some faint grey transverse patches on the sides. The fish remained in this tank until the 2nd December, when it was found to have undergone a further change. The ground colour was pale olive-grey, diversified with dark grey transverse bars and patches on the back and sides, and with whitish blotches on the fore part of the abdomen. This pattern is very common in the Plymouth district. It may be described with sufficient exactness as follows: A number (often four) of dark transverse bars pass from the dorsum to the region of the lateral line. The first originates below the first rays of the dorsal fin, the last below the extremity of that organ. These bars have no regularity of outline and are often split into two by the intervention of a pale transverse stripe. Another bar occurs on the caudal peduncle. About the lateral line the dorsal transverse bars are irregularly continued backwards by short longitudinal patches; below these originate a series of ventral transverse bars which alternate more or less in position with their dorsal fellows, and are connected one with another by an irregular network of dark lines. The pale antero-ventral blotches are of more variable occurrence, and the ground colour and the colour of the dark markings are in no way constant.

On the south side of the Aquarium is a large tank devoted to bream and wrasse. It is lined at the back and sides with rock-work of red granite, now become brownish by the accumulation of foreign matter. A large projecting boulder forms a cavern at the back of the tank, much frequented by the prominent members of the wrasse community. The bottom is gravel of a light colour.

The wrasse with which we are dealing was pitched into this tank as soon as its colours had been noted. It immediately bolted into the cavern already mentioned, and, in the course of the initiation ceremonies inevitable on the admission of a new member, was summarily ejected a few minutes later. But, whereas it went in grey with dark bars, &c., it came out green with only very faint grey marblings. The sun being still in the east and the atmosphere dull, the illumination of the tank was decidedly dim, but as the fish rested on the botton near the glass its colours could easily be seen. After retaining the colour phase just noted for perhaps a few minutes, the dark bars were suddenly resumed within an interval of a few seconds, but the green ground colour remained. The fish has since remained in this tank, but varies constantly in colour, retaining, however, the general scheme of grey markings on a green or olive-green ground. On the 2nd January, 1898, it was observed to be for a short time almost uniformly green, but on the posterior part of the side, from the level of the soft dorsal backwards, it was noted that a number of the scales exhibited a pale roundish spot. Such a marking could not have escaped notice at an earlier date. It is, in fact, an approach to what we may call the typical colouration of the species, in which every scale shows a pale spot and the fins are similarly spotted, though the darker ground colour is extremely variable.

Our observation, such as it is, demonstrates clearly enough that the uniform green, and the barred and patched liveries, can be achieved by the manipulation of the chromatophores of a single individual, according to the stimulus. It suggests, as we suppose, that the typical spotted livery may not be distinct from the others, but does not go far enough to show whether it is a question of the manipulation of chromatophores capable of presenting the other liveries, or a gradual alteration of the chromatophores themselves. As to the nature of the stimuli which effect the colour-changes we have no evidence, except that the colour environment is certainly not constant in its effect. For in the same tank, under the same circumstances of illumination and environment, may be seen wrasse of several different liveries.

The uncertainty of the nature of the stimulus is further borne out by the observation of five small *L. maculatus* taken in the Yealm zostera beds on the same date as the large one.

These specimens measured from $2\frac{1}{4}$ to 3 inches in length. During a period of 48 hours they were transferred to different vessels in the following order:—

1. White porcelain pots sheltered from bright sunlight.
2. Glass bell-jars similarly sheltered.
3. A table-tank with black sides and bottom.

(*a*) 3 inches long, uniform bright green on reaching the Laboratory, unchanged in 1 and 2; escaped from 2 and died.

(*b*) 3 inches long, uniform dark olive in 1, uniform but brighter and greener in 2, duller with very faint bars in 3.

(*c*) 3 inches long, uniform pale olive in 1, uniform buff in 2.

(*d*) $2\frac{3}{4}$ inches long, uniform pale olive in 1, uniform darker olive in 2.

(*e*) $2\frac{1}{4}$ inches long, uniform pale olive in 1, slightly darker olive with faint bars in 2.

c, *d*, and *e* all assumed in 3 the ordinary olive ground colour with faint bars.

E. W. L. H. and L. W. B.

The Incubation of the Skate-leech.
Pontobdella muricata. Linn.

The ova of the skate-leech are probably familiar to most marine zoologists, and, apart from any literature on the subject, can almost always be recognised by the presence of the parent. The shell is hard and chitinous, of an olive-brown colour. It is almost spherical, about 4 to 5 mm. in diameter, and attached by the flattened base of a short peduncle to the object selected by the parent. On either side of the spherical part of the shell is a rounded fenestra, of which one at least is simply closed by dark membranous matter. The chitinous matter of the other appears to be, at all events occasionally, imperforate. The ova are deposited separately, but for the most part close to each other, either on an old shell or on some other convenient object.

On the 31st July, 1897, about four miles W.S.W. of the Plymouth Mewstone, the trawl brought up a large and fairly recent scallop shell, *Pecten maximus*, the valves still united by the hinge. Inside was a skate-leech mounting guard over a group of eggs attached to the flat valve, rather near the hinge. A few eggs were also attached to the outer side of the same valve.

Parent and progeny were placed in a small bell-jar under a siphon. The circulation was occasionally stopped by accident, and a large quantity of dirt accumulated from time to time at the bottom of the jar around the eggs and parent. In spite of these drawbacks the latter survived, and the eggs began to hatch out on the 1st December of the same year. Most of them had hatched by the 10th December. The newly-hatched young, about 22 mm. in length, more or less according to the state of contraction, are reddish yellow in colour, and have, essentially, the external features of the parent.

The eggs, when trawled, were velvety in appearance, subsequently becoming smooth and shiny, and finally, by the accumulation of dirt, rather rough. No examination of the embryo was made at the time of capture, but the appearance of the shell may probably indicate that the eggs had not long been deposited. In any case it is evident that the incubation of this particular clutch occupied at least 123 days, and may reasonably be supposed to have been somewhat accelerated by the warmer temperature of the Laboratory. After 136 days the parent was still alive, though by no means vigorous. It was not observed to make any attempt to leave the bell-jar, although there was nothing to prevent it doing so, nor was it noticed to occupy any constant position in relation to its eggs. No food whatever was supplied.

For what purpose the skate-leech remains with its eggs during incubation appears uncertain. One may presume that their protection is the chief object: whether from active enemies or from the mere accumulation of sand, &c., is doubtful. The flocculent diatomaceous dirt which accumulated in the vessel in which our specimen was confined was too light to be removed, and appears to have been quite innocuous. No experiments were made with sand or other matters.

Hatching is accomplished by the perforation of the membrane of one of the fenestræ. The chitinous part of the shell is not ruptured in any way.

Larval Lobsters at the Surface. Although young lobsters must be plentiful, they are but rarely encountered in our tow-nets. During 1897 we have only taken them on three occasions. On the 10th July, while the *Busy Bee* was trawling in the outer part of Falmouth Bay, Mr. Vallentin caught one in a hand-net. The sea was absolutely calm, and we saw a great many "mackerel-midges" (*pelagic Motellæ*) and caught a quantity of brachyurous zoëæ, apparently Portunus. These were either swimming freely, or, more frequently, resting on drift blades of zostera. Many fragments of this were literally crowded by them, but we saw no more young lobsters on this occasion. On the 23rd of the same month the surface otter-net, which has a mouth about 15 or 20 feet wide and about 6 feet deep, caught one larval lobster two or three miles outside the breakwater of Plymouth Sound. The sea was calm, with a long swell, and mackerel were schooling all round us. On the following day, as we lay to taking temperatures, &c., about a mile and a half outside the Breakwater, I noticed a lobster at the surface, and in a short space of time we dipped up over two dozen as they drifted alongside. They occurred singly, not in a shoal. The sea was quiet, but not calm, as a fair breeze was blowing from the east. On all occasions the larvæ were either newly hatched or had only passed their first moult.

Cepola rubescens. *Linn.* Two red ribbon-fish, 30·8 cm. ($12\frac{1}{8}$ in.) and 27·4 cm. ($10\frac{3}{4}$ in.) in length, were caught in shrimp-trawls in Plymouth Sound on the 17th and 22nd December, 1897, and brought to the Laboratory alive. Both proved to be females, the larger one having the ovaries swollen but far from ripe.

The red ribbon-fish can hardly be considered rare on the S.W. coast of England and S. and W. coasts of Ireland, but it is not very often caught. I have known or heard of several instances in which a number of specimens have been caught at about the same date, none having previously occurred. Day concludes that it occurs most frequently on our own coasts after heavy weather, but its sporadic appearances may really be due to some normal phase of its habits about which little is known.

Trachinus draco. *Linn.* The greater Weever is said by Day to reach a length of at least 17 inches. A specimen landed at Plymouth on 20th November, 1897, measures $17\frac{1}{4}$ inches, 43·8 cm. *ca.* It is a female, with ovaries rather enlarged.

Trigla obscura. *Linn.* On the 2nd March, 1897, I saw a number of specimens mixed up with young *T. pini* and *T. gurnardus* in the Plymouth market. I was told that they came from the rough ground off the Start, are locally known as "Offing Gurnard," and are not uncommon in the district. None of these items of information were derived from the actual captors, and may all be erroneous, though the accompanying species suggest a British origin. I have never been able to find any more specimens among the small gurnards brought in by trawlers. In view of the confused synonymy of the gurnards, recently assisted by Smitt's revival of forgotten names, it is, perhaps, necessary to state that the species now under discussion is characterised by the attenuated form of the body and by the great elongation of the second dorsal spine.

Trygon pastinaca. *Linn.* Sting-ray. Two small examples were trawled 20 miles off Plymouth on the 19th January, 1898. Several were taken on the trawling ground off Salcombe a few days previously. The fish is well known to local fishermen, and perhaps hardly deserves especial mention as a rare form.—E. W. L. H.

Myliobatis aquila. *Linn.* Eagle-ray. A female, taken in company with the sting-rays previously mentioned, was brought to the Laboratory on the 19th January, 1898. It measures 34 inches across the disk, and shows what we suppose to be an interesting phase of the renewal of the caudal spine. A large spine occupies the normal position, and is backwardly directed; a shorter and slightly curved spine, originating a little in front of the other, passes forward on the right side of the dorsal fin. We suppose that, as the larger spine becomes obsolete, the smaller is rotated backwards, but the condition may possibly be abnormal. We have not dissected the basal parts. A large Trygon has one spine directly overlying the other.

In another place one of us has shown that the egg-purse attributed by Couch to the Eagle-ray belongs in reality to a Raia. Myliobatis is known to be viviparous; in our specimen the oviducts lead directly into a pair of "uteri," apposed together in the middle line. The strong muscular walls are continuous externally. Internally each uterine chamber is thickly clothed with long vascular villi. The shell-gland, if represented at all, was not found. So far only a hasty examination has been possible.—E. W. L. H. and W. G.

Report on the Surface Drift of the English Channel and neighbouring Seas during 1897.

By

Walter Garstang, M.A.,

Naturalist in charge of Fishery Investigations, M.B.A.

I. Introduction.

Some eighteen months ago the Director of the Plymouth Laboratory of the Marine Biological Association decided to carry out a series of investigations concerning the surface currents of the English Channel at different seasons of the year, and for a series of years, by means of properly devised floating bodies which would attract attention when stranded on the shore, and the recovery of which could without difficulty be recorded. At the commencement of the investigation Mr. Allen communicated his scheme to the editors of the west-country Press, and these gentlemen kindly gave publicity to the plan, the success of which depended very largely upon the co-operation of residents and visitors frequenting the sea-shore. Mr. Allen's letter expresses so clearly the object and method of the investigation, that I cannot do better than reproduce it here:—

"THE DRIFT OF FLOATING FISH-EGGS IN THE CHANNEL.

"*January 27th*, 1897.

"SIR,—I should be obliged if through the medium of your paper you would be good enough to give publicity to a series of experiments which have just been commenced by the Marine Biological Association, with a view to determine the direction of the drift of floating bodies in the western part of the English Channel. The experiments are of such a nature that any of your readers, who either from business or pleasure frequent the sea-shore, may be able to assist materially in their successful completion.

"We are preparing a large number of ordinary egg-shaped soda-water bottles, weighted with shot in such a way that they float vertically in sea-water, with only a very small portion of the neck exposed. In each bottle a stamped and numbered post card is placed, and the bottle is corked and sealed. Each post card has the following notice upon it:—

"'*For Scientific Enquiry into the Currents of the Sea.*

"'Whoever finds this is earnestly requested to write distinctly the *Date* and *Locality*, with full particulars, in the space below, and to put the card in the nearest post office. [No.]

"'Locality where found ....

"'Date when found..............................

"'Name and address of sender ....'

"We are placing the bottles in the sea at various points, the exact locality where each starts upon its journey being recorded. It is hoped that several gross of bottles will be put out during the next few months.

"Might I ask, therefore, that anyone who may find such a bottle washed up on the shore will break it, take out the post card, fill in the required information, and put the card in the nearest post office?

"Teachers in the schools of the various towns and villages along the south coast could do us a great service by asking their boys to look out for the bottles, and in case of any being found, seeing that the post cards were correctly filled in.

"It might interest your readers if I explain shortly the reason for making these experiments. It is now a well-known fact that the majority of the food-fishes spawn in the sea at some distance from the coast, and that the eggs float in the water. These floating eggs are carried about by the currents for some considerable time before they are hatched, and the little fish (larva), when it leaves the egg, is still so small and light that it is at the mercy of the wind and waves. Now it is a fact that although the fish generally spawn at some distance from the coast, the young fish are usually found close inshore. This is particularly the case with flat-fishes. For instance, there are important spawning grounds for plaice south-east of the Eddystone, whilst young plaice, under one inch long, are found only in shallow water in sandy bays or estuaries, such as Whitsand Bay or the mouth of the river Exe. These very young fish have probably been brought ashore by currents, when they were floating eggs or larvæ carried about by the sea. It is very important, therefore, to know the direction of these currents, in order that we may be able to tell where the eggs from the fish spawning upon any particular ground will be carried. At present we do not know whether the eggs from the plaice spawning on the Eddystone grounds are carried towards Plymouth and Whitsand Bay, or whether they are carried eastward towards some point on the Devonshire coast, or westward to the coast of Cornwall. Upon questions of this kind our experiments should throw light.

"Investigations of a similar kind have been made in the Irish Sea by Professor Herdman, and in the North Sea by the Scottish Fishery Board. In the case of the experiments in the Irish Sea, about 35 per cent. of the bottles put out were found and the post cards properly filled up and returned, whilst in the case of the North Sea experiments from 20 to 30 per cent. were recovered. The latter experiments showed that the inshore waters of the Firth of Forth and St. Andrews Bay derive their main supplies of young fish, not from the waters lying contiguous to them to the eastward, but from areas further north, such as the spawning grounds off the Bell Rock and those of the Forfarshire coast. It was also shown that a southerly current runs down the eastern side of Scotland and England to the coast of Norfolk, where it turns to the eastward and crosses the North Sea. Of the bottles set free off the east coast of Scotland many were picked up on the east coast of England as far south as Norfolk, but none further south than this. Many were, however, carried across the North Sea and found on the coasts of Schleswig and Jutland. This will explain the immense nurseries of young fish which are found in the eastern portions of the North Sea—the so-called 'Eastern Grounds,' so well known from the large number of immature flat-fish which are trawled there. E. J. ALLEN.

"Marine Biological Association, Plymouth."

It will be seen in the sequel that Mr. Allen's experiments to determine the currents in the neighbourhood of the Eddystone grounds have provided data not only for the settlement of these local problems of importance to the west-country fisheries, but for determining many matters connected with the surface currents of all the three seas which wash the shores of England. The majority of the bottles put overboard near the Eddystone have been recovered on the south coast, along the whole length of the English Channel; but a very large number have made a safe passage through the Straits of Dover, stranding eventually on the shores of Holland, Germany, Denmark, Sweden, and Norway; a few have rounded the Land's End and travelled as far as Barnstaple Bay; and others put out in the Irish Sea and St. George's Channel have stranded on the west coasts of England, Wales, and Scotland, even so far to the northward as the Isle of Colonsay in the Firth of Lorne.

Most of the drift-bottles have been put overboard in the neighbourhood of the Eddystone by different members of the scientific staff of the Marine Biological Association in the ordinary course of their trawling and dredging excursions; but, as the *Busy Bee* is incapable of making long journeys far from land, we have always been glad to accept the services of others who have kindly come to our assistance in this part of the work. We are under a particular debt of gratitude to Admiral the Hon. Sir E. R. Fremantle, K.C.B., C.M.G., in this connection. He very kindly permitted the distribution of a number of the bottles among the torpedo-boat destroyers cruising from Devonport, and to him, to Commander Shirley, of H.M.S. *Decoy*, and to the commanding officers of H.M.S. *Lynx*, H.M.S. *Skate*, H.M.S. *Sunfish*, H.M.S. *Opossum*, and H.M.S. *Ferret*, we desire to express our warm thanks for the material assistance they rendered us in this part of the work.

We are also indebted to H. E. M. Studdy, Esq., and other yachtsmen, for similar assistance kindly given us.

It gives us particular pleasure to thank the officers and boatmen of H.M. Coastguard at innumerable points along the coast for the promptitude with which they have returned the post cards to us upon the recovery of any bottles. We owe a very considerable number of our records to the vigilance of the members of this efficient branch of the service.

We desire also to thank the numerous private individuals and fishermen, both home and foreign, who have increased the value of these experiments by properly inscribing and returning the post cards contained in bottles they have found, and for the information they have always been willing to convey in reply to our inquiries.

For the meteorological work of this report I have received valuable data from Edward Kitto, Esq., Superintendent of the Falmouth Observatory; C. E. Peek, Esq., Superintendent of the Rousdon Observatory, Lyme Regis; Alfred Chandler, Esq., Borough Meteorologist, Torquay; and H. Victor Prigg, Esq., Meteorologist to the Borough of Plymouth. To these gentlemen I beg to convey my warm thanks for their assistance, which has been generously given.

II. The Drift-bottles.

Various objects have been employed by different investigators in their experiments upon surface currents. The Prince of Monaco employed small floating vessels of copper, specially prepared, but their fitness to indicate accurately the course of surface currents has been criticised owing to the ease with which they could be propelled at the surface of the water by the direct action of the winds. Any small buoyant object of spherical and, still more so, of cylindrical form, floating at the sea-surface and bobbing up and down under the action of the waves, inevitably exposes a considerable part of its bulk to the direct action of the winds, and experiments founded upon the journeys of such objects are vitiated in proportion to the relative bulk of the part exposed to wind-action. Mr. Allen selected common "egg-shaped" soda-water bottles (used by Schweppe and other manufacturers of aërated waters) for our experiments, and their admirable adaptability to the purpose will be generally conceded. These bottles are 9 inches long (varying between 9 inches and 9¼ inches), and their maximum diameter is a little below the middle of the bottle, at 5½ inches from the mouth. From this zone the bottle tapers towards each extremity, being conical at the closed end, but produced into a cylindrical neck at the open end. This neck is 2½ inches long, and its diameter is 1 inch. The mouth is surrounded by a slight rim ¾-inch deep, which increases the outside diameter of the neck in this region to a maximum diameter varying between 1⅛ and 1¼ inches.

The preparation of these common objects for their scientific mission is as follows:—The bottles are washed and thoroughly dried. A piece of wire, the counterpoise of the post card to be eventually enclosed, is inserted, a piece of hard paraffin is dropped inside, and small quantities of leaden shot are added until the bottle floats upright in sea-water, with its mouth all but submerged. The wire is then removed and the bottle placed upright in a pail of hot water until the paraffin is melted, when it is placed aside—still in a vertical position—until the paraffin has thoroughly hardened again. The object attained by this means is to prevent the shot from rolling about inside the bottle, and so displacing the centre of gravity. The post card and a conspicuous notice marked "Break the Bottle" are then introduced, and the bottle is thoroughly corked, the cork being pushed in flush with the mouth of the bottle and sealed with paraffin wax. The whole of the neck and upper half of the bottle is then painted with red enamel paint, so as to render the bottle conspicuous.

III. Results of Experiments.

The actual localities where our bottles have been sent adrift and where they have been subsequently recovered are given in tabular form at the end of this report. The experiments fall into two categories dealing with distinct areas, viz.: (1) the English Channel and North Sea, and (2) St. George's Channel and the Irish Sea. Only the former group of experiments approaches completeness, and in the subsequent discussion of the results I shall deal more particularly with this area.

In the course of the year 430 bottles were sent adrift in 53 batches in the English Channel, and 117 bottles belonging to 40 batches have been recovered up to the present time (Feb. 28, 1898). Thus 27 % of the bottles, or rather less than one-third, have been recovered from the Channel lots.

In the Irish Sea and St. George's Channel 36 bottles were sent adrift in 6 batches, all on the 30th of March, and 20 bottles, representing all six batches, have been recovered. This gives the high percentage of 55, or rather more than half of the total number put out.

The total percentage of recoveries from both areas combined is 29·4 %.

1. The English Channel and North Sea.

§ 1. *The Direction of Drift.*—The general direction and rate of the surface drift in this area are well seen by reference to Table I., batch no. III. Out of 27 bottles sent adrift near the Eddystone in the latter part of January, 10 have been recovered, and these were picked up at places successively further away to the E. and N.E., the only break in the sequence being the recovery of a bottle at Terschelling on August 15th, twelve days after a bottle had been found at Schiermonnikoog, 40 miles to the eastward. The general rate of drift is seen from the table to be about 3 miles a day, which yields about 90 miles a month. Fjellbacka, on the west coast of Sweden, was reached in October—a distance of over 900 miles—in little more than nine months.

The regularity of this drift to the north-eastward is, however, frequently departed from; for example, out of six bottles sent adrift off the Lizard on March 31st (batch no. XXX.) two bottles were picked up at Sennen Cove, situated round the corner of Land's End, on April 6th—a journey of 35 miles to the westward in six days, at an average rate of nearly six miles a day.

Again, a drift may begin in one direction and end in another, as is shown very clearly by batch no. XL. In this case bottles put out near the Eddystone on May 11th went westwards to Mounts Bay, arriving at Penzance on June 2nd; they then rounded the Land's End and arrived at Croyde, on the north coast of Devon, three weeks later. Here their progress appears to have been arrested, and apparently a retrograde movement set in, for on August 20th a bottle was picked up at Bude, in North Cornwall, and—still more remarkable—another was recovered at Eastbourne three months later.

The general features of the direction of drift throughout the year may conveniently be summarised by plotting out for each successive month the number of batches recovered to eastward or westward of their position in the preceding month. The following table contains the results of an analysis of this kind for the English Channel, the North Sea records being for the present omitted :—

Monthly Summary showing the direction taken by drift-bottles in the English Channel, 1897.

Commencement of Drift.	No. of batches put out.	Month of Recovery.	Direction of Drift.	No. of batches recovered.	Remarks.
January.	3	January.	...	0	January batches were in the North Sea after the end of March.
		February.	[E.]	0 (but cf. III. 1).	
		March.	E.	2	
February.	20	February.	W.	*1 (x.)	February batches were mostly near Calais in May, and in the North Sea subsequently.
		March.	E.	6	
		April.	E.	1	
		May.	E.	4	
		June.	E.	2	
		August.	E.	1	
March.	7	March.	W.	*1 (xxv.)	Batch no. xxx. was put out on March 31st, and properly speaking, illustrates April and not March conditions
		April.	W.	1 (xxx.)	
April.	9	April.	N.	*1 (xxxii.)	The westward drifts here recorded for the summer months were subsequently overpowered by the preponderating eastward movement
		April.	W.	2	
		May.	W.	1	
		June.	W.	2	
		August.	E.	2	
		December.	E.	1	
May.	4	May.	W.	1	Temporary westward drifts subsequently overpowered by eastward movement.
		June.	W.	1	
		October.	E.	1	
		Nov.	E.	1	
June.	3	July.	E.	1	These cases show that even in summer the preponderating drift was eastwards.
		August.	E.	2	
		Sept.	E.	1	
		October.	E.	1	
July.	2	July.	E.	1	
		August.	E.	2	
		August.	N.	1 (XLVIII.)	
		Sept.	E.	1	
September.	4	October.	W.	4	Marked westward drift in October.
		October.	E.	1 (LI., 1).	
		December.	W.	1 (XLIX.)	
October.	1	October.	W.	1	

* These drifts were of very short duration (only one day each).

If now we condense this summary into a statement of the aggregate number of westward and eastward drifts for each month in the year (neglecting, however, the three cases of drifts not exceeding twenty-four hours' duration) we obtain the following results:—

Direction.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Westward.	—	0	0	3	2	3	0	0	0	5	0	1	... 14
Eastward.	—	[all]	8	1	4	2	2	7	2	2	1	1	... 30

This table shows that the surface drift was markedly to the eastward in March and August, and also to the eastward, although not so conspicuously so, in July and September. The drift was variable in direction in April, May, June, and October, with a marked westward preponderance in April and October. The evidence in regard to November and December is equivocal, owing to the small number of recoveries in these months, and to the long lapse of time between the recovery of the bottles and the time when they were sent adrift. The drift in February was clearly to the eastward, although no recoveries are recorded for this month; but the stranding near St. Alban's Head on March 1st of a bottle which was put overboard near the Eddystone on January 29th leaves no doubt about the matter.

There was, accordingly, for the whole year 1897, a preponderating drift to the eastward in the English Channel, the proportion of eastward to westward drifts being as 30 : 14. This eastward movement of the surface water attained its maximum in March and August, but was strong in February, and not inconsiderable in July and September. In October, on the other hand, a westward movement predominated, and this was also distinct during parts of April. In May and June the drift, as already remarked, was variable in direction.

§ 2. *The Direction of the Local Winds.*—It is desirable at once to compare these data with the direction and force of the wind during the successive months of the year. On the upper line of the following table I give the resultant wind for each month at Plymouth (which may be taken roughly as representative of the general state of the wind in the Channel); on the second line, the force of the resultant wind; and in the third and fourth lines I give an abstract of the monthly summary concerning the winds of the British Islands as a whole from the publications of the Meteorological Office.

The great gale in November, which I specially mention, will be remembered as that which, springing from the West, and veering to N.W., caused immense damage on our east and south-east coasts, owing to the exceptional height of the tide forced up. Cases of this kind are important from our point of view, since the enormous volume of water banked up along the coast has eventually to settle down to a uniform level, and this process entails the formation of currents along the path of least resistance which may be completely different from the direction of the wind at the time. The currents produced on this occasion must have profoundly modified the course taken by those of our bottles which were in the southern part of the North Sea at the end of November and beginning of December.

	January.	February.	March.	April.	May.	June.
Plymouth .	N.E., moderate.	W.S.W., strong.	S.W. by W., very strong.	S., weak.	N.W., weak.	W.S.W., weak.
British Isles .	N.E., variable.	S. to W., light gales.	S.W. to W., stormy.	E. strongest, variable.	Very variable.	Very variable.

	July.	August.	September.	October.	November.	December.
Plymouth .	W., weak.	S.W. by S., very strong.	W., moderate.	E.S.E., stiff.	E. by S., moderate.	S.W., strong.
British Isles.	S.W. to N.W. variable.	S. to W., gales in west, none in east.	S.W. to N.W. variable in south-west.	S.E., variable in south-east.	Variable, great gale from N.W., 28th to 29th.	S. to W., some east on south coast.

It will at once be seen that there was a close correspondence in 1897 between the direction of the surface drift in the Channel at different times of the year and that of the winds for the same periods. It is unnecessary to go into details, but I may point out that, in view of this general correspondence, the non-recovery of drift-bottles in January and February is probably to be explained by the marked northerly element in the winds of January. Bottles sent adrift off the Eddystone in this month must have drifted out towards mid-Channel, requiring the strong south-westerly winds which prevailed during the whole of February to bring them ashore at the beginning of March. By a method to be described below, moreover, I have calculated that by the end of February the bottles sent adrift between the 15th and 18th of that month had in all probability been carried north-eastwards into the great bight formed by Lyme Bay, where the conditions as regards wind and tide differ considerably from those prevailing in the fairway of the Channel.

An equally complete analysis of the northward and southward drifts is unnecessary, since the recovery of almost all the bottles on the northern coasts of the Channel speaks for itself. Almost all the drifts, whether to eastward or to westward—but especially in the former case—had a northward element, which carried the bottles to some part or other of the English coast. Two cases of due northward drift are included in the preceding table, one for April, the other for August. In the former case the drift was short and rapid (ten miles in 27 hours, no. XXXII.); in the latter the resultant distance was equally short, but the duration was prolonged to 22 days (assuming here, as elsewhere, that the bottle was picked up soon after getting ashore), thus depriving the case of any special significance.

The only period of marked southward drift which is actually indicated by the bottles was in the month of May, when—between the 13th and the 19th of the month—as many as five bottles, belonging to four February batches, were stranded on the French coast in the neighbourhood of Calais. It is clear also, from evidence supplied by batches XXXVIII. and XL., that similar conditions prevailed at the opposite extremity of the Channel during the same period, which was characterised, as already remarked, by a preponderance of north-westerly winds in the Channel.

The only other month during which northerly winds prevailed was January, and I have already mentioned that the negative evidence supplied by the non-recovery of bottles in February, in spite of strong southerly winds during that month, points clearly to the conclusion that a strong southward drift occurred in January as well.

A temporary southward drift probably occurred also about the middle of June, at any rate in the eastern portion of the Channel, since two bottles, belonging to different batches, stranded at Calais and Boulogne on the 18th and 19th of that month. It is, moreover, difficult to account for the curious data supplied by batch no. XL., except by the assumption that there was a surface current to the southward on the north coast of Cornwall between the middle of June and the middle of August, and again during September. These were periods of variable winds.

§ 3. *Other Causes of Surface Currents in the Channel.*—By the use of the word "drift" in connection with the movements of the surface water which have been described above, I have already indicated that these movements are principally due to the driving power of the wind exerted upon the surface of the water. My employment of the word is amply justified by the close correspondence between the movements of wind and water in the Channel revealed in the preceding section of this report. But it is desirable, before we assume that the local winds have been the only factors concerned in the production of these surface currents, that we should consider for a moment the other causes which may be expected to affect the circulation of the water in the regions under discussion.

In the first place we have to entertain the possibility of a current setting normally through the Channel, independently of the local winds, in connection with the general circulation of Atlantic water. As the Channel is open to the eastward through the Straits of Dover, we might, *à priori*, expect a continuance through it of the great eastward drift of the North Atlantic. Into the Bay of Biscay this drift sets with a velocity varying between 8 and 30 miles a day, while to the north of Scotland, over the Wyville-Thomson ridge, it sets towards the Norwegian coast with a velocity of 5 miles a day. But it has to be borne in mind that the orifice of the Dover Straits is very small and the depth exceedingly shallow, scarcely exceeding 20 fathoms along a line drawn from Dungeness to Boulogne, while the depth of water over the Wyville-Thomson ridge, with which comparison is invited, is 300 fathoms. Moreover, the whole bed of the English Channel scarcely exceeds a depth of 50 fathoms in any part. Friction with the bed of the Channel, combined with the obstacles to further progress presented by the narrowness and shallowness of the Straits of Dover, would appear to be sufficient to prevent the ingress into the English Channel of any serious portion of the general Atlantic drift already retarded by the shallowness of the sea between France and Ireland. That this is actually the case appears from the Admiralty chart of Atlantic surface currents (1875). The bifurcation of the Atlantic drift (the time-honoured Gulf Stream) takes place opposite the entrance to the English Channel, outside a line connecting Ushant with the west of Ireland, thus indicating the serious nature of the obstacle presented by the shallow bed of the Channel; and in this part of the chart the currents are marked as "variable and uncertain."

The improbability of any serious current setting through the Channel as an offset from the general Atlantic drift is in agreement with the results of our experiments. The surface currents in the Channel have been shown to be in general agreement with the direction of the local winds from time to time; and in July, at any rate, there is some direct evidence from our bottles that the water in windless weather is stationary, except for the regular swing imparted to it by the tides. Out of a number of bottles put overboard on the 17th July, during a voyage of the *Busy Bee* from Falmouth, two, at any rate, were recovered three days later afloat in practically the same spot as that in which they were sent adrift. The weather during this period was almost dead calm, none but the lightest of southerly airs being perceptible. Had any appreciable current, say, of 4 miles a day, been setting up-Channel at the time, the position of the bottles would have been deflected a corresponding amount to the eastwards—12 miles in the example taken. The velocity of the tidal stream at springs in this region is small, from $\frac{1}{2}$ to $\frac{3}{4}$ knot.

At the same time, as the velocity of the Atlantic drift is admittedly dependent on the force of the winds blowing over that ocean, these considerations do not preclude the possible occurrence of eastward currents in the Channel, independently of local winds, after unusually heavy gales to the west of our islands. We shall, I think, be able to determine the existence of such occasional currents by applying to the data provided by drift-bottles a method of analysis to be described below.

The possibility of a permanent westward current through the Channel from the North Sea is precluded by the results of Fulton's experiments, which were briefly summarised in Mr. Allen's letter at the commencement of this report.

A second cause of surface currents independent of local winds is to be found in the tides. The tidal stream in the Channel runs with a velocity which in different parts varies from about half a mile to about three miles an hour. There is no need to sum up here the peculiarities of the Channel tides, but as the courses of the flood and ebb streams are approximately parallel over the greater part of the Channel, it does not appear that the course of drift-bottles would be materially affected by them in the long run, except in certain well-defined regions of the Channel. These are principally the two orifices of the Channel, together with Lyme Bay, the neighbourhood of the Solent and Spit Head, and the Gulf of St. Malo.

At the western entrance to the Channel the West Channel tidal stream runs in opposite directions to the oceanic tidal stream, and where the two streams meet the tides are rotary, with scarcely any interval of slack water. Off Mounts Bay the ebb, or west-going stream, runs longer and stronger than the flood, or east-going stream, so that a vessel leaving Mounts Bay at half ebb counts upon a nine hours' tide to carry her up the Bristol Channel. This preponderance of the westward current is due partly to the meeting of the two tidal streams referred to, and partly to the indraught into the Bristol Channel during flood tide. The effect of the tidal currents in this neighbourhood is clearly seen in the case of two of our batches of drift-bottles, nos. XXX. and XL., as will be shown below.

The conditions in the Straits of Dover are similar in principle, though more complicated in detail. Here the West and East Channel streams meet at high water and separate at low water, and there is the phenomenon of an "intermediate tide," which is found running along the shore at high and low water when the main streams are at rest. The Strait of Dover thus never has slack water throughout its extent at any one time, and, as stated in the *Channel Pilot*, "if a vessel having come up Channel with the last of the West Channel stream running E. enters the intermediate tide running E. off Hastings, she will have a continuation of it for four hours longer, and, if sailing eight knots, will carry it to the N. Foreland."

On the other hand, at the commencement of flood in the southern portion of the Straits, owing to a simultaneous set of the intermediate tide to the south-westward and of the West Channel stream to the south-eastward, there is a strong convergence towards the French coast between Dieppe and Boulogne. I have not, however, examined minutely the effects of the Dover tides upon any of our drift-bottles on the present occasion. The general occurrence of a southerly component in the Channel winds renders it probable that most of our bottles entered the Straits on the English side, where the net resultant of the tidal influences appears to be in the same direction as the prevalent winds, whose drift they would merely reinforce. In the case of Mounts Bay, as already pointed out, the stronger currents are in the opposite direction.

The influence of the tidal indraught towards Boulogne possibly accounts for the fact that the only bottles recovered on the French coast west of Calais were found at Le Portel, near Boulogne—one on June 19th, the other on August 5th (batches XX. and XXII.).

The strong tidal currents at the entrances to the Gulf of St. Malo may have to be considered in future reports; but as only one batch of our bottles approached this region last year, it does not appear to be profitable to discuss their course on the present occasion.

In Lyme Bay, however, partly owing to the conformation of the coast line, and partly to the indraught of the great tides in the Gulf of St. Malo, the tidal currents are very weak, and, instead of a parallel ebb and flow in the northern part of the bay, the tidal stream in this position is rotary in direction, changing, with the hands of a clock, "round the compass, with little or no velocity." The slight velocity of this vortex, compared with that due to wind-action, enables us to neglect its effects upon the surface drift under ordinary circumstances. But on the eastern side of the bay a stream runs to the south-eastwards for nine hours out of the twelve, after apparently making the circuit of the bay from the Start to Portland. Off Portland Bill the well-known "Race" is due to a combination of this outset from the bay, which has gradually increased in velocity along its course, and a counter-stream from East Portland Bay which sets for 9½ hours. In N. winds the race extends nearly two miles from the Bill, with great overfalls beyond that distance; but with S. winds it scarcely exceeds half a mile. The velocity of the race at springs is six or seven knots.

It is clear that drift-bottles in the eastern part of Lyme Bay will tend to the southward, independently of the winds, as a direct result of the tidal currents here. In the western part of the bay they are not only protected from the direct action of westerly and south-westerly winds, but as a result of the slow tidal vortex tend to be carried northwards and then eastwards with the stream which sets to Portland. It is a remarkable fact that only two of our bottles were recovered on the shores of Lyme Bay: one on August 22nd on Chisel Beach, the other on August 30th at Charmouth, near Lyme Regis. Yet there is every reason to believe, as will be shown below, that most of the February bottles were in the western part of Lyme Bay at the end of that month. We are conducting a special series of experiments in this region during the current year.

It appears accordingly, as a result of the above considerations, that the general eastward drift of the Atlantic is probably not continued through the English Channel as a current independently of the local winds; and that the deflecting influence of the tides upon the surface drift is immaterial in the fairway of the Channel, but may be considerable in certain well-defined regions of the Channel in proximity to the shore.

The motion of the surface currents in the Channel will therefore depend principally on the force and direction of the local winds, but will be subject to modification by tidal currents in the regions enumerated.

§ 4. *The Law of Drift.*—When discussing the influence of the local winds upon the course of our bottles in § 1 the matter of direction was alone considered, questions of velocity being entirely neglected.

But as the exact route taken by the bottles is of considerable importance, it is desirable that some attempt should be made to determine the ratio between the velocity (or force) of the winds and the velocity of the surface currents set up by their action, even though we can only hope to attain a limited degree of accuracy.

The only investigation upon this point with which I am acquainted is contained in Mohn's classical memoir on the circulation of the North Ocean, published in the *Reports of the Norwegian North Atlantic Expedition* (1887, pp. 117–123). According to Mohn, a wind of force 3·9 on the Beaufort scale produces a drift having a velocity of 15 nautical miles per diem. Converting the force of the wind to its velocity according to Scott's table, he gets:

Wind force 3·9 = wind velocity 22·5 miles per hour = drift velocity 15 miles per diem.

This result was gained by computing the mean velocities of the equatorial current and of the trade winds from a large number of cases in which the mean directions of the current and wind approximately coincided. The resultants of the two sets of calculations were then regarded as respectively equivalent.

The velocity of the drift in this and subsequent cases considered by Mohn was taken to be directly proportional to the velocity of the wind.

It seems to me to be clear from this account that Mohn's drift equivalent is only applicable to cases of permanent currents. In his datum case a wind of force 3·9 was not shown to be capable of producing a current of velocity 15 miles per diem *from rest;* it is merely the force of wind sufficient to maintain such a current when already in motion with that velocity. It provides a datum for estimating the mean velocity of a permanent drift when the velocities of the winds in the same region are known, or conversely. But it does not establish a means of determining the effect of the wind upon the sea in a region not subject to a regular circulation, such as the English Channel, if I am right in my attitude upon this point. The currents in the Channel have to be raised practically from rest, since the great variability of the winds prevents the formation of currents with any such momentum as that of the permanent currents.

As, however, the wind frequently blows from the same quarter for several days in succession, its effect upon the water will be relatively greater under these circumstances than when blowing intermittently. The momentum of the drift produced by high winds will be considerably greater than for low winds, and the waves raised by strong winds will enable these winds to exert a propelling force upon the water, in addition to the normal dragging force. All these circumstances seem to me to show that the velocity of a current raised in a given time will be relatively very much greater when raised by a high wind than by a low wind. Without therefore attempting to treat the matter from the difficult point of view of hydrodynamics, it nevertheless seems justifiable to regard the velocity of the current as approximately proportional to the pressure rather than to the velocity of the wind, the pressure being a constant fraction of the square of the velocity.

§ 5. *Empirical Datum.*—On examining the results of the year's experiments one case of drift stood out clearly from the remainder as supplying a datum, comparatively free from sources of error, in regard to the measurable effect of the wind in producing a surface drift, viz., batch no. XXXIX. Out of five bottles put out near the Eddystone on April 22nd one was recovered exactly three days later (73 hours) at Portscatho, situated 25 miles to the westward. The wind during this period was remarkably uniform in force and direction from the eastward, owing to an area of high pressure lying to the N.E. of our islands; and the duration of drift was sufficiently long to allow the oscillating effect of the tides to be discounted. The winds during April, moreover, were very variable, so that we may assume this particular drift to have been raised from rest, especially as on the day preceding that on which the batch was put out a calm prevailed in this portion of the Channel. This assumption is confirmed by the fact that a bottle of batch XXXVII., put out in the same place on the preceding day (April

21st), was recovered at Portscatho also on the 25th. The two bottles were recovered by different individuals at different times of the day. We may assume, therefore, that they had not lain long on the shore before being picked up.

The force of the wind was taken to be the mean of the forces recorded at Prawle Point, Plymouth, and Falmouth. The records for Prawle Point and Plymouth are expressed in terms of the Beaufort scale, the former being extracted from the Daily Weather Reports of the Meteorological Office, and the latter being supplied to me by the Borough Meteorologist at Plymouth. The Falmouth records are the readings of the automatic anemograph at the Falmouth Observatory, and are expressed in units of velocity (miles per hour). To compare these records I have employed Scott's table of the velocity-equivalents of the various figures of the Beaufort scale. The recorded direction of the wind during the period was approximately the same at all three stations, *i.e.*, about E.N.E., but the records of the force of the wind showed more discrepancy than might have been expected. At Prawle Point the force varied between 5 and 7 throughout the period, the average being 6; at Plymouth it was more variable, and the average was 4; while at Falmouth the resultant average velocity compiled from the 73 hourly records during the period only amounted to 13·9 miles per hour, which is equivalent to a force intermediate between 2 and 3 on the Beaufort scale, but much nearer 2 than 3. It is reasonable to expect that the force of an E.N.E. wind blowing over the southern part of our islands should be weaker at Plymouth than at Prawle Point, owing to the retarding effects of greater friction, for such a wind at Prawle Point would come to an observer there direct from the sea (Lyme Bay), while at Plymouth it would be distinctly a land breeze. But it is difficult to understand the low readings of the anemograph at Falmouth during this period, especially as there was no corresponding reduction in the force of the wind further westward, the force at Scilly being recorded in the Daily Weather Reports as varying between 4 and 6, the average being 5. The error introduced by the employment of a table of velocity-equivalents of the Beaufort forces no doubt partly accounts for the lack of correspondence between the data, and the records at Prawle Point were possibly in this case slightly in excess of the actual velocities; but there is still a residuum of error which must apparently be attributed to the effects of local environment upon the velocity of the wind recorded at the Falmouth Observatory.

However, by taking the mean of the observations at Prawle, Plymouth, and Falmouth we shall probably eliminate the errors of observation and measurement, and obtain a fairly true measure of the force of the winds over the sea in this district for the period in question. The resultant winds were calculated independently in each case in terms of pressure, by constructing a polygon of forces from each set of data, the length of each line being made proportional to the sum of the wind pressures from the corresponding quarter. The records on the Beaufort scale and those in terms of velocity were reduced to terms of pressure by means of the following table* of equivalents:—

Force, Beaufort scale . .	0	1	2	3	4	5	6	7	8	9	10	11	12
Velocity, miles per hour .	3	8	13	18	23	28	34	40	48	56	65	75	90
Pressure, pounds per foot .	0·05	0·3	0·8	1·5	2·5	4	6	8	11·5	15	21	28	40

This method is founded on that employed by Dr. Fulton † in his report on the drift-bottle experiments of the Scottish Fishery Board, but differs, for reasons already stated, in the employment of terms of pressure instead of terms of "force" for the construction of the polygon. The practical result of this change is easily seen from the following examples: —On Fulton's method a wind of force 9 is regarded as only 3 times as effective (in the production of currents) as a wind of force 3; by using terms of pressure, however, the same wind is regarded as 10 times as effective $\left(\frac{15}{1 \cdot 5} = 10\right)$. Similarly on Fulton's method a wind of force 8 is only twice as effective as one of force 4; on mine it is regarded as between 4 and 5 times as effective $\left(\frac{11 \cdot 5}{2 \cdot 5} = 4 \cdot 6\right)$.

In the case of the Prawle winds the observations taken daily at 8 a.m. and 6 p.m. were used, for Plymouth those at 9 a.m. and 9 p.m., while at Falmouth the hourly records were used, amounting to 73 in all for this period of drift. As the bottle was put overboard at 3 p.m. on April 22nd, and recovered at 4 p.m. on the 25th, half the wind-pressure on the evening of the 22nd was combined with half the pressure on the morning of the 25th in the Prawle and Plymouth cases. The results, as determined by the length of the resultant line in the polygons, was as follows:—

Prawle Point—Resultant sum	of Pressures		= 38	} based on 2 observations daily.
Plymouth ...	Ditto	ditto	= 15·5	}
Falmouth ...	Ditto	ditto	= 76·7	" 24 " "

Dividing the Falmouth resultant by 12, in order to put it on a par

* This is the table authorised by the Meteorological Office in 1875 after the publication of Scott's paper, with the addition of a table of pressure-equivalents. The latter are computed from the velocities by multiplying the squares of the velocities by the factor 0·005, and expressing the results as far as possible in whole numbers. A more recent table of velocity-equivalents by Mr. Curtis (*Quart. Jour. Met. Soc.*, XXIII., 1897), has been kindly forwarded to me by Mr. Scott, but reached me too late for use in the present report. It differs from Mr. Scott's table in assigning somewhat lower velocities to all the figures of the Beaufort scale.

† *Fifteenth Annual Report of the S.F.B.*, Part III., 1897, p. 357.

with the other figures based only upon two observations daily, we get the mean of these three resultants as follows :—

$$\text{Mean} = \frac{38 + 15{\cdot}5 + 6{\cdot}3}{3} = \frac{59{\cdot}8}{3} = 19{\cdot}9, \text{ or, practically } 20,$$

which is the measure in pounds per foot of the resultant of the wind-pressures, taken twice daily, during the period of drift.

The mean average pressure is, of course, this sum divided by the number of days and the number of observations per diem, or $\frac{20}{3 \times 2} = 3{\cdot}3$, which is equivalent to a velocity of 26 miles per hour, or a "force" intermediate between 4 and 5 (4·6) on the Beaufort scale.

The resultant or minimum distance traversed by the drift-bottle from the Eddystone to Portscatho = 25 geographical miles.

We conclude therefore that a wind exerting a horizontal pressure of 3·3 pounds per foot (= a velocity of 26 miles per hour, or a force intermediate between 4 and 5), and blowing steadily for three days, will cause a surface drift in the same direction of 25 miles in that time, *i.e.*, a current having a surface velocity of 8·3 miles per diem.

This result is considerably lower than that attained by Mohn, and bears out my remarks concerning the inapplicability of Mohn's current-equivalent to cases of currents produced by the wind from rest.

Having thus determined the drift-equivalent, it is easy to construct a factor from it by which the resultant wind pressure for any period may be quickly converted into the number of miles travelled by the surface drift for the same period.

If D be the Distance travelled in miles, and P_2 the resultant Wind-Pressure in pounds per foot computed from 2 observations daily,

$$\text{then } D : P_2 :: 25 : 20,$$

$$\text{or } D = \frac{5\ P_2}{4};$$

and since P_2 may be taken as merely $\frac{2}{n}(P_n)$, where P_n is the Resultant Pressure determined from n observations daily, we have the general formula

$$D = \frac{5\ P_2}{4} = \frac{5\left(\frac{2}{n}P_n\right)}{4} = \frac{5 \times 2\ P_n}{4 \times n} = \frac{5\ P_n}{2n}.$$

In most cases it is, of course, sufficient to determine the resultant wind and wind pressure for any period from the observations recorded twice daily at different stations, and the factor then becomes simply $\frac{5}{4}$; or

$D = \frac{5 \times \text{Resultant Pressure}}{4}$, which gives us the number of miles drifted.

The accuracy of this equivalent can only be determined by the frequency with which its results accord with those of direct experiment. It depends on an assumption which may invite criticism, viz., that the velocity of the drift varies as the pressure of the wind, and not directly as its velocity. This pressure-ratio is confessedly only an approximation to the true law of drift, but I consider it to be nearer the truth than the velocity-ratio adopted by Mohn, which assumes the existence of a level sea for winds of all velocities.

§ 6. *Application of Factor to cases of Drift.*—The use of drift-bottles for estimating the velocity of drift is attended by a possible source of serious error, viz., the difficulty of determining the length of time between the actual stranding of a bottle and its subsequent recovery. In some cases this source of error is removed by the statements made by the finders of the bottles, but in most cases it must always remain as a condition to be taken into account. On the whole, however, I believe that the maximum error due to this cause is inconsiderable except when the bottles have been recovered in unfrequented parts of the coast. Most bottles are picked up in the neighbourhood of towns and fishing ports where the shore is much frequented, and in other regions the coastguardsmen are always on the look-out. The conspicuousness of our bottles must also tend to reduce the error due to this cause. Altogether I should estimate the average error as amounting to not more than 12 hours in summer and 24 hours in winter, which is inconsiderable except for short journeys. I would particularly point to the records of batches LII. and LIII. in support of these remarks. The simultaneity with which so many of these bottles were recovered by different individuals after drifting for more than a fortnight is well worthy of note, and we have had still more striking examples of the same thing this year.

The following table shows the results of an application of the drift-factor to certain cases of drift recorded in Table I. Open water and an absence of deflecting currents are assumed. The actual direction and distance of drift are compared side by side with the estimated direction and distance of drift, and these have been calculated from the winds prevailing at the time by the employment of the factor and the method already described. The wind records, except those of Rousdon and Falmouth, were extracted from the Daily Weather Reports of the Meteorological Office.

Table comparing the Estimated and Actual Drift for various periods.

Batch.	Direction of Drift.		Distance.		Position at end of Drift.		Records of Wind Employed.
	Estimated.	Actual.	Estimated.	Actual.	Estimated.	Actual.	
II. 1.	E. 18° N.	E. 11° N.	172	180	23 miles N.N.W. of Eastbourne.	Eastbourne.	Jan. 22–Feb. 28. Prawle Point. March 1–March 16. Mean between Dungeness and Hurst Castle.
III. 1.	E. 20° N.	E. 17° N.	99	90	10 miles N.E. of Chapman's Pool.	Chapman's Pool.	Jan. 29–Feb. 28. Prawle Point.
VII. 1.	E. 23° N.	E. 15° N.	216	175	51 miles N.E. of Seaford. (Sheppey.)	Seaford.	Feb. 16–28. Prawle Point. March 1–15. Rousdon (Lyme Regis). March 16–31. Mean between Hurst Castle and Dungeness April 1–17. North Foreland.
2.	E. 14° N.	E. 14° N.	210	240	30 miles W. by S. of Calais.	Calais.	Feb. 16–March 31. As for VII. 1. April 1–May 13. North Foreland. May 14–19. Cape Gris Nez.
VIII. 1.	E. 15° N.	E. 15° N.	237	260	28 miles W. by S. of Dunkerque.	Dunkerque.	Feb. 17–May 13. As for VII. 2. May 14–15. Cape Gris Nez
IX. 1.	E. 18° N.	E. 18° N.	120	120	Sandown Bay.	Sandown Bay.	Feb. 17–28. Prawle Point. March 1–15. Rousdon. March 16. Hurst Castle.
2.	E. 15° N.	E. 14° N.	237	235	8 miles N. by E. of Calais.	Calais.	Feb. 17 to May 15. As for VIII. 1.
XIV. 1.	E. 15° N.	E. 15° N.	240	255	15 miles W. by S. of Calais.	Calais.	Feb. 18–May 13. As for VII. 1.
XXX. 1.	W. 6° N.	W. 6° N.	7	35	28 miles E. ½ S. of Sennen.	Sennen Cove.	March 31–April 6. Scilly.
XL. 1.	S. 32° W.	W. 13° S.	52	50	36 miles S.S.E. of Mullion.	Mullion.	May 11–27. Mean between Prawle Point and Scilly.

It is seen from the preceding table that in only one out of ten cases of drift does my calculated drift exactly coincide with the records of the bottles (IX. 1); but in several other cases the results correspond in a sufficiently close manner for all practical purposes. Some further examination, however, is necessary before the reliability of my method can be depended upon, because the estimated results depend upon the assumption of open water, and this cannot always be conceded.

In the case of II. 1 there is an angular error of 7° in a course of 180 miles, the estimated and actual distance of drift being practically identical. In this instance there can be no question of any deflection of the drift by the proximity of the shore. My calculations from the winds at Prawle Point, from January 22nd to January 28th, give an estimated drift of 34 miles in a S. by E. direction, which would thus convey the bottles well into mid-Channel. The Prawle winds for the ensuing period, January 29th to February 28th, give an estimated drift of 99 miles in an E.N.E. direction, bringing the bottles to a position about 26 miles S. by W. of the Needles. The direction of the drift during March 1st to 16th was estimated as N.E. ½ E. in this part of the Channel. The direction of the strong winds immediately before the recovery of the bottle was as follows:—March 16th, S. to S.S.W.; March 15th, S.S.W.; March 14th, S. to S.S.E. Clearly the bottle was not driven to Eastbourne from the westward side of Beachy Head by a current parallel with the shore, but must have been almost due S., or even S.S.E., of Eastbourne when overtaken by the gale, as the recovery of another bottle to the eastward a few days later also shows. The error in my estimate is not due therefore to shore-deflection, but to an excess in the southerly component of the wind records employed This is just what one would expect under the circumstances, since the records employed were those of Prawle Point, Hurst Castle, and Dungeness. All of these stations are situated on the northern coast of the Channel, and are consequently more exposed to the full force of southerly than of northerly breezes. The course of the bottles, however, was in mid-Channel for a considerable distance, and thus equally subject to the influence of winds from north and south. That this is the true explanation is seen from the fact that while the resultant wind for March 1st to 16th was S.W. ¾ S. at Hurst Castle, and S.W. ⅓ W. at Dungeness, it was nearly W.S.W. at Jersey (S.W. by W. ½ W.), the force at the three stations being approximately the same. The error could have been avoided by taking the mean between these three winds for the period; but I have preserved my estimate in its original form in order to show by an example the precautions in this respect which must be taken when very accurate results are desired.

In the second case (III. 1) we have again an angular error to the northward, but of small value (3°). The disturbing effects of Portland Race perhaps account for this slight discrepancy; but a closer estimate would probably have been obtained by taking the mean between the Prawle Point and Rousdon winds. During March, when the state of the wind was very similar to that in February, I found that the records at Rousdon indicated a stronger component from the northward than did those at Prawle Point.

The six succeeding cases deal with batches all of which were represented in the neighbourhood of Calais by bottles recovered between the 13th and 19th May. They are, therefore, of particular interest as throwing light on the whole course of drift. There is a glaring discrepancy between the estimated and actual drift of the Seaford bottle (VII. 1); but the remainder conform moderately well, especially when the length of the journeys involved is taken into account. From the close correspondence between estimated and actual drift in cases IX. 1 and 2 we may, I think, conclude that the inferences to be drawn from the use of the drift-factor in all these cases are reliable. In the Seaford case there is an angular error of 8°, a distance error of 41 miles, and a serious geographical discrepancy of position. Had there been open water in the estimated direction of drift, the Seaford bottle should have been on the east coast of Sheppey on April 17th. We see, however, from IX. 1 that these bottles, which from their eventual destination we may shortly term the Calais bottles, were off the south coast of the Isle of Wight about March 16th, and so violent were the westerly gales of the latter half of March that the estimated drift during that period was 120 miles in a N.E. by E. direction, which would bring the bottles to a position 5 or 6 miles E.N.E. of the Nore Lightship off the mouth of the Thames. The Sussex coast, however, would interpose an impassable barrier to such a course, and two alternatives would present themselves: (1) the bottles must drive at once ashore, or (2) the bottles must be deflected from their estimated course by a current racing eastwards along the shore towards the Straits of Dover. The latter course appears to have been taken in most cases, and the bottles were probably in the lower part of the North Sea, between the Essex and Belgian coasts, at the end of the month. That the passage of the Straits was made at this time in spite of the southerly component in the winds is rendered all the more probable because a bottle of batch II., which was off the coast of Eastbourne on March 16th, was recovered at Terschelling on March 30th. This is equivalent to a distance of 250 miles in 14 days, or almost 18 miles a day. Now the estimated drift, directly dependent on the pressure of the wind during this period, was 120, or at most 140 miles. This velocity was therefore nearly doubled, no doubt partly owing to the head of water accumulated in the eastern part of the Channel during the gales, and partly to the narrowing of the Channel in this region. This result accords with the experience of navigators, for, according to the *Pilot's Handbook* (12th ed., 1893, p. 142), "strong W. gales prolong the intermediate stream running E., and retard the stream running S.W. At such times the streams at the Ridge shoal have been found to run 8 hours to the N.E., and only 4 hours to the S.W."

But there is no reason to assign to any of the Calais bottles the remarkable velocity attained by this Eastbourne-Terschelling bottle (II. 3) during the latter half of March. The latter bottle would begin to experience the acceleration caused by the narrowing of the English Channel almost immediately after the commencement of the westerly gales in mid-March, as Beachy Head marks the western boundary of the funnel-shaped extremity of the Channel; but the Calais bottles at this time (March 16th) were 50 miles to the westward, off the east coast of the Isle of Wight, in one of the widest parts of the Channel. During the third week of March, therefore, although the direction of drift of the Calais bottles would be deflected to a course parallel with the coast, their velocity would scarcely differ from that directly due to the pressure of the wind, which we have already seen was calculated to be 120 miles for the fortnight, or 60 miles for the week, which would bring them slightly to the eastward of Beachy Head. From this point they would begin to experience an accelerated velocity; and, if we assume that they travelled at the same average rate as the Eastbourne-Terschelling bottle (18 miles a day), their position at the end of March would be 125 miles to the north-eastward of Eastbourne, or somewhere in a line between Harwich and the Hook of Holland, and probably on the westward side of the middle of this line. Such a position would be about 60 miles N.N.E. or N. by E. of Calais. Now the estimated direction of drift in this region from April 1st to 30th, based on the North Foreland winds, was W. ½ S., 29 miles, which would bring the bottles to a position slightly south of Harwich, off the Naze, by the end of that month. The Naze is rather under 60 miles N.N.W. of Calais. The estimated drift from May 1st to 13th, based on N. Foreland winds, was approximately E.S.E. (actually S.E. by E. ⅞ E.), 56 miles; or, based on the winds of Cape Gris Nez, S.E. ⅛ S., 59 miles; so that, obeying this drift, the bottles on May 13th would be within a mile or two of the French coast between Calais and Dunkerque, a result which coincides remarkably with the actual position of the bottles about that time, and demonstrates the general accuracy of the method employed in this report for deducing the course of drift from the direction and pressure of the winds.

Apart from the employment of this quantitative method, a mere survey of the records contained in the table showing the recovery of drift-bottles would have led one to the conclusion that the eastward drift of these bottles was a more or less steady and continuous one from March 16th, when they were off the Isle of Wight, until the middle of May, when they were stranded on the French coast. The recovery of a bottle at Seaford in April points clearly to such a conclusion, and the direction of the resultant winds at Dungeness during the latter half of April (E.N.E., light) and the first half of May (W. by N., moderately strong) appeared to me at first sight to accord with the view that all the Calais bottles were in the neighbourhood of Seaford in mid-April. It was not until I made the extensive calculations required for the above analysis that I finally convinced myself of the serious error of this view, and of the certainty that the Calais bottles had already made the passage of the Dover Straits in the last week of March, owing to the production of a current along the coast of Sussex at an angle with the direction of the wind during the last fortnight of March.

In order to explain the case of the Seaford bottle we must go back to the position of the Calais bottles prior to the southerly gale of March 16th, which drove so many ashore. On March 16th and 17th several bottles were stranded on the S.E. coast of the Isle of Wight by this gale, but one, at least (XI. 1), was stranded about the same time on the S.W. coast of the same island, and another was recovered in the Solent on March 31st (XIII. 1.). Now this latter batch did not arrive at Calais until June 18th. It is probable, therefore, that the cause of retardation in this case was that these bottles had not easted sufficiently by the 15th March to be able to round St. Catherine's Point when the southerly gale of the 16th overtook them. Those which were to the eastward of the Point, and escaped stranding, were driven rapidly along the Sussex shore to the Straits of Dover; but those which were to the westward of the Point were either driven ashore on the west coast of the island or into the Solent. Their course through the Solent and Spithead to the eastward would be distinctly slow, as they would lose a considerable portion of the direct effect of the westerly gales; and I imagine that the Seaford bottle may have been retarded in this way, while others of the same batch succeeded in clearing St. Catherine's Point, and pursuing an unobstructed course. A difference of a few miles between the positions of bottles on the 15th of March would be sufficient to determine whether they would be carried to the eastward or westward of St. Catherine's Point. If the Seaford bottle actually took the course here suggested it must have slowly drifted eastwards through the Solent and Spithead, and emerged off Selsea Bill during the last few days of March, pursuing a course along the Sussex coast under the influence of the westerly winds. The resultant westerly wind of April 1st to 17th was estimated from the winds at Dungeness to produce a drift of 24 miles in an E.N.E. direction (actually N.E. by E. ½ E.). The distance of Seaford from Selsea Bill is 34 miles. This suggestion as to the course of the Seaford bottle, therefore, is sufficiently consistent with the conditions prevailing at the time, and with the remainder of our records, to render it the probable explanation of the conspicuous lack of correspondence between actual and estimated drift in this case. Another alternative is that the bottle may have been driven ashore between the 16th and 19th March on the east coast of the Isle of Wight, or on the Sussex shore west of Selsea Bill, as occurred in the case of III. 4, and that it remained ashore until the latter end of March, when it resumed its eastward drift; but I consider this theory much less probable. What I hold to have established is that the course of the Seaford bottle was quite exceptional, and that its position on the 17th April does not indicate the position of the remaining bottles of the same batch on that date; for there was a general tendency for bottles put out near the Eddystone between the 16th and 18th of February to arrive on the French coast between Calais and Dunkerque between the 13th and 19th May, and I have shown that this could be achieved, provided the bottles passed through the Straits of Dover in the last week of March. It was, on the other hand, impossible, if the bottles were in the neighbourhood of Seaford in mid-April. The distance from Seaford to Calais is 70 miles, the direction E. 12° N.; but the estimated drift for the period April 17th to May 13th (based on the winds at Dungeness) is only 35 miles, and the direction E. 30° S., an error both of direction and distance which is too serious to be due to the method of computation, and which admits of no explanation from the nature of the winds prevailing at the time.

The two last cases in the table now require consideration. The first of these (XXX. 1) is the drift of *two* bottles from the Manacles to Sennen Cove, a distance of 35 miles, during the first week of April. The fact that two bottles pursued the same course shows that the causes of the drift were very constant. The case is the more remarkable as two headlands—the Lizard and the Land's End—had to be rounded during the drift. Now my estimated drift for this period, though in the right direction, is remarkably deficient in distance. Indeed, so variable were the winds in this part of the Channel during this period that it is quite impossible to attribute the drift in this case to the action of the wind. As a check upon my estimate based on the Scilly records, I have also made a calculation as to the direction and distance of drift based on the winds at Falmouth, using the complete set of hourly records of the anemograph for the period. The result is equally inadequate. I have also estimated the drift on the assumption that the rate of drift is proportional to the *velocity* of the wind, which only made matters worse, since it yielded an estimated drift of only 3 miles in a direction W. 24° N. It is obvious that in this case the rapidity of the drift round the Cornish headlands was due to some cause other than the winds, and, as already described in an earlier section of this report, the known peculiarities of the tidal streams in this region provide an adequate explanation. The indraught into the Bristol Channel during the flood-tide here causes a marked set to the northward round the Land's End, and this brings about a predominance of the westward tide over the eastward tide in this part of the English Channel. In fact, the English Channel supplies more water to the Bristol Channel during flood-tide than returns to it on the ebb from the same region.

The last case of all (XL. 1) appears to illustrate the same point. There is an angular error of 45° in my calculated drift, but the estimated distance is approximately correct. The deflecting cause may be regarded as equivalent to a current in a N.N.W. direction having an average velocity of 36 miles in 16 days, *i.e.*, rather over 2 miles per diem. There seems to be no reason for doubting that this deflection was due to the influence of the resultant northward tendency of the tides in the western region of the Channel, which is determined by the indraught into the Bristol Channel during flood-tide in that region. We have seen in the preceding case (XXX. 1) that the force of this indraught determines a current round the Lizard and Land's End of some 30 miles in 6 days, *i.e.*, 5 miles a day; so that, although this deflecting influence was not fully felt during the whole period of drift in the present case, we are probably correct in attributing the observed deviation to the same cause, since the south-westward drift caused by the winds would bring the bottles nearer to the influence of the indraught on each successive day; and, in order to complete the distance between the eventual estimated and actual positions, it would suffice if the full influence of the indraught (5 miles per diem) were only felt during the last seven days of drift.

§ 7. *Conclusions.*—Enough has been said, I think, to show that the method employed here for tracing the actual influence of the winds on the water is sufficiently accurate for practical purposes, and that by its employment, with proper precautions, the influence of the winds may be separated from that of other factors which operate in the production of surface currents. From this point of view the method may be of considerable use in the future for determining the existence of currents not produced by local wind-action. At the same time the method requires to be tested extensively before it can be used as a basis for conclusions. The present report pretends only to show that the relation between wind-action and surface currents is capable of quantitative study, and that the results obtained by the use of the methods here described are sufficiently accurate to encourage the further use of them. This we are doing during the present year on a larger scale, and the results will be set out in next year's report. It is very desirable that experiments should be made to determine the depth of the currents induced by wind-action, and we propose to attempt this work during the present year. A comparison of results obtained by bottles floating at the surface, and by other objects designed to come under the influence of lower strata of water, should yield results of considerable value. Until such experiments are made, however, it does not appear to be desirable to say too much upon the practical aspects of the experiments described in this report. We have obtained a general view of the movements of the uppermost layer of water, and we may be certain that similar, though slower, movements also affect the layers immediately subjacent; but the actual depth to which this movement would be communicated under different conditions of wind and tide is a matter of too much practical importance to be left to mere guesswork. As Mohn has well said: "Neither argument nor estimate, but carefully worked-out computations alone, can lead to a lasting result."

II. St. George's Channel and Irish Sea.

Owing to the fact that our experiments in this area only cover the summer and autumn months, it does not appear to be advisable to make any attempt to generalise the results obtained, the data given in Table II. being self-explanatory. I may remark, however, that in all the cases which I have specially analysed, the actual drift differs from the estimated drift in taking a more northward direction. This result appears to agree with that obtained by Professor Herdman in his experiments in the Irish Sea. (*Proc. Liverpool Biol. Soc.*, vol. x.).

Note.—In the tables which follow, as well as in the preceding portion of this report, the positions of places and directions of currents are invariably indicated by their true geographical bearings, and not by their compass (magnetic) bearings. As the directions of winds are uniformly indicated in true geographical terms, and as compass bearings differ with latitude and longitude, it seemed desirable to use true geographical bearings throughout this report, in order to avoid the possibility of confusion.

TABLE I.—ENGLISH CHANNEL AND NORTH SEA.

Bottles Sent Adrift.				Bottles Recovered.			Distance and Rate of Drift.		
No. of Batch.	Date.	Locality.	No. of Bottles.	No. of Bottle.	Date.	Locality.	Minimum distance (Geog. miles).	Time occupied (days).	Rate of Drift (miles per day).
I.	Jan. 19.	4 miles E. of Eddystone.	7	1	May 11.	Terschelling I., Holland—(afloat).	430	112	3·8
				2	,, 13.	Ditto (ashore).	430	114	3·8
II.	,, 22.	3½ miles N.E. of Eddystone.	6	1	Mar. 16.	Eastbourne, Sussex.	180	53	3·4
				2	,, 19.	Bexhill-on-Sea, Sussex.	190	56	3·4
				3	,, 30.	Terschelling I.	430	67	6·4
				4	May 25.	Borkum I. (Germany).	480	123	3·9
III.	,, 29.	2 to 3 miles off the Eddystone. (E., S., and S.S.W. from the Lighthouse.)	27	1	Mar. 1.	Chapman's Pool, nr. St. Alban's Head, Dorset.	90	31	2·9
				2	,, 16.	Sandown Bay, I. of Wight.	130	46	2·8
				3	,, 17.	Ditto ditto	130	47	2·7
				4	,, 18.	East Withering, Sussex.	145	48	3·0
				5	July 10.	Texel I., Holland (3 miles off shore).	400	162	2·4
				6	Aug. 3.	Schiermonnikoog I., Holland.	470	186	2·5
				7	,, 15.	Terschelling I., Holland.	430	198	2·1
				8	Sep. 3.	Thyboron Kanal, Denmark.	650	217	2·5
				9	Oct. 12.	Fjellbacka, Sweden.	930	256	3·6
				10	,, 21.	Vordkosterön, Strömstad, Sweden.	940	265	3·5
IV.	Feb. 15.	3 miles S.W. of Eddystone.	6	1	Mar. 20.	Warbarrow Bay, Dorset.	90	33	2·7
				2	,, 28.	Portland Beach, Dorset.—(Card only; bottle broken.)	85	41	2·0
				3	Nov. 24.	Bröns, Nordschleswig, Germany.	590	282	2·0
V.	,, 16.	5 miles E. by S. of Eddystone.	6	1	July 20.	Zuiderzee, near Nieuweschild, Holland.	430	154	2·8
VI.	,, 16.	18 miles S.E. ¾ S. from Eddystone. { Lat. 49° 57′ 10″ N. Long. 4° 0′ 30″ W.	6	1	Oct. 15.	Bröns, Nord Schleswig.	585	241	2·4
VII.	,, 16.	10½ miles S.S.E. from Eddystone.	6	1	Apr. 17.	Seaford, Sussex.	175	60	2·9
				2	May 19.	Calais, France.	240	92	2·6
				3	Aug. 2.	Langeoog I., Germany.	520	167	3·1

VII.	Feb. 16.	$10\frac{1}{2}$ miles S.S.E. from Eddystone.		4	Aug. 15.	1 mile S.E. of Heligoland.	540	180	3·0
VIII.	,, 17.	11 miles S.S.E. $\frac{1}{2}$ S. from Eddystone.	6	1	May 15.	Dunkerque, France.	260	87	2·9
				2	,, 19.	Baraques, near Calais.	240	91	2·6
				3	June 27.	North Sea, 26 miles N.W. by N. from the Hook of Holland—(afloat).	345	130	2·6
				4	July 31.	Amiland I., Holland.	450	164	2·7
IX.	,, 17.	11 miles S. by W. from Bolt Tail, S. Devon.	6	1	Mar. 17.	Sandown Bay, I. of Wight.	120	28	4·2
				2	May 19.	Calais.	235	91	2·5
X.	,, 17.	10 miles S.S.W. of Bolt Tail (2 miles to N.W. of IX.).	6	1	Feb. 18.	E. end of Plymouth Breakwater.	15	24h.	15·0
				2	Mar. 3.	Laira, Plymouth.	18	14	1·2
XI.	,, 17.	11 miles S.S.E. from Dodman Point, Cornwall.	6	1	Mar. 18.	Brighstone Bay, I. of Wight.	135	29	4·6
XII.	,, 18.	5 miles S.S.W. from Eddystone.	6	1	Oct. 13.	Nymindegab, Denmark.	600	237	2·5
XIII.	,, 18.	17 miles S.S.W. $\frac{1}{2}$ S. from Eddystone.	6	1	Mar. 31.	Solent.	125	41	3·0
				2	June 18.	Calais.	255	120	2·1
XIV.	,, 18.	$18\frac{1}{2}$ miles S.S.W. from Eddystone. (2 miles to W.S.W. from XIII.)	6	1	May 13.	Calais.	255	84	3·0
				2	Nov. 10.	Nymindegab, Denmark.	605	265	2·2
XV.	,, 23.	10 miles W. $\frac{3}{4}$ S. from Lizard Point.	6						
XVI.	,, 23.	5 miles S.S.E. from Wolf Rock.	6	1	Mar. 3.	Porthleven Harbour, Cornwall.	22	8	2·7
XVII.	,, 23.	$12\frac{1}{2}$ miles E. $\frac{1}{4}$ S. from Start Lighthouse.	6						
XVIII.	,, 23.	14 miles from Start Lighthouse (? S. $\frac{3}{4}$ W.).	6	1	Sep. 14.	Juist I., Germany.	485	203	2·3
XIX.	,, 24.	10 miles S.S.E. from St. Mary's Sound, Scilly Is.	6						
XX.	,, 24.	$7\frac{1}{2}$ miles E. $\frac{1}{2}$ S. from Eddystone.	6	1	June 19.	Le Portel, near Boulogne, France.	225	115	1·9
XXI.	,, 24.	2 miles W. $\frac{1}{4}$ N. from Eddystone.	6						
XXII.	,, 24.	5 miles W.S.W. from Eddystone.	6	1	Mar. 1.	Sharping Point, Bigbury Bay, Devon.	20	5	4·0
				2	Aug. 5.	Le Portel, France.	210	162	1·3
XXIII.	,, 25.	8 miles W. $\frac{3}{4}$ S. from Eddystone.	6						
XXIV.	Mar. 11.	3 miles N.N.E. of Eddystone.	6						
XXV.	,, 11.	$2\frac{1}{2}$ miles S.S.E. from Rame Head.	6	1	Mar. 12.	Whitsand Bay, Cornwall (between Coastguard Station and Tregantle Fort).	4	1	4
XXVI.	,, 11.	$\frac{3}{4}$ mile S.S.W. of Breakwater Lighthouse, Plymouth.	5						
XXVII.	,, 15.	5 miles S.W. from Eddystone.	6						
XXVIII.	,, 31. 1 a.m.	4 miles W. $\frac{3}{4}$ S. of Wolf Lighthouse.	6						

ENGLISH CHANNEL AND NORTH SEA—*continued.*

BOTTLES SENT ADRIFT.				BOTTLES RECOVERED.			DISTANCE AND RATE OF DRIFT.		
No. of Batch.	Date.	Locality.	No. of Bottles.	No. of Bottle.	Date.	Locality.	Minimum distance (Geog. miles).	Time occupied (days).	Rate of Drift (miles per day).
XXIX.	Mar. 31. 2 a.m.	Off Wolf Lighthouse (? E.S.E.).	6						
XXX.	,, 31. 4 a.m.	8 miles N.E. by E. of Lizard.	6	1	Apr. 6. 9 a.m.	Sennen Cove, near Land's End, Cornwall.	35	6	5·8
				2	,, 6. 12-30p.m	Sennen Cove, near Land's End, Cornwall.	35	6	5·8
XXXI.	Apr. 11	3 to 4 miles outside Eddystone.	4						
XXXII.	,, 12.	4 to 5 miles westwards of Eddystone.	4	1	,, 13.	Windsworth, 2 miles E. of Looe, Cornwall.	10	1 d. 3 h.	8·8
				2					
XXXIII.	,, 13.	9 miles E. of Eddystone.	6	1	Aug. 22.	Chisel Beach, Dorset.	77	131	·6
				2	Oct. 14.	Oesterhever, Eiderstedt, Schleswig Holstein, Germany.	565	184	3·0
XXXIV.	,, 16.	3 to 4 miles S.W. of Eddystone.	6	1	Aug. 31.	Seaford, Sussex.	178	137	1·3
				2	Oct. 14.	Wieringen I., Holland.	415	181	2·2
XXXV.	,, 21.	2 miles E.S.E. of Wolf Rock.	6	1	Feb. 21, 1898.	Amrum I., Schleswig, Germany.	643	306	2.1
XXXVI.	,, 21.	5 miles E.S.E. of Eddystone.	6	1	Dec. 21.	Ramsgate, Kent.	250	214	1·0
XXXVII.	,, 21.	3 to 4 miles S.W. of Eddystone.	5	1	Apr. 25.	Portscatho, Gerrans Bay, Cornwall.	25	3d 21 h.	6·4
				2	June 2.	Penzance, Cornwall.	52	42	1·2
XXXVIII.	,, 22.	10 miles W. $\frac{3}{4}$ S. of Wolf Rock.	6	1	May 7.	Bryher, Scilly Isles.	15	15	1·0
				2	June 2	18 miles S.W. $\frac{3}{4}$ S. of Bishop Lighthouse, Scilly Isles.	30	41	0·7
XXXIX.	,, 22.	3 to 4 miles S.W. of Eddystone.	5	1	Apr. 25.	Portscatho, Cornwall.	25	3 d. 1 h.	8·2
XL.	May 11.	3 miles E. $\frac{1}{2}$ N. of Eddystone.	18	1	May 27.	Mullion, Mounts Bay, Cornwall.	50	16	3·1
				2	June 2.	Penzance, Cornwall.	60	22	2·7
				3	,, 22.	Croyde, N. Devon.	160	42	3·8
		[*Distance calculated to Croyde, then back to Bude and Eastbourne.*]		4	Aug. 20.	Bude, North Cornwall.	190	101	1·8
				5	Nov. 17.	Eastbourne, Sussex.	500	190	2·6
XLI.	,, 25.	22 to 25 miles S. by E. from Mewstone, Plymouth.	2						

XLII.	May 25.	55 to 60 miles S. by E. from Mewstone, Plymouth.	2						
XLIII.	,, 27.	4 to 5 miles S.S.W. from Eddystone.	2	1	Oct. 27.	Eastbourne, Sussex.	187	153	1·2
XLIV.	June 1.	15 miles S.E. by S. from Eddystone.	6	1	Aug. 25.	Brook, Isle of Wight.	115	85	1·3
				2	Sep. 1.	Hamble Battery, Southampton Water, Hants.	125	92	1·3
				3	Oct. 29	Bexhill-on-Sea, Sussex.	190	150	1·2
XLV.	,, 14. 8 p.m.	34 miles S. ¾ E. from Eddystone. { Lat. 49° 37′ N. Long. 4° 9′ W.	6	1	July 8.	6 miles S.W. from Les Hanois Lighthouse, Guernsey.	55	24	2·2
				2	Aug. 25.	Vauville, Manche, France.	90	72	1·2
				3	Feb. 19. 1898.	Near Farsund, Norway.	750	248	3·0
XLVI.	,, 15. 11-30 a.m.	18 miles S. by E. from Eddystone. { Lat. 49° 53′ N. Long. 4° 10′ W.	6	1	,, 12	Farsund, Norway.	750	241	3·1
XLVII.	July 17.	6 (?) miles S. from Looe I., Cornwall. [*Dead reckoning 22 miles E. ¼ S. (magnetic) from St. Anthony's Buoy, Falmouth; thick fog.*]	18	1	July 20.	Off Polperro, Cornwall; 10 miles E.S.E of Dodman Point—(afloat).	8 (?)	3	2·6
				2	,, 20.	6 miles S.S.E. of Polperro—(afloat).	1 (?)	3	0·3
				3	,, 20.	Ditto ditto ditto	1 (?)	3	0·3
				4	Aug. 15.	Barn Pool, Plymouth Sound—(afloat)	15	29	0·5
				5	,, 16.	Polhawn, Whitsand Bay, Cornwall.	10	30	0·3
				6	,, 16.	Kingsbridge, S. Devon.	30	30	1·0
				7	,, 17.	Estuary of R. Erme, S. Devon.	20	31	0·6
				8	,, 18.	Portwrinkle, Whitsand Bay.	9	32	0·3
				9	,, 18.	Challaborough, Bigbury Bay, S. Devon.	21	32	0·6
				10	,, 21	Bridgend, Yealm Estuary, S. Devon.	16	35	0·4
				11	,, 25.	Mouth of R. Erme, S. Devon.	19	39	0·5
				12	Sep. 2.	Compton Bay, I. of Wight.	130	47	2·7
XLVIII.	,, 27.	3 miles N.W. by W. from Eddystone.	18	1	Aug. 18.	Portwrinkle, Cornwall.	10	22	0·4
				2	,, 30.	Charmouth, Dorset.	70	34	2·0
XLIX.	Sep. 10.	4 miles E.N.E. from Eddystone. [*Tide going W., one hour to run.*]	13	1	Oct. 17.	Charlestown, Cornwall.	24	37	0·6
				2	,, 24.	Mevagissey, Cornwall.	24	44	0·5
				3	,, 25.	Golant (3 m. up the Fowey R.), Cornwall.	23	45	0·5
				4	Dec. 4.	Helford River, Cornwall.	40	85	0·4
L.	,, 10.	4 miles E.N.E. from Eddystone. [*Tide going E., just commenced.*]	12	1	Oct. 18.	Par, Cornwall.	23	38	0·6
				2	,, 19.	Ditto	23	39	0·6
LI.	,, 15.	1 mile W. by S. from Eddystone.	21	1	,, 25.	Yealm Estuary, S. Devon.	12	40	0·3

English Channel and North Sea—*continued.*

Bottles sent adrift.				Bottles recovered.			Distance and rate of drift.		
No. of Batch.	Date.	Locality.	No. of Bottles.	No. of Bottle.	Date.	Locality.	Minimum distance (Geog. miles).	Time occupied (days).	Rate of Drift (miles per day).
LI.	Sep. 15.	1 mile W. by S. from Eddystone.	21	2	Oct. 27.	Maenporth, near Falmouth.	33	42	0·8
				3	,, 28.	Ditto ditto	33	43	0·7
LII.	,, 30.	3 miles N.E. by E. from Eddystone.	24	1	,, 17.	Windsworth (between Looe and Downderry), Cornwall (card only, bottle broken).	13	17	0·7
				2	,, 17.	Downderry, Cornwall.	13	17	0·7
				3	,, 17.	Ditto ditto	13	17	0·7
				4	,, 17.	Ditto ditto	13	17	0·7
				5	,, 17.	Ditto ditto	13	17	0·7
LIII.	Oct. 1.	4 miles S.S.W. from Rame Head, near Plymouth.	33	1	,, 16.	Par, Cornwall.	20	15	1·3
				2	,, 16.	Ditto	20	15	1·3
				3	,, 16.	Ditto	20	15	1·3
				4	,, 16.	Polkerris, near Par.	19	15	1·2
				5	,, 16.	Ditto ditto	19	15	1·2
				6	,, 16.	Pridmouth, near Fowey.	17	15	1·1
				7	,, 17.	Lansallos (between Fowey and Polperro), Cornwall.	13	16	0·8
				8	,, 17.	Ditto ditto	13	16	0·8
				9	,, 17.	Ditto ditto	13	16	0·8
				10	,, 18.	Par, Cornwall.	20	17	1·2
				11	,, 18.	Ditto	20	17	1·2
				12	,, 18.	Ditto	20	17	1·2
				13	,, 18.	Lansallos, Cornwall.	13	17	0·8
				14	,, 19.	Fowey, ½ mile from shore.	16	18	0·9
				15	,, 19.	Par Bay, 1 mile from shore.	19	18	1·0
				16	,, 20.	Par.	20	19	1·0
				17	,, 23.	Bodinnick, Fowey estuary.	17	22	0·7
				18	,, 27.	Golant, 3 miles up Fowey River.	19	26	0·7

Table II.—St. George's Channel and Irish Sea.

Bottles sent adrift.				Bottles recovered.			Distance and rate of drift.		
No. of Batch.	Date.	Locality.	No. of Bottles.	No. of Bottle.	Date.	Locality.	Minimum distance (Geog. Miles).	Time occupied (days).	Rate of Drift (miles per day).
I.	Mar. 30. (11 a.m.)	10 miles N.N.W. of Great Orme's Head, N. Wales. [*Distance calculated viâ the east of the Isle of Man.*]	6	1	May 11.	Duddon Sands, Asham-in-Furness, Lancashire.	50	42	1·2
				2	June 9.	Black Head, Antrim, Ireland.	115	71	1·6
				3	July 7.	Ardwell Bay, Stoneykirk, Wigtown, N.B.	90	99	0·9
				4	,, 26.	Fleetwood Beach, Lancashire.	45	118	0·4
II.	Mar. 30. (1 p.m.)	12 miles S.S.W. of South Stack Lighthouse, Anglesey.	6	1	,, 26.	Dally Beach, 2½ miles S. of Corsewall Lighthouse, Wigtown, N.B.	115	118	1·0
				2	Sept. 5.	Glenluce, Wigtown, N.B.	108	159	0·7
				3	Nov. 22.	Colonsay I., Argyleshire, N.B.	210	237	0·9
III.	Mar. 30. (3 p.m.)	52 miles S.S.W. of South Stack, Anglesey.	6	1	May 1.	Trearddur Bay, Holyhead.	52	32	1·6
				2	,, 8.	Ditto ditto	52	39	1·3
				3	,, 10.	Pontlyfni, 8 miles S. of Carnarvon.	47	41	1·1
				4	June 23.	Aberffraw Bay, Anglesey.	50	85	0·6
IV.	Mar. 30. (4 p.m.)	17 miles N.N.W. of South Bishop Lighthouse, Pembroke.	6	1	,, 23.	Ditto ditto	77	85	0·9
				2	Sep. 21.	Lendalfoot, Ayrshire, N.B.	190	175	1·1
				3	Nov. 7.	Bay of Rigg, E. coast of Wigtownshire, N.B.	175	222	0·8
V.	Mar. 30. (6 p.m.)	1 mile N.N.W. of the Smalls Lighthouse, Pembrokeshire.	6	1	May 13.	Abercastle, Pembrokeshire.	27	44	0·6
				2	June 22.	Cymyran, Anglesey.	101	84	1·2
				3	Aug. 7.	Rhosnegir, Carnarvon Bay, Anglesey.	100	130	0·8
VI.	Mar. 30. (8 p.m.)	37 miles S. of the Smalls Lighthouse.	6	1	May 13.	Off Abercastle, Pembroke.	61	44	1·4
				2	July 10.	Barmouth, Merioneth.	122	102	1·2
				3	Aug. 31.	Borgue Shore, Kirkcudbright, N.B.	236	154	1·5

Director's Report.

THE various researches detailed in my last Report, which are being conducted by the Association's Naturalists, have been continued during the winter. Mr. Garstang has been chiefly occupied in investigations relating to the migratory pelagic fishes, giving special attention to the characteristics of mackerel from different localities, some 1500 of these fish having been subjected to detailed examination in the course of this enquiry. The samples of mackerel have been obtained from the south-west of Ireland (through H.M. Inspectors of Irish Fisheries), from the North Sea and from America, in addition to those captured near Plymouth. As the results so far obtained refer only to the autumn fish, it has been thought better to defer their publication until after the coming spring fishery, when further samples from the same localities, as well as from the Mediterranean and from Norway, will be examined.

Mr. Garstang has also given much time to working out the results of the drift-bottle experiments, a report of which for the year 1897 will be found at p. 199. These experiments have proved more interesting and successful than we had anticipated when they were undertaken, and we purpose continuing and extending them during the coming year.

Mr. Holt's papers in the present number of the Journal represent but a portion of the many observations which he has been able to make during the year on the eggs and larvæ of fishes. He has also given much attention to the question of the distribution of fish at different ages in this neighbourhood.

The following is the list of workers at the Laboratory since my last Report:—

Brebner, G., August 17th to August 31st (*Marine Algæ*).

Browne, E. T., B.A., August 24th to October 9th (*Medusæ*).

Church, A. H., B.A., December 20th to January 20th (*Marine Algæ*).

Cunningham, J. T., M.A. (*Crabs*).

Jenkinson, J. W., B.A., September 9th to September 30th (*Crustacean Larvæ*).

Lanchester, W. F., August 24th to September 29th (*Phoronis*).

Lubbock, M., M.D., August 9th to September 9th (*Fishes*).

Minchin, E. A., M.A., January 8th to January 19th (*Protozoa*).

Taylor, T. H., M.A., August 25th to September 12th (*Polyzoa*).

Weldon, Prof., F.R.S., December 20th to January 10th (*Variation of Crabs*).

Wylde, N., October 11th to November 11th (*Variation of Galathea*).

In another part of this number of the Journal Mr. E. T. Browne describes the use of an apparatus for keeping medusæ and other pelagic organisms alive in confinement, which has given very satisfactory results. With a view to using the method upon a more extended scale, and of applying it to the hatching and rearing of pelagic fish-eggs and larvæ, I have fitted up in the Laboratory an arrangement of a similar kind upon a larger scale, so that many of the glass plungers can now be worked without difficulty. In some cases a glass funnel, with a small hole in the top, has been used in place of the glass plate described in Mr. Browne's apparatus. By this arrangement a funnel-full of air is carried down each time the plunger descends, and the escape of this air through the hole in the top assists in the aeration of the water. We have found the glass plungers to give very good results when used for hatching purposes, and the method is in many ways much simpler to work than those previously employed, in which the eggs were kept in motion by means of a constant current of sea-water.

The specimens of different stages in the development of food-fishes and of invertebrate animals which serve as food for fishes, exhibited during the summer at the Yachting and Fisheries Exhibition held at the Imperial Institute, have been returned to Plymouth, and have, during the winter, been arranged in a room adjoining the Aquarium, where they could be seen by visitors.

I am glad to be able to report that the appeal made in the last number of the Journal on behalf of our Library has not been without success. Our thanks are due to the Council of the Zoological Society for an almost complete set of their *Proceedings* from the year 1832, and all the *Transactions* from 1862. Mr. J. P. Thomasson, who has on so many former occasions generously supported the Association, has sent a donation of £20 for the purchase of books and for binding. With the help of this donation we have been able to obtain for the library a copy of Smitt's costly work on Scandinavian Fishes, and also to bind the complete set of the publications of the Zoological Society.

We have also to thank Mr. W. F. Sinclair for a donation of ten guineas, and Mr. W. R. Adams for one of three guineas towards the Steamboat Fund, and Messrs. J. Straker and W. F. Lanchester for subscriptions of £15 each as life-members of the Association.

E. J. ALLEN.

March, 1898.

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THE NATURAL HISTORY

OF THE

Marketable Marine Fishes of the British Islands.

Prepared expressly for the use of those interested in the Sea-fishing Industries,

BY

J. T. CUNNINGHAM, M.A.,

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

With Preface by

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

PROFESSOR OF COMPARATIVE ANATOMY IN THE UNIVERSITY OF OXFORD.

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PART I.—GENERAL.

PART II.—HISTORY OF PARTICULAR FISHES.

MACMILLAN & CO., LTD.,

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OBJECTS

OF THE

Marine Biological Association of the United Kingdom.

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

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

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

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

The Association has received some £29,000, of which £13,000 has been granted by the Treasury. The annual revenue which can be at present counted on is about £1,820, of which £1,000 a year is granted by the Treasury, the remainder being principally made up in Subscriptions.

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

The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

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

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

New Series.—Vol. V., No. 3—issued November, 1898.] [Price 3s. 6d.

Journal

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On the Variation, Races and Migrations of the Mackerel (*Scomber scomber*).

By

Walter Garstang, M.A., F.Z.S.,

Naturalist in charge of Fishery Investigations under the Marine Biological Association; late Fellow of Lincoln College, Oxford.

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Pour bien savoir les choses il en faut savoir le détail.

DE LA ROCHEFOUCAULD.

INTRODUCTION.

THE present investigation was undertaken at the invitation of H.M. Treasury, in consequence of an application to the government from H.M. Inspectors of Irish Fisheries for a scientific investigation into the life-history of the mackerel. The problem to the solution of which the inspectors attached particular importance was the relation to one another of the spring and autumn schools of mackerel which regularly visit the Irish coasts. In the spring a multitude of large fish approach the south and west coasts of Ireland to breed. In the autumn schools of immature, but usually well-grown, mackerel come around the island. According to one of the inspectors, the Rev. W. S. Green, there is a sharply defined interval between the two visitations of fish.

The first result of the Treasury's communication was the preparation by Mr. Allen of a report on the "Present State of Knowledge with regard to the Habits and Migrations of the Mackerel," which was published in this Journal in the autumn of last year. (vol. v., No. 1, August, 1897, pp. 1–40.) This report contains a compendious and suggestive summary of all the reliable information we possess up to the present concerning the geographical and seasonal distribution of the mackerel, its rate of growth and breeding habits, and the extent and causes of its migrations.

It will readily be understood that the investigation of the relations between the spring and autumn fish of the Irish coasts could not profitably be undertaken except as part of a general scheme which should embrace the study of the mutual relations of the mackerel of neighbouring seas as well; for hitherto it has not been ascertained whether the Irish fish as a whole are peculiar to Irish waters, or whether there is any intermingling with the mackerel of the English Channel and North Sea. The general impression appears to be that the mackerel round all the British coasts form a single race or family, which becomes dispersed during the summer in order to occupy the various seas and channels round our islands, but becomes largely reunited in the winter after the autumn migrations. Upon this theory the separation of the mackerel family is determined principally by size, the larger fish remaining near the shores of the ocean, from the Irish coast to the Lizard, the smaller fish pushing their way northwards and eastwards into the shallower waters of the Irish Sea, the English Channel, and the North Sea. This view is expressed, for example, by Day in his *British Fishes*, and by Mr. Matthias Dunn (*Report Royal Cornwall Polytechnic Soc.*, 1893). But the separation of the large Atlantic class from the small class found in the more enclosed waters is not regarded by these writers as in any way permanent. Every year, according to Mr. Dunn, the Atlantic (or Irish) class receives a reinforcement from the larger fish of the second (or shallow water) class; while the younger fish which have been bred off the Atlantic coast tend, in the spring of the year, to make common cause with the fish which frequent the English Channel. There is thus a complete mixture between the two classes, which cannot consequently be regarded as constituting local races in the sense in which we speak of Baltic and North Sea herring as forming separate races.

A still more decided view of the unity of the mackerel family has been entertained by Mr. W. S. Green, the energetic Inspector of Irish

Fisheries, who points to the similarity of the mackerel on both sides of the Atlantic as evidence of probable intercommunication between the American and European representatives of the species (Bull. U.S. Fish. Com., xiii., 1893, p. 357), and the same view appears to have been held, though reservedly, by Mr. Dunn (*loc. cit., p.* 3 *of reprint*).

Clearly the first thing to be settled at the outset of the investigation was the relationship between the mackerel of different seas. In addition, therefore, to consignments of fish from Irish and English ports, I have endeavoured at different times to secure representative samples of foreign fish. Of American fish I examined a number during my visit to Canada and the United States in the autumn of 1897, both at Toronto and in the Fulton Market at New York, and the Association is indebted to the United States Fish Commission for the transmission, in October, 1897, of an excellent sample of one hundred fish from Newport, Rhode Island. To Mr. W. de C. Ravenel, Acting Commissioner at that time, I desire to express my thanks, on behalf of the Association, for his kind and courteous assistance in the matter. To the Directors of the Hamburg-American Line we are also under a debt of gratitude for their gratuitous conveyance of this box of fish in a refrigerator of one of their express steamers direct from New York to Plymouth, an arrangement which contributed largely to the excellent condition of the fish on arrival after their long journey. From Brest I received a consignment of one hundred fish, for which, as for many other services, I have to thank Mr. W. S. Hoare, the British Consul at that port. Capt. W. Arthur, of the s.s. *Gipsy*, who had rendered me much assistance on an earlier occasion, by placing his boat at my disposal for securing some temperature and other observations, kindly conveyed the box of fish direct to Plymouth. I have also much pleasure in thanking Prof. Marion, of Marseilles, for a sample of Mediterranean fish, though they arrived too late to enable me to incorporate the results of their examination in the present report. Unfortunately, a consignment of fish which I expected from Norway has not arrived, and I must postpone until next spring any comparison between the British fish and those which annually visit the Scandinavian coast.

The sources of the English and Irish fish examined are given in the tables, and in the list of particulars concerning the consignments. It will suffice to say that I have received samples of several hundred fish from each of the following regions: the West and South coasts of Ireland, the English Channel, and the North Sea. Altogether I have examined in detail some 1800 fish, and the total number included in the tables of variation appended to this report amounts to 1649. The omission of about 150 fish from the tables is due to the fact that about 100 Plymouth fish were used in a preliminary enquiry before the general plan of investigation was decided upon, and that a number of fish caught at Plymouth during the summer of 1897 were so much smaller than any from other localities (from 4 to 9 inches in length), that I have thought it better to reserve most of the results of their examination until a sufficient number of young forms has been also obtained from other parts. These small fish are frequently taken in sprat seines, weirs, and in other ways on various parts of the British coast, and I should be much obliged to any who read these lines, and have the opportunity of assisting, if they would kindly forward to me any specimens of the common mackerel they may come across below 8 inches in length. They should be forwarded fresh (but damp) by post, if in small quantity; or in seaweed or ice by train, if in quantity; and the locality, date, and method of capture should be recorded. The cost of carriage, &c., will be willingly paid by the Association.

As regards the condition of the fish in the different consignments under examination, I should say that the Plymouth fish have been examined in a perfectly fresh condition, but that all other fish, except those in two Irish consignments, have been iced before examination, in order to enable them to withstand the effects of a more or less lengthy journey by rail or sea. The two Irish consignments referred to were those dated Kinsale, July 30th and September 3rd, 1897. These fish arrived during my absence in Canada, and after measurement were placed in tanks of formaline to await my return. With this exception, the condition of the different consignments at the time of examination may be regarded as practically uniform, so far as external characters are concerned. The viscera of the fish from Brest, and of some of the earlier Irish samples were, however, so rotten, owing to delays in transit, that no attempt was made to record the sexual condition of all the fish in these particular samples.

After this introduction I may proceed at once to describe the methods and results of the investigation up to the present time.

I. The Method of Investigation.

As all attempts to discover constant individual peculiarities in the mackerel of any one locality, as compared with those from any other, have completely failed, it is clear that, in order to determine whether local races exist or not, recourse must be had to the detailed study of the variation of certain chosen characters in the fish of different localities. The range of variation in these different local groups of fish can then be compared, and the frequency with which particular variations, or combinations of variations, occur in any one group can be compared with its frequency in all the others. Thus, if we suppose the number of finrays in the first dorsal fin to vary between 10 and 14, the value 12 will *probably* occur with greatest frequency. But other possibilities occur; and while 12 might be constantly the most frequent value in samples of one local group of fish, it is quite conceivable that 13 might be constantly the most frequent value in samples of another group; in which case, if the two groups were examined under similar conditions of sex, size, preservation, and so forth, we should be prepared to regard the two groups as racially distinct, the one indispensable condition being that the frequency of the particular variation shall have been determined in all instances upon a sufficient number of specimens.

It is, however, impossible to assign any one number beforehand as universally sufficient. The minimum sufficient number may be regarded as that which yields results approximately coinciding with those derived from an infinitely large number, *i.e.*, the percentages of frequency derived from it must bear some close degree of correspondence with the percentages derived from a much larger number. I have taken 100 as the minimum number of mackerel from which it is possible to derive a fairly reliable statement concerning the relative frequency of the variations exhibited by any one of the chosen characters. But the number of specimens requisite to yield a reliable statement of the frequency of variations of any organ bears a relation to the variability of the organ. If an organ varies slightly, the number of specimens must be increased. It is certain, for example, that 100 is an inadequate number for determining the normal frequency of the variations in the number of the dorsal finlets in the mackerel of British seas (see table H, p. 295); for, among 100 fish from Ramsgate, not a single specimen possessed less than 5 finlets, and 5 specimens possessed more than that number; whereas, of 300 fish from Lowestoft, 1 % possessed only 4 finlets, and only 3 % possessed 6; and of 300 Plymouth fish, the percentage (3) of specimens with the lower number was almost as great as the percentage (4) of those with the higher. On the other hand, the number (100) is quite sufficient to show a marked difference between the American and the British fish in regard to the same character, since nearly 20 % of the American fish possessed 6 finlets—a percentage almost four times as great as that observed in any other sample of 100 fish.

In order to check the adequacy of this number as a unit-sample for determining the frequency of the variations of more variable characters, we may turn to table B (p. 290), which deals with the variation in number of the black stripes or bars across the sides of the fish. We see there that in each sample of 100 fish from Lowestoft, Ramsgate, and Plymouth, the frequency of the values above 27 is constantly less than that of values below 27; whereas for each sample of about* 100 fish from Ireland, the values above 27 are, with only one exception, in excess of the values below that number. The constancy of this relation for each of the geographical areas mentioned appears to me to show that 100 is very nearly a sufficient sample, in the sense already defined, so far as this character is concerned.

As a matter of fact, the four important regions for mackerel fisheries round our coasts, viz., the North Sea, the Channel, the South and West coasts of Ireland, are each represented by a totality of fish of not less than 300; but I have entered at some length into this question, because I think that the division of the local groups into unit-samples provides a valuable means of checking the significance which may be attributed to the differences as determined for the local groups *en masse.*

II. The Characters Investigated.

After a preliminary study of the question, it seemed desirable to select numerical rather than dimensional characters for investigation, their variations being less dependent than those of the latter upon variable factors, such as disproportionate growth, food-supply, and enlargement of the reproductive organs. The characters eventually selected were the following:—

1. The Number of black Transverse Bars or Stripes across the sides of the fish, beginning at the point where the lateral line meets the posterior border of the scapular arch, and ending just behind the last dorsal finlet.
2. The Number of the same Transverse Bars which meet or cross the lateral line.
3. The Number of round black Dorso-lateral Intermediate Spots situated between the Transverse Bars.
4. The Number of Finrays in the First Dorsal Fin.
5. The Number of Finrays in the Second Dorsal Fin.
6. The Number of Dorsal Finlets.

The condition of each fish in regard to these six characters was recorded from the commencement of the investigation, in addition to the length of the fish, and, in the majority of cases, its sex. But I soon began to take note of other characters, in the hope of finding them useful in the end, and among these were the following:—

7. The general Shape and Regularity of Arrangement of the Trans-

* The irregularity in the number of fish in the samples from Ireland was due, I understand, to a curious system of depredation during transit which prevails in those parts, and is sanctioned by custom or, at least, endurance.

verse Bars, *i.e.*, whether straight, > shaped, or wavy; and whether regular, fairly regular, rather regular, or irregular.

8. The Continuity or Degree of Discontinuity of the black longitudinal Streak which is present in most mature fishes below the lateral line. I call this character the "Lateral Streak."

9. The extent and character of the Dusky Markings which are frequently found in mature fishes below the Lateral Streak, especially in the anterior half or third of the body length. These markings, when well developed, have the form of a fine zigzag tracery, but they are often diffuse and blurred. I call this character the "Sublateral Tracery."

10. The Abundance and Distribution of small irregular dusky Spots, frequently found on the posterior part of the abdominal region, and scattered over and among the Transverse Bars of the Dorsolateral Area. They are to be sharply distinguished from the round black Spots which I have termed "Dorsolateral Intermediate Spots." The pigment of these latter is a deep black, and it is situated at a lower level in the tissues than the pigment of the irregular "Dusky Spots." Moreover, the Dorsolateral Spots are invariably situated *between* two adjacent Transverse Bars, of which, in a morphological sense, they are undoubtedly discontinuous modifications. The Dorsolateral Spots are independent of the growth of the fish, being as frequent in small fish as in large, but the "Dusky Spots" appear to make their first appearance about the time of maturity.

11. The Extent of a black longitudinal Connecting Streak which connects the ventral ends of the Transverse Bars. The Connecting Streak is usually confined to the posterior quarter or third of the body-length, but occasionally extends further forwards, and in rare instances traverses the whole length of the body, intersecting the lateral line at an acute angle. In such cases the "Lateral Streak" is frequently ill-developed.

Of these accessory characters, only the first (No. 7—the Shape of the Transverse Bars) has been considered in the present report, owing to its suggested bearings on the question of secondary sexual peculiarities.

The data acquired in regard to the variation of the remaining accessory characters are not discussed in the present report, although I hope to make use of them on a future occasion. My reasons for omitting them are chiefly that some of the characters (Nos. 8, 9, and apparently 10) were found to arise rather late in life, about the time of maturity; and as the exact size at which they make their appearance is itself subject to variations, it was considered inadvisable to introduce such characters into a discussion of racial peculiarities until the causes which determine their appearance have been more definitely ascertained.

These three characters, in fact, depend upon a formation of pigment in the superficial layers of the skin, apparently different in kind from that which brings about the transverse bars and intermediate spots. Some further study of the pigmentation of the mackerel will be necessary before their value for racial determinations can be assured. This objection does not apply, it is true, to the last character enumerated (No. 11); but my records of the variation of this character were commenced much later than those of all the others, and are not yet sufficient to yield any general results.

The investigation in hand accordingly rests upon an examination of the variation of seven characters, of which six are numerical and one morphographical. Four of these characters deal with the characteristic markings of the fish, and three with the structure of the dorsal fins.

It will be noticed that the number of transverse bars has been recorded twice for each fish; firstly, as an entire series, and secondly, between certain arbitrary limits. This has been done with a view to expose any errors which might arise from the fact that the bars are not always distinct and parallel, but are frequently branched and anastomosed with one another, broken, or otherwise irregular, rendering the task of enumeration not always easy, and so introducing a certain subjective element into the records. Now the number of bars, or portions of bars, which cross or meet the lateral line admits of fairly exact enumeration, and seemed to me to offer an excellent method of checking the estimate formed of the number of bars in the entire series. In this expectation I have not been disappointed, as the discussion of tables B and C will reveal, although the fact that the course of the lateral line itself is also subject to slight variations has naturally prevented an absolute correspondence in all details between the two modes of enumeration.

It only remains to add that the number of transverse bars and of intermediate spots, together with the data concerning the shape of the bars, have all been determined upon the same side of the fish, viz., the left. I frequently took note of the condition of the right side of the fish also, but these notes are nowhere referred to in the present report, and are not incorporated in any of the tables.

III. Particulars Concerning the Consignments of Mackerel Investigated.

In this section are given the place, date, and method of capture, the name of the consignor, and such other information as may bear upon the authenticity and representative character of the samples. All the samples were forwarded to Plymouth in ice, except those which were caught in the neighbourhood of that port. The samples are enumerated in the order in which they appear in the tables at the end of this report. The order is geographical, except that the American sample, the characters of which are shown to be quite peculiar, is placed at the head of the list.

NEWPORT, U.S.A., October 18th, 1897. 100 fish. "The mackerel are just as they were taken from the water, without selecting as to sizes, but being a perfect sample of a catch of 400 fish taken in a trap or pound net in the waters near Newport, R.I."—Messrs. Blackford, of Fulton Market, New York. (See Introduction.)

LOWESTOFT (1.) October 7th, 1897. 100 fish. Caught in nets 4 miles S.E. from Lowestoft. "These are the finest sample of fish to-day for the season. They have been much smaller hitherto. They are not selected."—Mr. Alfred T. Turner, Trawl Market, Lowestoft.

(2.) October 12th, 1897. 50 fish. Caught in nets 14 miles S. by E. from Lowestoft—Mr. Turner. These are the half of an average 100 of fish taken direct from the boat; but they are *not representative* of the whole catch, as, owing to a misunderstanding, the 50 smaller fish out of the hundred were alone forwarded. "The difference in size between the two half-hundreds was, however, not great."—A. T. T.

(3.) June 28th, 1898. 50 fish. Nets. A representative sample from Mr. Turner.

(4.) July 12th, 1898. 100 fish. Caught in nets 10 or 12 miles E. of Lowestoft, "quite abreast of the town."—Mr. Turner. A representative sample, except that the four smallest fish (measuring $11\frac{1}{2}$ and $11\frac{3}{4}$ inches in length), out of a total of 104 examined, have been eliminated.

RAMSGATE, October 27th, 1897. 100 fish. Caught in nets off the Kentish Knock, about 20 to 24 miles from Ramsgate Harbour. A representative sample. Messrs. W. Ferridge & Co., Central Fish Market, Ramsgate.

PLYMOUTH (1.) July to October, 1897. 76 fish. Caught in a variety of ways. *Not representative.* The following are the dates, places, and methods of capture.

July 21st.	In the Sound near the Laboratory. Seine. 12 fish.
„ 22nd.	1 mile S. of Breakwater. Hook and line. 13 fish.
Sept. 21st.	*Probably* off Penlee Point. Hook. 10 fish.
„ „	River Tamar, 5 miles above Saltash. 1 fish.
Oct. 7th.	River Tamar, Saltash to Cargreen. Small-meshed drift net. 3 fish.
„ 20th.	Between Eddystone and Mewstone. Pilchard nets. 19.
„ 27th.	*Probably* off Eddystone. Pilchard nets. 18 fish.

(1*b*.) September to November, 1897. This modification of the preceding sample occurs in table D. It consists in the substitution of 25 small November fish, caught principally in herring nets, for the 25 fish caught in July. It was required owing to the fact that the character to which table D refers was not examined in any British fish before my visit to America in August.

(2.) Nov. 16th to 20th, 1897. 100 fish. Caught on the 16th, 17th, 18th, 19th, and 20th November, in drift nets worked a few miles S.E. from the Eddystone (14–18 miles S. of Plymouth Breakwater). Supplied by Mr. J. Turner, Plymouth. The sample is *not quite representative.* The total number examined was 109, but the nine smallest (from 10¼ to 11¾ inches in length) were eliminated.

At this time enormous numbers of drift mackerel were being taken in this locality, especially on the nights of the 16th and 17th November. Smaller fish, from 7¾ to 11 inches in length, were commonly taken at the same time in herring nets worked nearer shore.

(3.) July 6th, 1898. 100 fish. Caught in nets 30 miles south of the harbour. Supplied by Mr. Turner. *Not quite representative.* The total number examined was 118, but the 18 smallest (from 10 to 11 inches in length) have been eliminated.

(4.) July 11th, 1898. 24 fish. Caught at mid-day in the Sound, immediately below the Laboratory, in a seine. The sample is fairly representative of the total catch of 600 fish.

SCILLY (1.) May 8th, 1898. 12 fish. Caught off Bishop Lighthouse, May 7th and 8th. Landed at Plymouth, May 9th.

(2.) June 2nd, 1898. 12 fish. Caught "in light green water" 80 to 90 miles S.W. by W. (magnetic) from Newlyn, *i.e.*, about 65 miles S.S.W. (true) from St. Mary's, Scilly. Total catch, 600. Forwarded by Mr. B. J. Ridge of Newlyn, Penzance. ["Fish caught off the Bishop Lighthouse about this time were mostly shotten."—B. J. R.]

(3.) June 9th, 1898. 50 fish. Caught 20 miles S.W. from the Wolf Lighthouse. Forwarded by Mr. B. J. Ridge.

BREST, June 20th, 1898. 100 fish. Caught by hook and line off Camaret, south of Brest, France, and forwarded in ice by steamer direct from Brest to Plymouth. (See Introduction.) The length of one fish was not recorded, but is assumed to have been 14 inches, the most frequent size.

KINSALE (1.) July 30th, 1897. 119 fish. Caught with nets off the Old Head of Kinsale. Forwarded by Mr. James Carroll, Fish Merchant, Kinsale, per Cork steamer to Plymouth. *Note from sender*:—"They are a fair average specimen of the fish now being taken. All mackerel now captured are of small size and poor quality—

will much improve about September." *Placed in formaline* on arrival at the Laboratory, and examined Sept. 19th, 24th, and 25th.

(2.) Sept. 3rd, 1897. 99 fish. Caught with nets off the Old Head of Kinsale. "A fair average specimen of the fish now being taken." Forwarded by Mr. Carroll. *Placed in formaline* on arrival at the Laboratory, and examined Sept. 16th to 19th.

(3.) Sept. 17th, 1897. 92 fish. Caught with nets off the Old Head of Kinsale. "A fair average specimen of the fish now being taken." Mr. Carroll.

(4.) July 1st, 1898. 100 fish. Mr. Carroll.

SMERWICK, March 12th, 1898. 99 fish from Smerwick Harbour, County Kerry; forwarded by Mr. John McKenna, Butter Merchant, Dingle.

BRANDON (1), April 16th, 1898. 45 fish. Caught at Brandon Creek, County Kerry; forwarded by Mr. McKenna. 46 fish actually arrived, but the smallest (length, 12¼ inches) has been eliminated, owing to its marked divergence in size from the rest of the sample.

(2.) April 23rd, 1898. 101 fish. Caught at Brandon Creek; forwarded by Mr. McKenna.

IV. SIZE OF THE MACKEREL INVESTIGATED.

The length of the body has been taken as the basis for comparing the relative sizes of the fish investigated, and this has been measured in all cases from the tip of the closed jaws to the median extremity of the fork of the tail. The longer rays of the tail-fin are subject to accidents in capture and transit, and cannot therefore be included in an accurate comparative table of measurements; but it should be remembered that these rays are generally included in ordinary measurements of body-length, which would consequently be somewhat in excess of my determinations. The fish have always been measured in the same way, by placing them with their left sides uppermost upon a measuring-board, with the tip of the jaws touching a vertical plate immoveably fixed at the zero of the scale, which is accurately ruled to quarters of an inch. The length of the fish has been read off to the nearest quarter.

The observed number of specimens of the different sizes represented in each consignment of fish is recorded in table A. The general size of the fish representing each locality can, however, be more readily gathered from the more condensed statements given below, which are in percentages of the total number from each locality. In Table I. the size is indicated in inches, the fractional differences recorded in table A being neglected. In Table II., which is still further condensed, the range of size included in each vertical column is 2 inches.

TABLE I., *showing Distribution of Size in One-inch Groups.*
(Percentages.)

Place of Capture.	No. of Fish.	Length of Fish (inches).							
		10+	11+	12+	13+	14+	15+	16+	17+
Newport, U.S.A. .	100		2%	53%	33%	10%	1%	1%	
Lowestoft . .	300		3	28	48	20	1		
Ramsgate . .	100		4	23	40	25	5	3	
Plymouth . .	300	5	29	38	21	5	2		
Scilly . . .	74		5	33	27	22	8	4	1
Brest . . .	100		1	2	36	42	14	4	1
Kinsale . . .	410	½	23	55	15	5	1		
Kerry . . .	245			7	20	33	29	11	¼
Irish: Autumn .	310	⅓	30	63	7				
Irish: Spring .	345		1½	14	25	30	21	8	¼

TABLE II., *showing Distribution of Size in Two-inch Groups.*
(Percentages.)

Place of Capture.	No. of Fish.	Length of Fish (Inches).			
		10+11	12+13	14+15	16+17
Newport . .	100	2	86	11	1
Lowestoft . .	300	3	76	21	
Ramsgate . .	100	4	63	30	3
Plymouth . .	300	34	59	7	
Scilly . . .	74	5	60	30	5
Brest . . .	100	1	38	56	5
Kinsale . . .	410	24	70	6	
Kerry . . .	245		27	62	11
Irish: Autumn .	310	30	70		
Irish: Spring .	345	2	39	51	8

These tables show that the great majority of fish investigated were from 12 to 13¾ inches in length.

The Lowestoft and Ramsgate samples closely resemble one another in size, the latter having a slight preponderance of the larger fish.

The samples of smallest-sized fish were those from Plymouth and Kinsale, and these may be regarded as practically similar to one another in this respect. They show a considerable percentage (24°/₀ to 34°/₀) of fish below 12 inches in length, a percentage much higher than that in any other of the local samples. The percentage of fish above 13¾ inches in length is also excessively small in these two samples, being only 6% or 7%, whereas it is 21% for Lowestoft, 30% for Ramsgate, and about 60% for Brest and County Kerry.

The samples of largest-sized fish are those from Brest and County Kerry, in which there are practically no fish below 13 inches in length.

The American fish are intermediate in character between the Lowestoft and Plymouth samples, but are unique in regard to their great uniformity in size, 86% being between 12 and 13¾ inches in length.

The fish in the Scilly sample are a mixed lot, obtained over a wide area at the western entrance to the English Channel. As the total number of these fish does not amount to the number already assigned as the minimum for a unit sample, their variations are not much discussed on the present occasion; but it is interesting to notice the curious distribution of sizes among these 74 fish which were all captured within a single month. The sample shows three distinct maxima of frequency, one at 12 inches, another at 13 inches, and another at 14 inches (see table A). This phenomenon is not due solely to the mixture of samples from different localities, for it is shown also in the single consignment of 50 fish captured on June 9th.

From what has been said, it will be seen to be possible to divide the local samples into groups characterised by the preponderance of large, moderate, or small sized fish. This grouping takes the following form :—

Large :	Kerry.
	Brest.
Moderate :	Lowestoft.
	Ramsgate.
	Scilly.
	Newport, U.S.A.
Small :	Plymouth.
	Kinsale.

This grouping is by no means to be understood as implying that the mackerel found in these localities constantly bear the size relations assigned to them here. It is no doubt true that the largest fish are always most abundant on the Atlantic coast, but the correspondence between the samples and the natural distribution of the fish in this instance must be regarded as an exceptional coincidence. The samples are only representative of the fish caught at the dates mentioned in the tables (subject to certain reservations already given in the particulars concerning the consignments). To draw general conclusions upon the natural distribution of size among the fish all round our coasts, it would be necessary to secure the regular delivery of representative samples from fixed stations throughout the year, as was done, for example, by the Scottish Fishery Board in the case of the herring (4th Report S.F.B., 1886, pp. 65–72). Such an arrangement would be decisive, but expensive, and could not, I believe, be undertaken by the Association under present conditions. An attempt which I made in the Autumn of 1897 to secure the periodic consignment of a small sample from Kinsale fell through owing to the refusal of the fish merchant to undertake the supply of small quantities, the price of which would not repay him for his trouble.

Nevertheless, in spite of their incompleteness, the following general features of the samples may be advantageously summarised, if only as a means of inviting further attention to the subject:—

1. Large fish, measuring 14 inches and upwards, preponderate only on the Atlantic coasts of Ireland and Brittany. The sample from Brest is particularly valuable as an index of distribution, because the fish composing it were all caught with hook and line, the sizes in most of the other samples being partially determined by the mesh of the nets with which the fish were captured. The late date (June 20th) at which these large Brest fish were taken close to shore is also worthy of notice. The sample caught at Kinsale some ten days later (July 1st) consisted of distinctly smaller fish.

2. On the Irish coast the spring fish are much larger than the autumn fish; but in the Channel and North Sea no such difference is to be recognised. Indeed, in the latter areas the autumn fish appear on the whole to be slightly larger than the early breeding fish, and seem to be the same fish at a later stage of growth.

3. The sequence of events on the Irish coast, as indicated by table A, appears to be as follows: In March * moderately large fish (13 and 14 inches) arrive; in April the size of the fish attains its maximum (a preponderance of 14 and 15 inch fish); at the end of June (Kinsale, July 1st) the proportion of large fish is greatly reduced, and there is a considerable accession of small fish (11 and 12 inches), the total *range* of size being now at its maximum; by the end of July the large fish have all disappeared, and there is a preponderance of 11 inch fish; and from now onwards the size gradually but slightly increases, as though by growth rather than by new immigrations of larger fish. In this summary I have assumed that samples of fish caught off the South and West coasts of Ireland (*i.e.*, Kinsale and Kerry) are equally representative of the general size prevailing at the periods of capture, though I have no doubt that the examination of simultaneous samples from the two coasts will reveal slight differences, at any rate, in this respect. This point I hope to elucidate during the present autumn and the next spring seasons.

* Two large mackerel, one of each sex, were forwarded to me by Mr. Green in February. They measured 16 ins. in length, and were caught off Gariness, Co. Cork, on Feb. 23rd, 1898.

V. Sex.

§ 1. *Proportion of the Sexes.* Out of a total of 918 mackerel caught in British waters 423 were males and 495 females, forming a percentage of 46 males to 54 females, or a proportion of 117 females to every 100 males.

This excess of females over males is slight compared with the preponderance of this sex which Fulton has shown to exist in the case of most sea-fishes with pelagic eggs. (8th Report Scottish Fishery Board, 1890, p. 349; 9th Report, 1891, p. 247. Partially quoted in Cunningham's "Marketable Fishes," 1896, p. 76.) In this respect the mackerel comes nearest to the cod, in which the proportion of females to 100 males is 133.

The explanation which Fulton suggests of the general preponderance of females in species of sea-fishes is founded on the great difference in bulk between the ripe ovary and testis, which often leads to obvious differences in the degree of distension of the abdominal cavity in the two sexes during the breeding season. The necessity for the annual production of a certain minimum number of eggs, coupled with the difficulty experienced by the females of many species in carrying their proper quantity of ova, has accordingly led in some cases to a relative increase in the size of the females, in others to an increase in their relative number, or even, as indeed is generally the case, to an increase of the females under both these heads. The duration of the spawning season is also affected by the same factors.

As the general size of the female mackerel is shown in a subsequent section to be only slightly in excess of that of the male, we are probably correct in attributing the relatively slight preponderance of females in the mackerel to the relatively large body-cavity which this species possesses, as compared with the body-cavity of a gadoid or flatfish. The small size of the mackerel's egg also obviates the necessity for a large preponderance of females.

The large size of the body-cavity in the mackerel is probably, in its turn, connected with the active pelagic habits of this fish, as it would be a manifest impediment to vigorous movements if the abdominal region should become so distended in the spawning season as it is in the more lethargic cod and flatfish tribes. As the same feature is also found in the herring and pilchard, it would appear to be a general phenomenon among pelagic and so-called "migratory" species.

§ 2. *Segregation of the Sexes.* It has been maintained by Couch (*British Fishes*, vol. ii., p. 68) that the sexes of the mackerel become much divided during the early migration. Out of 20 specimens taken indiscriminately on one occasion during March he counted 16 males and only 4 females. During another season he counted 17 males to 3 females. It is true that on a third occasion Couch found the sexes to be equally represented in a sample of the earliest spring fish; but he explains this exception by adopting the opinion of the fishermen that the fish of this particular school belonged to a different class from the ordinary spring fish—that they were old fish of the preceding season which had not moved out into deep water, and that they did not represent the usual spring immigrants from the Atlantic.

The evidence of American observers on this point is conflicting (Commissioner's Report for 1881, U.S. Fish Com., 1884, p. 114).

My own observations on the proportion of the sexes in various samples of mackerel at different seasons are recorded in table E (p. 293). The only sample examined during March was one from Smerwick, County Kerry, and it certainly supports Couch's statements that in this particular sample the males were nearly twice as numerous as the females, 63 out of a total of 99 fish being of the former sex.

But it must be pointed out at the same time that an actual excess of males over females in particular samples is also found at other seasons of the year. Thus, out of 25 Lowestoft fish, captured October 12th, 1897, there were 15 males to 10 females; and out of 100 Ramsgate fish caught a fortnight later 55 were males. In the American sample, also caught during October, 55 % were males. The preponderance of males in these cases is certainly not so great as in the Smerwick sample, but it is sufficient to show the necessity of caution in accepting conclusions of this kind based upon relatively small samples. Until observations on the subject shall have been considerably multiplied, I think it will be best to suspend judgment upon a matter which may be, biologically, of considerable importance.

In this connexion I would draw attention to the evidence submitted in the succeeding section, which shows that the numerical proportion of the sexes differs, as a whole, according to the size of fish under consideration, owing to a difference in the rate and limits of growth of the two sexes. Now it is an open question whether the so-called "schools" of mackerel are formed by the chance association of fish which happen to be near one another, independently of sex and size, or whether they are not due to the selective association of fish having some common characteristic. The evidence derived from samples of fish caught in drift-nets is of little value, owing to the selective action of the mesh of the nets. The evidence from samples caught in small-meshed seines would be fairly conclusive, but the existing data are too few to be of any use. Nevertheless, such evidence as we possess in the case of other fishes tends to show that selective association plays a considerable part in the formation of shoals, and that similarity of size is one of the points selected. Bateson, for example, speaking of the grey mullet, says, "Similarity in size seems to be usual in these shoals." (Journal M.B.A., I., p. 250.) If, therefore, we assume this principle in the case of mackerel shoals, it is clear, from the facts to be adduced shortly, that the normal preponderance of females will tend to be reduced in the case of shoals of fish below 14 inches in length, and increased in the case of shoals of fish measuring 15 inches or more, quite independently of any selective segregation of the sexes.

It is then possibly not without significance that, so far as my own samples go, a preponderance of males was only observed in samples of relatively small fish, more than half the fishes in each sample being below 14 inches in length, and a very small number (from 0 °/₀ to 11 °/₀) attaining a length of 15 inches.

§ 3. *Sex and Size.* The following table shows the observed frequency of male and female fish of the various sizes mentioned, in a total population of 918 mackerel, and also the same facts as percentages of this latter sum. This population consists of all the samples of British fish in which the sex has been determined, as shown in Table E. The American sample has been excluded, since the present investigation clearly shows the American fish to constitute a distinct race, much more remotely allied to the European fish than are the British races *inter se.* The last horizontal row of figures shows the relative number of females of each size compared with the number of males of the same size taken as 100.

TABLE III., *showing relation between Sex and Size.*

Length (Inches).		10+	11+	12+	13+	14+	15+	16+	17+	Total.
Frequency observed.	♂	1	37	114	140	86	36	8	1	423
	♀	2	37	141	133	100	56	23	3	495
Frequency in percentages of the total number =918.	♂	0·1	4	12	15	9	4	1	0·1	46 %
	♀	0·2	4	15	14	11	6	2·5	0·3	54 %
Number of ♀ compared with ♂ taken as 100.		—	100	124	95	116	156	288	300	117 (mean.)

The table shows that the females in my samples exceed the males in number at almost every size, the exceptions being at 11 inches where the frequency of males and females is the same, and at 13 inches where the males exceed the females by 1 °/₀ of the total number. It is to be noticed that the males are relatively more numerous among the small fish than among the large; or, in other words, that the numerical ratio of males to females becomes more and more reduced as the size of the fish under consideration increases. This fact is expressed by the figures on the last horizontal line, which gives the number of females of each size corresponding to a constant number of males, taken as 100. It will be seen that, except for a slight irregularity in the columns representing 12 and 13 inches, the relative number of females becomes considerably increased as the size enlarges.

As, however, the extreme sizes, both small and large, are represented by relatively small numbers of fish, whether male or female, a more reliable result will be obtained by dividing the fish into a smaller number of size-groups. Thus, in two-inch groups, the proportion of females to every 100 males becomes—

10–11 inches . . .	103
12–13 „	108
14–15 „	128
16–17 „	289

thus revealing an increase in the preponderance of females at every successive grade. The increase is not quite regular, being slight from 10 to 13 inches, then rapid at 14 and 15 inches, and very highly marked above 15 inches.

Two explanations of this increasing preponderance of females with increasing size suggest themselves :—

1. The males may be subject to a more rapid death-rate than the females; or

2. The growth of the males may be arrested at an earlier stage than that of the females.

As the true proportion of the sexes of the mackerel at the time of hatching or *in ovo* cannot be ascertained with our present knowledge, it is difficult to test the former alternative, which is *a priori* improbable, owing to the absence of any known differences between male and female mackerel as regards habits of life or structure of the body. So far as the physiological wear and tear of reproduction goes, this probably affects the female more severely than the male.

The second alternative is the more probable one, since sexual dimorphism in regard to size is a very common phenomenon, and in fishes the female frequently exceeds the male in length. Still the cessation of growth in the males does not take place uniformly at any one stage, since the extreme limit (17 inches) attained by the females in my samples is also attained by the males. The exact stage of cessation is clearly subject to considerable variation, and is probably preceded by a retardation in the relative rate of growth, as compared with that of females of the same size. It is improbable that any considerable percentage of males actually stop growing at 11, 12, or 13 inches, so that, taking the normal number of females for every 100 males to be 117, as explained in the preceding section, we must explain the relative excess of males below 14 inches as due to retarded growth of the males in excess; but the increasing relative deficiency of males above 14 inches in length must be due to a large extent to actual arrest of growth, since the normal proportion of males to females is never realized in groups of fish measuring more than 14 inches in length.

The minute economy which prevails among species under natural conditions of existence is clearly revealed by the facts established in the preceding paragraphs; for it is obvious that, *ceteris paribus*, the equivalent growth of males and females would lead to an increasing superfluity of the male reproductive elements, owing to the great difference in size between an ovum and a spermatozoon.

It remains to add that the average size of 423 males recorded in the tables is 12·988 inches; that of the 495 females, 13·145 inches. Consequently, if the average size of the males be taken as 100, that of the females becomes 101. The difference between the size of *mature* males and females is probably a little greater than this, but the subject of maturity in the mackerel is reserved for a later report.

§ 4. *Secondary Sexual Characters.* Apart from size, I have been unable to discover any evidence whatever of the existence of secondary sexual peculiarities in the mackerel. My investigations of this point will be found under the special sections dealing with the shape of the Transverse Bars (p. 261), the Dorso-lateral Intermediate Spots (p. 263), and the First Dorsal Fin (p. 267). With the exception already mentioned, I can therefore repeat the remark of Smitt that "all the statements as to an external difference of sex in the mackerel which have been made up to the present have proved untrustworthy on closer examination" (*Scandinavian Fishes*, I. 1892, p. 112).

VI. Number of Transverse Bars.

§ 1. *The Entire Series.* The frequency of the variations in the entire number of transverse bars in the various local samples and in certain chosen combinations of these is set out in Table B. (p. 290).

The extreme range of variation is from 23 to 33, *i.e.*, 11 bars.

The modal (*i.e.*, most frequent) number is almost invariably 27, there being only three exceptions to this rule among 21 samples, viz., Scilly, June 9th, (50 fish), Kinsale, July 1st (100 fish), and Brandon, April

16th, (45 fish). Two of these samples, it will be noticed, are small: in one the modal number is 26, in the other 28.

The first impression made upon a survey of the figures in the table is undoubtedly the slight nature of the differences in the range and frequencies of variation in the different samples. But the next impression is the remarkable constancy with which mean-values of less than 27 are associated with samples from localities in the North Sea and English Channel, while the means for the Irish and American samples exceed that figure with only one exception. This indicates, as can easily be seen by comparison, that in North Sea and Channel samples the values below 27 always occur more frequently than those above 27; while in the Irish and American samples, with only one exception, the reverse is the case.

For North Sea and Channel samples, the means vary from 26·50 to 26·94, and, for Irish samples, from 26·90 to 27·56. The American mean is 27·38.

If we exclude all samples of less than 90 fish, the means, taken in the same order, vary from 26·62 to 26·91, and from 26·90 to 27·32.

Analysing this contrast still further, by means of the table of percentages for the local groups (neglecting groups of less than 200 fish), we see that the frequency of the value 26 varies from 30 °/ₒ to 31 °/ₒ in the case of Lowestoft and Plymouth, but from 21 °/ₒ to 23 °/ₒ in the case of Kerry and Kinsale. Similarly the frequency of the value 28 varies from 14 °/ₒ to 15 °/ₒ for Plymouth and Lowestoft, but from 23 °/ₒ to 25 °/ₒ for Kinsale and Kerry. The frequency of the modal value 27 is constant at 38 °/ₒ for the two Irish groups, but varies from 38 °/ₒ to 42 °/ₒ for Lowestoft and Plymouth.

The conclusion is irresistible that the Lowestoft and Plymouth fish resemble one another very closely, and that the Kerry and Kinsale fish do so likewise, but that there is a comparatively serious difference between the Irish fish and those from the North Sea or Channel.

Hitherto, however, we have not taken into consideration the actual frequencies of the extreme values (*i.e.*, those below 26 and above 28). These values occur very rarely, and their separate frequencies cannot consequently be compared with exactitude in samples of ordinary magnitude. To bring their frequencies into consideration, it will be necessary to merge all the extreme values into two groups, one of low, and the other of high value, and to compare the frequencies of the combined values. This has been done in the following condensed table, in which, also, the Ramsgate data have been combined with the Lowestoft records to form a single group representative of the North Sea, and Brest has been combined with Scilly. No one, I imagine, will be prepared, on the evidences provided in this report, or on any other grounds, to regard the Ramsgate autumn fish as anything but the southern extension of the Lowestoft shoals. The Scilly data closely resemble those from Brest in many respects, and the combined data may be regarded as representing the mackerel off the mouth of the Channel during June.

TABLE IV., *showing frequencies of values of Transverse Bars.*

(Percentages.)

	Number of Fish.	23 to 25	26	27	28	29 to 33
Newport, U.S.A.	100	6	13	37	28	16
{ North Sea	400	9	29	42	15	5
{ Plymouth	300	8	30	42	14	6
{ Brest and Scilly	174	5	32	41	17	5
{ Kinsale	410	5	23	38	23	11
{ Kerry	245	3	21	38	25	13

This table strikingly confirms the conclusions already drawn. The resemblance between the percentage frequency of the different values in the case of Plymouth and North Sea fish amounts practically to identity, and the resemblance between the same data for Kinsale and Kerry fish is almost equally exact. The combined Brest and Scilly data also closely resemble the North Sea and Plymouth records.

On the other hand, the American and the two Irish groups diverge considerably from the others in the low percentage of the low values and in the high percentage of the high values, and the American sample shows this contrast still more markedly than the Irish groups.

From the variation of this character, therefore, I conclude that the mackerel examined fall into three groups, characterised by differences in the frequency of high and low values of the transverse bars. These groups, arranged in order of frequency of the high values, are:—

1. American, in which 44 °/₀ of the fish have 28 or more bars each.
2. Irish, in which the number of fish having the same high number of bars varies between 34 °/₀ and 38 °/₀.
3. English Channel and North Sea (including Brest and Scilly), in which the number of fish having the high number of bars varies between 20 °/₀ and 22 °/₀.

I also conclude that these differences indicate a racial separation between the three groups. The American fish are shown in the sequel to be distinguishable from European fish in regard to every character, so that I do not anticipate that my conclusion as to the existence of a peculiar American race of mackerel will be disputed. But the differences between the Irish and the Channel fish are not so sharply defined in all respects as those between the American and European, so that the same degree of certainty cannot be attached to my conclusion as to the existence of a separate Irish race. Nevertheless, I would point out that, if the racial distinctness of the American fish be admitted, it is impossible to avoid a similar conclusion in regard to the Irish fish also, if we confine our attention to the evidence of the variation of the transverse bars, for the difference between the Irish and Channel samples is greater than the difference between the Irish and American, and is almost as great as the difference between the American and the European as a whole.

Moreover, the general difference between the Irish and English fish is not confined to the gross samples from these localities as a whole—in which case it might be attributed to errors of observation or calculation—but it has been shown to be also characteristic of the numerous individual samples of fish from these localities, almost without exception. This fact, in my opinion, is one of very great importance.

It must also be stated that the differences between the samples are not due to any increase in the number of bars with the growth of the fish. This can be inferred merely by comparing the sizes of the fish in the different samples. Thus the highest mean number of bars occurs in the American sample, which consisted almost entirely of relatively small fish, while the lowest mean number occurs in the Lowestoft sample, dated June 28th, in which the distribution of sizes was practically identical with that in the American. (See Table A.) Again the values are almost equally high for the Kinsale samples as for the Kerry samples, although the former consist exclusively of small fish, and the latter exclusively of large fish.

The following facts which I have ascertained point unequivocally to the same conclusion.

The transverse bars are formed at an early period, and the basis of their formation is a deposit of pigment along the free surface of the myotomes. It is this relation to the myotomes which gives the bars in the majority of cases a marked > shaped curvature. Now the number of myotomes corresponds to the number of vertebræ, which is almost invariable in most species of bony fishes, and particularly so in the mackerel. From the relation of the bars to the myotomes it may, accordingly, be assumed that no change in their number takes place after formation.

If the correspondence between transverse bars and myotomes were perfect, the number of the bars would be the same as the number of vertebræ, and equally invariable. This is obviously not the case. But it is important to notice that *the average, or rather modal, number of bars is exactly the same as the number of vertebræ.* The modal number of bars between shoulder girdle and last dorsal finlet is shown in my tables to be 27. The total number of vertebræ in the mackerel is 31. But the vertebral column extends a little in front and a little behind the limits mentioned, and by dissection I have found that this excess coincides with the extent of the two anterior and the two posterior vertebræ. Consequently the number of vertebræ in the region corresponding to the bars enumerated is four less than the total number, viz., 27; which is also the modal, or most frequent number of bars. This correspondence furnishes a conclusive confirmation of the general accuracy of my data in regard to the present character, as well as of my statement that the bars are formed in relation to the myotomes. The variation in the number of bars is due to the fact that the pigment is not deposited in a regular manner along the free surface of the myotomes, except in very rare cases. In most fishes the pigment streak can be seen to correspond with a particular myotome for part of its extent, and then to become broken or discontinuous, either remaining as an isolated fragment, or more frequently effecting an abrupt anastomosis with the pigment of a neighbouring myotome. These two facts, the discontinuous deposition of pigment along the myotomes, and the irregular anastomosis of the pigment streaks of neighbouring myotomes, account not only for the variable shape of the transverse bars, but also for their variable numbers. The variation in the number of the bars, in spite of the fundamental relation between the bars and the myotomes, does not involve any variation in the number of the myotomes or vertebræ. But, just as the number of myotomes is fixed for each fish, so the number of pigment-bars which are formed in connection with them is not subject to alteration after the period of formation. This period falls between the metamorphosis of the larva and the acquisition of a length of some 4 or 5 inches.*

To remove all doubt concerning this important point, I have calculated the mean number of bars in all the very small fish taken at Plymouth during the autumn of 1897. The total number of fish was 67, ranging in length from 5½ to 10 inches. The mean number

* It is curious to notice that the transverse bars of the adult mackerel occupy a position in relation to the myotomes which is quite different from that occupied by the vertical lines of chromatophores in young mackerel from 14 to 18 mm. in length, according to Holt's description and figures (this Journal, V., 1898, p. 116, figures 3 and 4). In preserved specimens at this early stage Holt states that, "on the sides of the trunk, the chromatophores are set more thickly at the lines of division of the myomeres than elsewhere," *i.e.*, along, instead of between, the septa which separate the myotomes.

of the bars was 26·66, a number well within the range of the means for North Sea and Channel samples, viz., from 26·50 to 26·94.

§ 2. *The Bars which cross or meet the Lateral Line.* The frequency of the variations in the number of these bars is given in Table C (p. 291).

It will be noticed that, in spite of the greater exactitude with which the number of these bars can be determined, the range of variation is distinctly greater. In the case of the entire series the range covered only 11 bars; in the present case the range is from 12 to 25, and covers consequently 14 bars. When it is remembered that in the former case the whole side, and in the present case only a part of the side of the fish, was under examination, the observed difference in the range of variation must be regarded as significant. I attribute the difference to the fact that the field occupied by the bars in the first case is invariable, being the whole side of the fish, while that which provides the material for variation in the present case is in itself variable. The anterior boundary is fixed by the shoulder-girdle, as in the entire series; but the posterior boundary of the field depends on the curvature of the lateral line in that part of the body. The place where the bars cease to meet the lateral line generally coincides with an abrupt downward bend in the course of the line; but, as the bend is sometimes absent, or takes place in front of, or behind, its usual position, the number of bars which meet the line is correspondingly increased or reduced.

The number of bars affected by this irregularity in the curvature of the lateral line is not great, and the error which is introduced by it into the records of the variability of the number of bars consequently tends to become smaller and smaller as the number of observations is increased. But, as the mean values in Table C show, it is sufficient to break down the high uniformity of results between the unit-samples of any one region which was exhibited in Table B.

Excluding the two small samples of 12 fish from Scilly, the modal number is seen to be usually 18; but the exceptions to this rule are more frequent in the present case than for the entire series, being 6 instead of 3.

The means for the samples from Lowestoft, Ramsgate, and Plymouth vary from 18·03 to 18·58; for Scilly and Brest from 18·64 to 18·65, and for the Irish samples from 18·15 to 18·62. The American mean is 18·88.

If we exclude all samples of less than 90 fish, the means for the North Sea and Channel vary from 18·04 to 18·43, those for the other localities being unaffected.

Thus the American mean, as before, is the highest, and the lowest means are found among the North Sea and Channel samples, as was also the case for the entire series of bars; but the contrast between the Irish and the Channel means is much less emphatic for the partial series than for the entire series of bars, owing to the more extended range of the mean values for both localities.

The explanation is, I believe, the same as for the greater range of variation of the partial series as compared with the entire series, viz., the irregularity introduced by the variability of the lateral line, which renders the number 100 insufficient as a unit-sample. If this is so, a closer approach to the former result ought to be revealed by comparing the means of the local groups of fish as a whole, neglecting groups of less than 200 fish. These means in fact for the Lowestoft and Plymouth groups vary from 18·21 to 18·23, and for the Kinsale and Kerry groups from 18·37 to 18·45, thus displaying a close agreement between the Lowestoft and Plymouth fish, and also between the Kinsale and Kerry fish, but a considerable difference between the Irish fish and those from the North Sea or Channel.

This relation is precisely the same as that revealed by the variation of the entire series of bars, the means for the North Sea and Channel being lower than those for the Irish groups in each case.

It is interesting to notice also that the close approximation between the Brest and Scilly means in regard to the entire series of bars is again shown in regard to those which meet the lateral line; but whereas the combined mean for Brest and Scilly only slightly exceeded that for the North Sea and Plymouth in the former case, here it is actually higher than the Irish mean. The significance of this difference it is impossible to decide at present, as the total number of fish from Brest and Scilly only amounts to 174, a number which cannot be regarded as sufficient to neutralise the error due to the curvature of the lateral line. If the mean, however, be provisionally accepted as approximately correct, it points to the conclusion that in some respects the mackerel which are found off the mouth of the English Channel and the neighbourhood of Ushant in June may form a connecting link between the Irish fish and those of the North Sea and Channel. From the geographical relations of the areas under discussion such a result would certainly accord with *a priori* expectations.

The percentages of frequency of high and low values of the bars may best be understood from the following condensed table:—

TABLE V., *showing frequencies of values of partial Series of Bars.* (Percentages.)

	Number of Fish.	12–16	17–18	19–20	21–25
Newport, U.S.A. .	100	7	35	42	16
{ North Sea . .	400	9	49	37	5
{ Plymouth . .	300	12	46	38	4
Brest and Scilly .	174	6	39	48	7
{ Kinsale . . .	410	8	43	41	8
{ Kerry . . .	245	10	45	37	8

We see from this table that the combined percentages in the two right-hand columns exceed those in the two left-hand columns in only two cases, viz., Newport, and Brest and Scilly. This preponderance of high values over low values corresponds to an excess of the mean values above 18·5.

In all other cases the figures in the two left-hand columns exceed those in the two right-hand columns. This preponderance of low values corresponds to mean-values less than 18·5.

The figures for the North Sea and Plymouth again correspond with remarkable exactitude, as also do those for Kinsale and Kerry. The difference between the Irish values and those for the groups from the North Sea and Channel is not great, but it is distinctly greater than the difference between the North Sea and Plymouth groups *inter se*, or between the groups from Kinsale and Kerry. The column which contains the highest percentages for each of these four localities is that recording the frequency of the numbers 17–18; and it will be seen that while the frequency of these values varies from 46 °/ₒ to 49 °/ₒ for the North Sea and Plymouth, it does not exceed 45 °/ₒ for Kinsale and Kerry.

In this connexion it should be noticed that both the minimum and maximum frequencies of the lowest values (12–16) are lower for the Irish groups than for the North Sea and Plymouth. On the other hand, the highest values of all (21–25) occur twice as often among Kinsale and Kerry fish as among North Sea and Channel fish, viz., 8 °/ₒ, as compared with 4 °/ₒ or 5 °/ₒ. This contrast in regard to the distribution of high and low values can be looked at in another way, viz., by comparing the relative frequency of the highest and lowest values in each group of fish. Thus in the American fish the frequency of the highest values is more than twice as great as that of the lowest values (16:7); for Brest and Scilly it is barely in excess (7:6); for Kinsale and Kerry the frequencies of the highest and lowest values are approximately the same (8 %); while for the North Sea and Channel the lowest values are twice or thrice as frequent as the highest values (9:5 and 12:4).

So far, therefore, as concerns the main conclusions drawn from the variation of the entire series of bars, the variation of the partial series furnishes a fairly satisfactory confirmation. These conclusions were the existence of three main races of mackerel in American and British waters, viz. (1) an American, (2) an Irish, and (3) a race common to the North Sea and the Channel.

The only respect in which the results are at variance concerns the affinities of the fish from Brest and Scilly, which were clearly with the Channel and North Sea fish for the entire series of bars, and with the Irish fish for the partial series. Nothing but the examination of a larger number of fish from this region will solve the difficulty. Additional facts, however, are adduced in the sequel which tend to show that the Brest and Scilly fish are intimately related to those of the Channel and North Sea, but show, under each character examined, a slight approximation towards the Irish race.

VII. Shape of Transverse Bars.

The cause which determines the general shape of the transverse bars has already (p. 256) been discussed, and has been found to be the deposit of pigment along the external surface of the myotomes. As the myotomes in the dorsal half of the body have a marked > shaped, or geniculate, curvature, the bars consequently show a marked tendency to assume a corresponding shape. The breaks and anastomoses, to which the bars are subject at the time of their formation, show, however, such diversity and complexity of form that they defied all my earlier efforts to discover a suitable system of classification by which the vagaries in the shape of the bars might be recorded for subsequent comparison.

I began by noting whether the general arrangement of the bars was regular or irregular, adopting several grades of regularity and irregularity to cover the intermediate conditions; but, although I have a complete set of data in these terms, and have tabulated the results for comparison, the examination which I have made of them shows them to be practically worthless for exact conclusions. This is largely due, as I now know, to the fact that regularity in the bars, *i.e.*, parallelism, with an absence of breaks and bifurcations, may be of two very distinct kinds, which may be termed, for comparison, primary and secondary. Primary regularity is due to the bars having retained their fundamental relations to the myotomes; they are not only parallel and unbroken, but also geniculate in shape. Secondary regularity is caused by the anastomosis of portions of the pigment streaks of neighbouring myotomes in such a regularly repeated manner as to produce an equally marked parallelism of arrangement, coupled with a partial or complete loss of the typical geniculate curvature and relation to the myotomes. Thus a parallel series of vertical, or oblique, bars is frequently exhibited; and in such a case each bar upon dissection has been found to cross several adjacent myotomes, instead of following any individual myotome along its course. By grouping those two types of arrangement under the same head "regular," I was unwittingly uniting things which should have been poles asunder.

On discovering this error, I proceeded to record the general shape of the bars in addition to their degree of regularity; but it would be unprofitable on the present occasion to give a general account of these later observations, owing to the fact that the majority of the fish examined during the autumn of 1897, including the bulk of the fish from Kinsale, would have to be omitted from consideration.

It has, however, been asserted by Donovan (*fide* Day, *British Fishes*, Vol. I. p. 84) that the sexes can be distinguished by the shape of the bars, these being "straight" in the male and "undulated" in the female. As my observations are amply sufficient to test the accuracy of this statement, I give some figures bearing on the question. As the term "undulated" is somewhat ambiguous, and may be held to apply to the angular > shaped, or geniculate, bars, as well as to those of a more truly wavy, or convoluted type, I have determined the proportion of the sexes exhibiting each of these characters, in addition to the proportion exhibiting straight or vertical bars. To avoid all doubt, I have eliminated all cases except those in which the bulk of the bars could be definitely described as either geniculate, wavy, or straight.

The results are shown in the following table:—

TABLE VI., *showing Shape of Bars in relation to Sex.*

Shape of bars.	Number of Fish.	♂	♀
Geniculate . .	75	34	41
Wavy . . .	78	36	42
Straight . . .	72	26	46
Total .	225	96	129

The figures in the table completely disprove the accuracy of Donovan's statement, and show, once for all, that the shape of the bars is entirely independent of the sex of the fish.

The percentages of the total numbers of males and females examined are 43 ♂ and 57 ♀; and for the first two types of bar this proportion is almost exactly reproduced, being 45:55 for the geniculate bars, and 46:54 for the wavy bars. So far from the straight bars being distinctive of male fish, there is a slight preponderance of females showing this character, the proportion being 36 ♂ to 64 ♀. For a total of 72 fish, however, this proportion is sufficiently close to the total proportion of males to females to show the entire absence of sexual peculiarities in the matter.

VIII. Dorso-Lateral Intermediate Spots.

The general character of these spots has already been given in the description of the characters investigated (p. 241). They are, strictly speaking, discontinuous portions of the pigment streaks of the myotomes, but they assume so definite a shape, and possess such clearly-defined relations to the transverse bars, that it is possible to discuss the variations in their frequency independently of the bars of which, theoretically, they form a part.

No fragments of the bars are here considered as "intermediate spots" unless they possess a sharply-defined round or elliptical shape, and unless they are situated between two neighbouring transverse bars, or are entirely or partly enclosed in a ring-like modification of two neighbouring bars.

It sometimes happens that the extremities of the bars are separated off as small "end-pieces," which may even assume a rounded form. Such end-pieces are undoubtedly connecting links, from a theoretical point of view, between perfectly linear and continuous bars and the pigment-spots which I distinguish as "intermediate"; but if these end-pieces plainly continue the lines of the bars, and do not occupy an isolated intermediate position between two adjacent bars, they have been excluded from consideration.

The importance which I attach to the extreme type of "intermediate spots," as defined, rests on the following grounds. The shape and course of the bars is fundamentally determined, as already shown, by the shape and course of the myotomes or muscle-segments. Bars, therefore, which follow the course of the myotomes may be regarded as primitive in character. In such cases, since the surface of every myotome is occupied by a pigment-streak, it is clear that spots, having an intermediate position between two adjacent bars, can have no existence. Spots of this kind can only be found in fish whose transverse bars have departed from their primitive relation to the myotomes, and in which the primitive symmetry has been replaced by a new symmetry, due to the breaking up of the primary bars and the anastomosis of the fragments of one bar with those of its neighbours. Some of these fragments remain permanently isolated, and constitute the intermediate spots under discussion; while to right and left of them are seen the new or "secondary" bars which have resulted from the union of the other fragments of the primary bars.

Thus the presence of intermediate spots is in itself evidence of the transformation of the primary bars, and the frequency of these spots in races of fish may be expected to vary according as the process of transformation has proceeded to a greater or less extent.

A comparison of the markings of the different species of the genus *Scomber* shows, indeed, that they are subject to extraordinary modifications. Thus, according to Günther's catalogue (vol. ii., pp. 357–362), the stripes are transverse in *S. scomber, pneumatophorus, janesaba*, and *tapeinocephalus*, irregularly reticulated in *S. colias*, longitudinal in *S. chrysozonus*, replaced by longitudinal rows of spots in *S. moluccensis*, and of indistinct dots in *S. microlepidotus*. Why the transverse stripes should be retained in one species and replaced by longitudinal stripes in another, I am unable at present to say; but it is evident that the markings of the mackerel tribe are, so to speak, in a state of very unstable equilibrium, and susceptible of considerable modification, a fact which should render them of much service in the investigation of racial differences in the more primitive species. To this group the common mackerel belongs, owing to its retention of the transverse stripes, modified though these are in a variety of ways.

The variations in the frequency and numbers of the intermediate spots are given in Table D (p. 292).

The number of fish exhibiting one or more spots (which for brevity will be termed "spotty fish") is seen, as a rule, to be but a small proportion of the whole; but in this respect there is a striking contrast between the European and the American mackerel. In European samples the number of spotty fish is usually about 25 °/₀ of the whole, varying from 7 °/₀ to 29 °/₀; but in the American sample the spotty fish predominate, and amount to 66 °/₀ of the total number.

Similarly the total number of spots for every hundred fish is usually about 30 in European samples, varying from 8 to 57, but attains the extraordinary total of 215 in the American sample. The table giving the frequency of the different numbers of spots shows that the high American total is not due to the accidental inclusion of some one or two very spotty fish, but is due to a regular and extensive variation in regard to the number of spots, the numbers from 1 to 11 occurring with a frequency which decreases fairly regularly as the number of spots increases. In one fish actually 17 spots were enumerated.

It is not to be expected that a character which is altogether absent in 75% of the fish would show any great uniformity of variation in samples of only 100 fish.

The range of variation in the samples, excluding those of less than 70 fish,* is, however, as follows:—

Locality.	Percentage of Spotty Fish.	No. of Spots per 100 fish.
Lowestoft and Ramsgate	17% to 28%	24 to 57
Plymouth	12% to 25%	25 to 57
Brest and Scilly	18% to 26%	32 (each)
Kinsale	16% to 23%	22 to 40
Kerry	7% to 12%	8 to 20

As we have already seen for previous characters, so here in regard to spottiness, the table brings out the close relationship between the North Sea and Plymouth fish with a fidelity which is really astonishing; and the close affinity of the Brest and Scilly fish with those of the former regions is also clearly shown. The novel feature of the table is the remarkable difference between Kinsale and Kerry fish in regard to this character, those of the West coast of Ireland having a very low degree of spottiness, while those of the South coast occupy an intermediate position between the Kerry fish and those of the Channel, approximating, however, more closely to the latter. The maximum percentage of spotty fish in the Kerry samples scarcely attains to the minimum percentage in the samples from every other region, and the maximum number of spots per hundred fish is actually less than the minimum number for other localities.

The reliability of the data as a test of racial peculiarities is established in my opinion by the close conformity of the results in regard to the North Sea and Plymouth fish, since these are groups the racial identity of which is rendered antecedently probable by the sequence of events in the fishing seasons, and by geographical and physical considerations. This antecedent probability has already been confirmed by the results described in the section on the number of transverse bars.

The sensitiveness of the character as a test of racial differences is also confirmed by the great contrast which has been shown to exist between American and European fish in regard to this character, a contrast which is borne out by the variation of almost every other character, but which is more striking for this character than for the remainder.

* The small Brandon sample, dated April 16th, has been combined with that dated April 22nd, in order to obtain a representative percentage for this locality.

The conclusion, therefore, seems to me to be inevitable that the mackerel which frequent the south and west coasts of Ireland are not a single stock of fish which visit both coasts indifferently, but are separable into two stocks, one of which inhabits the waters off the west coast, the other those off the south coast.

I find some support for this conclusion in Mr. Green's statement that he has met with no evidence to show that mackerel in approaching the Irish coast "travel along it, either to north or south. From Cork to Donegal, which are the extreme limits of the fishery on the Irish coast, they appear at the same time." (Bull. U.S. Fish Com., xiii. 1893, p. 358.)

There is, of course, no impassable barrier between the two stocks of fish. Mixture must undoubtedly take place at the imaginary borderline between the southern and western areas, and in the spawning season a variable number of the floating eggs from one stock must be carried by currents into the area of the other; but it must be remembered that my samples are derived from localities relatively far apart, viz., Kinsale and off the mouth of the Shannon, and that while the west coast fish are only subject to mixture with the closely related south coast fish, those which are found in the eastern waters of the south coast are also liable to mixture with the mackerel of the English Channel. It is probably significant, therefore, that the differences between the Kinsale and Kerry fish consist in an approximation of the former fish, and not of the latter, towards those of the Channel in regard to the present character.

I may draw attention to the fact that this intermediate condition of the Kinsale fish is not confined to the present character. If reference is made again to Table B, it will be seen that the mean number of transverse bars is distinctly lower for Kinsale (27·15) than for Kerry (27·27), and consequently approximates towards the mean value for the Channel, which is the lowest of all (26·79). In this character, however, the Kinsale fish maintain a closer resemblance to the Kerry fish than to those of the Channel. Similar results have also been yielded by the first dorsal fin, as will be described later on (p. 275).

From a comparison of all three tables (B, C, and D) it would appear to be probable that the mixture which actually accounts for the intermediate condition of the Kinsale fish is rather with the Brest and Scilly fish than with those of the Channel in its narrower sense. Such a conclusion would harmonise well with the known range in the position of the fishing quarters during the spring season.

To conclude this chapter, I give a more condensed statement of the results for the four principal regions.

TABLE VII., *showing variation in Spottiness.*

Locality.	Number of Fish.	Percentage of Spotty Fish. Total.	Fish with 1 spot.	Fish with 2 or more spots.	Total number of spots per 100 Fish.
America	100	66	23	43	215
North Sea and English Channel .	700	21	13	8	37
Brest and Scilly	174	22	15	7	32
Ireland, W. and S. . . .	556	15	11	4	23

This table brings out clearly (1) the decisive racial distinctness of the American fish, (2) the affinity between the fish from Brest and Scilly with those of the Channel and North Sea, and (3) the racial difference between the Irish fish and those of the preceding area.

In general terms it may be said that the American fish are very spotty, and the Irish fish, particularly off the west coast, are very free from spots, while the fish which frequent the English Channel, from its mouth to the coast of Norfolk, have a somewhat higher percentage, both of spots and spotty fish, than those of the Irish coast.

That spottiness has no connexion with the size of fish examined is clear from a comparison of the results with the table of sizes.

The following figures prove the absence of any sexual peculiarities in the matter. They are based on the entire set of samples in which the sex of the fish was recorded, *i.e.*, 100 American and 918 British fish.

American fish.—Proportion of males to females . . . 55:45
,, ,, male to female spotty fish . . 59:41
Deviation = 4 %

British fish.—Proportion of males to females . . . 46:54
,, ,, male to female spotty fish . . 44:56
Deviation = 2 %

IX. NUMBER OF FINRAYS IN FIRST DORSAL FIN.

According to Günther's *Catalogue of Fishes* (vol. ii., p. 357), the number of finrays in the first dorsal fin of the common mackerel is higher than in any other species of the genus *Scomber*, and varies from 11 to 14. The lowest number is presented by the Spanish mackerel (*S. colias*), which is stated both by Günther and Day (*British Fishes*, i., p. 91) to possess only 7 rays. An intermediate condition is shown by *S. pneumatophorus*, which possesses 10 rays, according to the same authorities. Steindachner, on the other hand, regards the two latter forms as varieties of one and the same species, in which the number of finrays would vary accordingly from 7 to 10. From an examination of several specimens from the Mediterranean, which I owe to Professor

Marion's kindness, I am inclined to agree with Steindachner in the matter. In any case, there is a marked difference in the number of finrays characteristic of the common and the Spanish mackerel, the two best known species of the genus *Scomber*. If there are any separate races of the common mackerel, there exists, accordingly, an *a priori* probability that the distinction between these races will include differences in regard to the number of rays in the first dorsal fin, especially as the variability of this character in *S. scomber* is already known to be considerable.

Before proceeding to an examination of my results, I should state that the determination of the exact number of rays present in the first dorsal fin of any mackerel is a matter requiring considerable care, owing to the minuteness of the posterior rays. The second or third ray is usually the longest, and the length of the remaining rays decreases gradually to zero. If one wished to omit the minute hinder rays from consideration, it would be as difficult to determine a just arbitrary limit as to endeavour to count the entire series. I have therefore adopted the latter course, and my figures represent the maximum number of finrays recognisable in each fish without actual maceration.

Upon a first inspection of the figures representing the average number of rays in the fish from each locality, I feared, from their apparent irregularity, that the difficulties of exact determination had proved too great for the acquisition of definite results, and this remark was made in the preliminary account of my researches communicated to the British Association at Bristol. From the more complete analysis of the figures, however, which I now provide, it will be seen that my fears were groundless, for the data have proved to be of sufficient exactitude to establish an unexpected but convincing relation between number of finrays and size of fish.

§ 1. *General variation.* The distribution of finray values among the various consignments of mackerel examined is given in Table E.

The range of variation is shown to be from a minimum of 9 rays to a maximum of 16 rays, but in a total number of more than 1600 fish the former value was only found twice and the latter value only once. The most frequent value was 12, which was found in about half the fish examined; 13 rays were found in about one quarter of the fish, and the remaining quarter consisted principally of fish possessing 11 and 14 rays, the former value being much more frequent than the latter. The fish with 9, 10, 15, and 16 rays formed a very small percentage of the whole (about 3 °/₀ altogether).

§ 2. *Local differences.* In a sample of 100 fish from the French coast near Brest, the variation of finray values was absolutely symmetrical (see Table E, p. 293), and exactly 50 °/₀ of the fish exhibited the modal or most frequent value.

In all other samples the distribution of values was asymmetrical. The percentages for the various localities show that the modal value is 12 for all localities except Scilly, for which it is 13. This exception is no doubt partially due to the smallness of the consignments from that locality (only 74 fish in all), and is paralleled by a similar phenomenon in the case of a small consignment from Brandon, April 16th, in which the most frequent value was 11, although 12 in a subsequent and larger sample.

For most localities the number of fish having 13 rays preponderates over the number having 11. This is true for Lowestoft, Ramsgate, Plymouth, Scilly, and County Kerry. But the American fish show a slight preponderance of the lower value, and the preponderance of this value is considerable in the case of the fish from Kinsale. In this respect the Kinsale fish differ from those from all other British localities, and the matter requires special consideration.

On examining the data for the various samples received from Kinsale (Table E), it is seen that the preponderance of low values was not exhibited by all the consignments, those taken on September 17th, 1897, and July 1st, 1898, being normal in this respect. The preponderance of low values was entirely due to the samples dated July 30th and September 3rd, 1897. Now these were the only samples in the whole series of fish which were not examined in a fresh condition. They arrived during my absence in Canada, and after measurement were placed in tanks of formaline to await my return. The excess of low values is so unique in these two cases that I consider myself justified in attributing the difference to the effects of this re-agent, the tendency of which to develop free formic acid is well known. The amount of calcareous matter in the minute posterior rays is so small, that its solution by the acid would be merely a matter of time. As the fish remained six weeks in the formaline before examination, there can be little doubt that the calcareous matter in the smallest rays was dissolved in a certain number of cases to an extent sufficient, at any rate, to invalidate the records. The omission of the posterior ray from 20 °/₀ of the fishes in these samples would be more than sufficient to account for the observed differences between the fresh and preserved samples of Kinsale fish.

If this correction be permitted, the variation of the first dorsal fin becomes very uniform for all British localities, with the exception of Scilly, an exception which is readily explicable by the inadequacy of the sample from that region. The numbers of finrays vary round 12 as a mode, and the percentage of values above the mode tends everywhere to exceed the percentage of values below it; but neither by a comparison of the percentages themselves, nor by the study of the average values for each locality, is it possible to trace any marked evidences of racial distinction among the British fish. The American fish alone seem to possess any distinguishing peculiarity as regards the variation of this organ.

The question, however, is complicated by the factors of growth and sex. Matthews has shown that in the herring there is a slight increase in the number of dorsal finrays with the growth of the fish, an increase which is not so much due to the appearance of new rays as to the enlargement of the minute anterior ray, which renders it less liable to escape notice in large fish than in small (4th Report Scottish Fishery Board, 1886, p. 92). It is therefore necessary to enquire whether there exists any similar relation in the mackerel between size of fish and number of recognisable rays.

Moreover, the first dorsal fin is frequently modified as a secondary sexual character in bony fishes, and although no such modification has ever been recognised in the mackerel, it is important to ascertain whether or not the number of rays is correlated with sexual distinctions. The proportion of the sexes in the various consignments of fish examined was not always uniform, and, if any correlation exists, the preponderance of opposite sexes in two different samples would occasion a difference in the results which might be readily mistaken for evidence of racial peculiarities.

§ 3. *Number of Finrays according to Sex and Size.* The sex of the fishes examined during the autumn of 1897 was not always determined, so that in the present enquiry we shall be restricted to the following samples of fish:—

Ireland.

(1) Kinsale, July 1st, 1898 . .	44	males	and	56	females
(2) Smerwick, March 12th, 1898 .	63	,,	,,	36	,,
(3) Brandon, April 16th, 1898 . .	20	,,	,,	25	,,
(4) ,, ,, 23rd ,, . .	43	,,	,,	58	,,
Total . .	170	,,	,,	175	,,

English Channel and North Sea.

(1) Plymouth, Nov. 16th to 20th, 1897	41	males	and	59	females
(2) ,, July 6th, 1898 . .	42	,,	,,	58	,,
(3) ,, ,, 11th ,, . .	10	,,	,,	14	,,
(4) Ramsgate, Oct. 27th, 1897 . .	55	,,	,,	45	,,
(5) Lowestoft, Oct. 12th ,, . .	15	,,	,,	10	,,
(6) ,, June 28th, 1898 .	21	,,	,,	29	,,
(7) ,, July 12th ,, .	39	,,	,,	61	,,
Total . .	223	,,	,,	276	,,

The size of the fish in these samples, irrespective of sex, is given in inches and quarters in Table A. In the enquiry before us, however, it is inadvisable to have too many size-groups, as that would reduce the number of fish in each group to a very small number. I have therefore subdivided the Irish males and females into groups according to the integral number which expresses the length of each fish in inches, the fractional differences being neglected. The fishes in each group have then been sorted according to the number of the rays in their dorsal fins. The same has been done with the males and females of the Channel and North Sea fish, and the resulting distribution of values is shown in Table F (p. 294). The upper half of the table represents the observed frequency of the various finray values, the lower half embodies the same facts reduced to percentages. The mean number of finrays for each inch-group of fishes has also been calculated, and is to be found in the column to the right hand of the frequency data for males and females alike.

The results contained in this table are particularly interesting. If we neglect the values ascribed to the extreme inch-groups, viz., those containing 11- and 17-inch fish, which are naturally erratic on account of the small number of observations, we see that on the whole there is a distinct tendency for the percentage of high values to diminish with increased size of fish. The Irish results are clearer than those for the Channel in this respect, owing to the greater number of large Irish fish. I will, therefore, direct attention to them in the first place. We see, for example, that for Irish fish of 12 and 13 inches length, whether males or females, at least 40 °/₀ possess more than 12 finrays; whereas for fishes above that size the percentage of high values (*i.e.*, above 12 rays) never exceeds 33 °/₀ and in most cases does not exceed 30 °/₀. On the other hand, the percentage of low values (*i.e.*, below 12 rays) does not exceed 22 °/₀ for fishes of 12 and 13 inches, but is increased to 30 °/₀ or more in the case of fishes of 15 and 16 inches in length. This general tendency is expressed fairly accurately by the mean values, which vary between 12·24 and 12·35 for the smaller fish (12 and 13 inches), and between 11·90 and 12·05 for the larger fish (15 and 16 inches).

We reach, accordingly, this general result, *that, among Irish fish, whether males or females, the average number of finrays decreases as the length of the fish increases.*

Of course, this generalisation only applies to fish within the size-limits of the present investigation, *i.e.*, to mackerel of marketable size, between 11 and 17 inches in length. I have not hitherto received any small first-year fish from Irish waters, and cannot, therefore, say at what stage the maximum number of finrays is present. Some remarks on this point in connection with yearling Plymouth fish will be found below.

A second conclusion is also forced upon us by a comparison of the figures on the left and right sides of the same Table (F), which deal with the frequency of the various values for males and females respectively. Subject to the same reservation in regard to the extreme size-groups, we may say that, *for each size of fish, the table shows a perfect agreement between males and females in regard to the relative frequency of high and low values.* When high values predominate among the males, they predominate also among the females of the same size; when the percentage of low values rises in one sex, it rises also in the other. There is accordingly a close agreement between the mean number of finrays in males and females of the same size.

In the series of size-groups of Irish fish, whether male or female, the first distinct fall in the mean number of finrays occurs in the group of 14-inch fish, in which there is a decrease of 0·25 for the males, and 0·29 for the females, as compared with the mean values for the corresponding groups of 13-inch fish.

Unfortunately the group of 12-inch Irish fish is inadequately represented, and when we pass to the Channel and North Sea fish, we see that the group of 14-inch fish is there represented in the case of the males by only 26 fish, which is also insufficient to yield a reliable result. This is seen, for example, in the lack of correspondence between the means for the Channel males and females of this size, a feature which is still more noticeable for the 15-inch fish, which are represented by only 6 specimens of each sex.

In order, therefore, to compare the Irish with the Channel results, it is necessary to enlarge the size-groups, and this I have done by dividing the whole set of fish into three, instead of eight, compartments according to the size of the fish.

These compartments are as follows:—

(1) 10, 11, and 12-inch fish.
(2) 13 and 14-inch fish.
(3) 15, 16, and 17-inch fish.

As we have already seen that the mean values indicate pretty closely the changes which take place in the percentage distribution of high and low values, it will be unnecessary to recombine the percentage values in a separate table, although anyone desirous of checking these results can readily do so from the data given in Table F. I will give here merely the mean values for the three compartments already defined.

TABLE VIII., *showing mean number of first dorsal finrays for males and females of different sizes.*

Size of Fish (inches).	Ireland.				Channel and North Sea.			
	No.	♂	No.	♀	No.	♂	No.	♀
10, 11, and 12 .	27	12·33	26	12·31	111	12·21	140	12·31
13 and 14 .	107	12·16	83	12·14	105	12·13	128	12·02
15, 16, and 17 .	36	11·92	66	11·94	7	12·00	8	12·00

This table shows two things:—

1. That a reduction in the number of recognisable finrays with increasing size is a general phenomenon, common to mackerel from Irish and English seas alike: and

2. That there are no sexual peculiarities at any size in regard to the number of finrays in the first dorsal fin.

The first of these conclusions is obvious enough. The second conclusion is founded on the practical identity of the mean values for Irish males and females at corresponding sizes, and on the inconsistency in kind of the differences which exist between the males and females of the Channel and North Sea. The mean for the females in the first compartment exceeds that for the males by 0·10, while in the second compartment the mean for the males exceeds that for the females by 0·11. Whatever may be the explanation of these deviations between the male and female values, it is clearly not due to the existence of any secondary sexual peculiarities in the number of finrays.

The questions naturally arise, at what period in the life of a mackerel does the process of reduction begin, and what is the cause of the reduction?

The first question can only be answered after the examination of large numbers of young mackerel. The material at my disposal is at present too limited for me to go minutely into the matter, but is sufficient to show that the reduction in the number of rays begins before the attainment of a length of 10 inches. The mean number of finrays in 127 Plymouth mackerel above 12½ inches in length is 12·02; the mean in 129 small mackerel from the same locality, all of which were below 10½ inches in length, is 12·49. The frequency of the different values is shown in the following table:—

TABLE IX., *showing frequency of finray numbers in small and large Plymouth fish, irrespective of sex.*

Small fish = below $10\frac{1}{2}$ inches; minimum size $5\frac{1}{2}$ inches.
Large fish = above $12\frac{1}{2}$ inches; maximum size $15\frac{3}{4}$ inches.

Size.	Number of Fish.	Number of Finrays. 10	11	12	13	14	15	Mean.
Small.	129		21	48	41	14	5	12·49
Large.	127	8	24	62	25	7	1	12·02
Small.	%		16	37	32	11	4	12·49
Large.	%	6	19	49	20	5	1	12·02

As regards the cause of the reduction in the number of recognisable finrays, there are two possibilities, (1) the gradual absorption, and (2) the gradual concealment of the minute posterior rays.

I have been unable as yet to determine the extent to which actual absorption of the rays takes place, but I believe that some part of the reduction, if not the whole of it, is due to changes in the relation of the fin to the neighbouring tissues during growth of the fish. In an adult mackerel the first dorsal fin is lodged in a deep groove, within which it can be entirely depressed—an adaptation, without doubt, to habits of rapid locomotion, as this fin is never used for swimming, and would only be a hindrance if incapable of being bent back and tucked away within its socket; but in young fish up to 7 or 8 inches in length the groove is not yet formed. Consequently, in old mackerel the basal part of the fin is sunk beneath the general surface of the skin, while in young mackerel every part of the fin is freely exposed. The minute posterior rays do not protrude outside the groove in old fish, but are clearly visible in young fish. In these they require no preparation or dissection to be displayed; but in old fish the groove has to be carefully explored with a seeker, and often the lateral flaps of skin have to be cut away for the purpose, before the number of projecting rays can be accurately ascertained. This, of course, is a mere matter of care, which it is needless to say was invariably bestowed in the course of the investigation, the number of rays in this fin having been counted in each fish at least twice, and often four or five times, before being recorded. But a real difference between the two conditions consists in the fact that the posterior rays in large fish generally project less above the floor of the groove than do the corresponding rays of small fish, thus indicating in large fish a process of encroachment upon the lower part of the fin by the surrounding tissues. I fancy, therefore, that as the fish grows, this encroachment leads to the gradual covering up of the smallest rays altogether, which would sufficiently account for the observed reduction in the number of finrays as growth of the fish increases. As already remarked, I cannot yet say whether the spines are ever actually absorbed. From the nature of the case such a conclusion could only be derived from an extensive study of macerated specimens of different sizes, since mackerel will not live more than a few days in captivity, and it has not been possible to devote the necessary time to such an enquiry.

§ 4. *Racial differences.* Owing to the reduction of the number of finrays with growth of the fish, it is clearly impossible to use the data given in Table E as a basis for conclusions as to racial peculiarities, since no account has been taken in that table of growth-changes. If any racial peculiarities exist, they can only be determined by comparing fish of the same size from the different localities. Accordingly, as the various localities are most uniformly represented by 13-inch fish (see Table I, p. 246), I have compared the mean numbers of finrays in local groups of fish of this size.

The results are as follows:—

American . . .	33 fish. . .	Mean number = 11·88
North Sea . . .	166 ,, . .	,, ,, 12·14
Plymouth . . .	64 ,, . .	,, ,, 12·00
Brest and Scilly . .	56 ,, . .	,, ,, 12·16
Kinsale . . .	49 ,, . .	,, ,, 12·14
Kerry . . .	49 ,, . .	,, ,, 12·33

The number of fish representing most of the localities is unfortunately too small to yield very accurate results, but the general trend of the differences is probably reliable. The American sample, as in other cases, yields one of the extreme values, in this case the lowest; and among European samples the Kerry and Channel values are widest apart, as was also the case in regard to the transverse bars (Table B) and intermediate spots (p. 266). The difference between the values for Plymouth and the North Sea is certainly rather large, as also is that between Kinsale and Kerry; but, in view of the small available numbers of fish of the proper size, I doubt whether any importance can be attached to these differences. A more reliable conclusion can probably be derived from the fact that the maximum value for the Channel and North Sea is no higher than the minimum value for the Irish coasts, and that Brest and Scilly yield a value which is intermediate between the two.

This result is in complete agreement with the results already obtained in regard to the number of bars and the degree of spottiness.

That this result is not accidental, but is founded on real differences in the degree of evolution of the different races of fish will be made clear in the next section.

X. Correlation between Spottiness and Number of Finrays.

We have already seen that the presence of intermediate spots among the transverse bars indicates a departure from the primitive arrangement of the bars, which coincided with the lines of the myotomes or muscle-segments. Increased spottiness accordingly indicates an increased departure from the primitive condition. We have also seen that the common mackerel belongs to the most primitive group of species of the genus *Scomber* so far as its markings are concerned. I have, moreover, briefly referred to the fact that the number of finrays in the first dorsal fin is higher in the common mackerel than in any other species of the genus *Scomber*. As the number of finrays has also been shown to be higher in young than in old mackerel, it is certain that, for the race as for the individual, a high number of finrays is the primitive condition for Scombroid fishes.

Accordingly, as increase in spottiness and reduction of finrays are equally departures from the primitive condition, we might expect to find a correlation between these two characters in well-defined races of mackerel; and if this correlation occurs in representative samples of fishes from different localities, it furnishes the strongest possible argument for their racial distinctness.

Such a correlation undoubtedly exists, as is shown in the following table, which gives for each group of fishes the indices of spottiness already ascertained (p. 267) side by side with the mean number of finrays in the first dorsal fin, as determined in fish of 13 inches length. Although an extensive examination of the variation of the Spanish mackerel, *Scomber colias*, has not yet been made, its spottiness is so marked, and the number of its finrays is so decidedly reduced, that I have no hesitation in placing it here as a type of extreme departure from the primitive Scombroid condition.

Race of Mackerel.	Percentage of Spotty Fish.	No. of Spots per 100 Fish.	Mean No. of Finrays (13 inches).
Scomber colias	100 %(?)	500(?)	7–10
Sc. scomber			
American	66 %	215	11·88
{ North Sea and English Channel	21 %	37	12·10
{ Brest and Scilly	22 %	32	12·16
Ireland, S. and W.	15 %	23	12·23

It would be difficult to find a more convincing demonstration than this table affords as to the existence of local races of the common mackerel; and when it is remembered that the variation in the number of transverse bars led to a precisely similar grouping of the local consignments (p. 255), there can remain, I think, no doubt as to the general accuracy of the conclusions which are drawn in this report concerning the races of the mackerel.

The contrast between the Irish and English races of mackerel is sufficiently clear from the figures in the table, but it becomes still more distinct if we contrast the English race with the West coast stock of the Irish race, since the Kinsale fish occupy an intermediate position between the Kerry fish and the English race in respect of both characters. The following are the distinctive characters of the two stocks of the Irish race:—

	Spotty Fish %	Spots %	Mean No. Finrays.
Kinsale . . .	19 % ...	29 ...	12·14
Kerry	10 % ...	15 ...	12·33

In respect both of spottiness and number of finrays, the Kinsale stock approaches the Channel race more closely than it does the Kerry stock, although intermediate between the two. In respect of the number of transverse bars it also holds an intermediate position, as already shown, but comes nearer the Kerry stock than the Channel race. The facts, therefore, demand the subdivision of the Irish race into West coast and South coast stocks.

On the other hand, it can be seen from the data already provided that no similar differences separate the North Sea from the Plymouth fish, the racial identity of which must accordingly be regarded as absolute.

The combined Brest and Scilly data approximate throughout to those for the North Sea and Channel, although they show a slight approach under each character towards the Irish, and particularly the Kinsale, values. In regard to the number of transverse bars, the high average of the Brest and Scilly fish shown in Table C would also appear to indicate an incipient racial divergence between the fish of the Channel proper and those which in summer haunt the mouth of the Channel west of a line from Mounts Bay to Brittany.

If this is so, it is a matter of the greatest importance, since it would necessitate the conclusion that the winter quarters of the North Sea and Channel fish are to be found in the Channel itself, and not to the west of it. This conclusion is by no means improbable, and would harmonize well with the peculiarities of the Plymouth winter fishery; but I cannot regard the evidence of the relatively small samples of

Brest and Scilly fish, or that of the partial series of transverse bars (Table C), as by any means decisive. I hope to re-examine these details by means of larger samples during the coming year.

XI. Second Dorsal Fin.

The variation in the number of finrays in the second dorsal fin is much slighter than in the case of the first dorsal. The extreme range of variation is from 9 to 15, *i.e.*, 7 rays; but the two extreme values on each side of the mode (*i.e.*, 9, 10, 14, and 15) occur very rarely, so that the range of variation scarcely covers more than 3 rays, viz., from 11 to 13.

Owing to the limited variability of the organ, no useful purpose would be served by publishing the separate data for the various consignments of fish, and I have therefore confined myself to a statement of the observed results for each locality as a whole. These are set out in Table G (p. 295).

There is a marked difference in the variability of this organ in the American fish as compared with the samples of European fish; for, whereas 12 rays occur in from 82 to 85 % of the European fish, they are found in only 63 % of the American, and the frequency of each of the remaining values is from twice to three times as great for the American fish as for the European. The mean value for the American sample is also considerably lower than for any European sample examined. The highest mean is that for the North Sea (11·950), and the lowest that for Kinsale (11·927), the difference between the two being 0·023. But the difference between the American mean and the nearest European mean is much greater than this, being 0·077.

The differences between the European samples are exceedingly slight, but attention may be drawn to the fact that the localities which provide the highest and lowest mean-values are geographically remote, viz., the North Sea and Kinsale.

The only satisfactory way of comparing values which present such slight local differences in the frequency of their occurrence, will be to combine the values above and below the mode (12) into two compartments of high and low value respectively, as below.

TABLE X., *showing frequency of High and Low Values of the Second Dorsal Fin.*

(Percentages.)

Locality.	Finrays. 9-11	12	13-15
Newport, U.S.A.	23 %	63 %	14 %
North Sea	10	84·3	5·7
Plymouth	12·3	81·3	6·3
Brest and Scilly	10·3	82·2	7·5
{ Kinsale	10·7	85·4	3·9
{ Kerry	9·8	85·3	4·9
{ North Sea and Plymouth	11	83	6
{ Brest and Scilly	10·3	82·2	7·5
Ireland, S. and W.	10·4	85·3	4·3

Undoubtedly the two groups which agree most closely according to the above table are those from Kinsale and Kerry. For these groups the frequency of the mode is the highest recorded, and is practically identical in the two cases (85·3 and 85·4 %). The two lowest frequencies of the high values (3·9 and 4·9 %) are also found in the same groups.

The figures do not appear to justify any further amalgamation of the groups; but it is worth noticing that the North Sea group approximates closer in its values to the Irish samples than does either of the others—a feature which is again exhibited with respect to the dorsal finlets.

We have already seen that, in respect to spottiness and the number of finrays in the first dorsal fin, the Irish fish approach most nearly to the theoretically primitive condition. Now the primitive number of rays in the second dorsal fin would appear almost certainly to have been 12, partly on account of the high frequency of this number throughout the samples, and partly on account of the fact, which is established below, that when this number is exceeded, the number of finlets tends to be reduced, and when the number of rays is reduced below 12, the number of finlets tends to be increased. This correlation implies a primitive constancy in the number of rays in the posterior dorsal fin of the ancestral mackerel prior to its subdivision into second dorsal and finlets. The total number of rays in the ancestral continuous fin was probably 17, which became subdivided into 12 rays for the primitive second dorsal fin and 5 rays for the finlets. If this view is correct, it is to be remarked that in the high frequency of the modal number of rays in the second dorsal fin, the Irish fish again display their primitive character. On this account, in spite of the slender basis for drawing racial distinctions from the variation of the present character, I think it will be conceded that, so far as any conclusions at all are permissible, they confirm the inferences which have already been drawn from the evidence of the more variable characters. It will be noticed, moreover, that the North Sea and Plymouth data are amalgamated, the percentages for Brest and Scilly approximate to the percentages for the combined groups in a remarkably close manner,—much more nearly than they do to the combined Irish percentages. This result is in complete agreement with the results already described for the characters previously discussed.

XII. The Number of Dorsal Finlets.

The number of dorsal finlets in my samples was never less than 4 nor more than 6; but there is a certain difficulty in enumerating them, owing to the fact that the last ray of the second dorsal fin is sometimes imperfectly separated off as an accessory, or incipient, finlet. As the finlets and second dorsal fin are both modifications of a primitively continuous fin (such as that which exists in *Caranx trachurus*, the horse-mackerel, and its allies), it is desirable to include these incipient finlets in an account of the variability of the number of finlets. They have been included in the account of the second dorsal fin as a matter of course, each incipient finlet counting as one dorsal ray; but in the present case, in order to reduce their value as compared with the fully constituted and independent finlets, I have regarded them as half-finlets. Thus, a fish which has 4 true finlets and one incipient finlet has been recorded as having $4\frac{1}{2}$ finlets.

The observed frequency of the different possibilities is recorded in Table H (p. 295).

The normal or modal number is, of course, 5. In the European samples this number occurs in from 92 to 94% of the fish, but the American race of mackerel is again distinguished from the European samples by its greater variability in regard to this character, the modal number being found in only 79% of the observed cases. In only 2% of the cases was the number reduced below 5, viz., $4\frac{1}{2}$, but no specimen was seen with only 4 finlets. On the other hand, 19% had more than 5 finlets, viz., 12% with $5\frac{1}{2}$ finlets, and 7% with 6.

The slight variability of the European fish in regard to this character renders necessary the same treatment as was applied in the case of the second dorsal fin, and I have therefore merged into a single compartment the cases showing less than 5 typical finlets, and into another compartment the cases with more than 5 typical finlets.

TABLE XI., *showing frequency of High and Low Numbers of Dorsal Finlets.*

(Percentages.)

Locality.	Dorsal Finlets. 4–4½	5	5½–6
Newport, U.S.A.	2 %	79 %	19 %
North Sea	2	94·5	3·5
{ Plymouth	3·3	92·3	4·3
{ Brest and Scilly	4	93	3
{ Kinsale	2·4	94·4	3·2
{ Kerry	2	94·3	3·7
North Sea and Plymouth	2·6	93·6	3·8
Brest and Scilly	4	93	3
Ireland, S. and W.	2·3	94·4	3·3

This table is, on the whole, similar in its general features to Table X., showing the variation of the second dorsal finrays. A very close affinity is revealed between Kinsale and Kerry, and again between Plymouth and the combined samples from Brest and Scilly, but the North Sea values, which merely approximated to the Irish values in the case of the dorsal fin, now entirely agree with them.

We again see that the Irish group is characterised by the high frequency of the normal number of finlets, or, as we may say, by its high normality.

In revealing the close affinity between the Kinsale and Kerry groups, and between the Plymouth group and the combined Brest and Scilly samples, this table furnishes a confirmation of what has previously been urged with regard to these points. The difference between the North Sea and Channel groups, although foreshadowed in the case of the second dorsal fin, is novel, and possibly significant; but in the next section it is shown that the variability of these organs is too slight to admit of any inferences being safely drawn as to the affinity between the various local groups of fish. The maximum number representing any one locality is only 410, while the deviations from the normal condition do not exceed 8 % for any of the British localities in the case of the dorsal finlets.

XIII. Correlation between Variations of Second Dorsal Fin and Number of Dorsal Finlets.

During the examination of the mackerel received, I frequently had occasion to notice that a marked degree of correlation exists between the number of finrays in the second dorsal fin and the number of finlets. I am not qualified at present to discuss the facts from a mathematical standpoint, but the existence of the correlation can readily be demonstrated.

As the variation of both characters is most marked in the American sample, I have analysed the data provided by it in the following manner:—

In 2 fish having 9 rays . . .	*both* had 6 finlets.	
Of 3 ,, ,, 10 ,, . . .	1 had 6 ,,	2 ,, 5 ,,
,, 18 ,, ,, 11 ,, . . .	4 ,, 6 ,,	14 ,, 5 ,,
,, 63 ,, ,, 12 ,, . . .	*all* ,, 5 ,,	
,, 13 ,, ,, 13 ,, . . .	11 ,, 5 ,,	2 ,, 4 ,,
In 1 ,, ,, 14 ,, . . .	1 ,, 5 ,,	

These figures show (1st) that the normal or modal number of finrays (12) is constantly associated with the normal or modal number of finlets (5); (2nd) that when the number of finrays is below 12, the variation in the number of finlets is confined to deviations above the mode; and (3rd) that when the number of finrays is above 12, the deviations from the modal number of finlets are exclusively below the mode.

This relation can be shown still more clearly as follows:—

Of 7 fish with 6 finlets	2 had 9 rays.
	1 ,, 10 ,,
	4 ,, 11 ,,
,, 91 ,, ,, 5 ,,	2 ,, 10 ,,
	14 ,, 11 ,,
	63 ,, 12 ,,
	11 ,, 13 ,,
	1 ,, 14 ,,
,, 2 ,, ,, 4 ,,	2 ,, 13 ,,

These figures show (1st) that the normal number of finlets (5) is associated with a wide range of variation in regard to the number of rays in the second dorsal fin (from 10 to 14), (2nd) that when the number of finlets is above 5, the number of rays is constantly below 12; and (3rd) that when the number of finlets is below 5, the number of rays is constantly above 12.

This correlation is also exhibited by the mean values of each character for the American sample, the mean number of finrays (11·850) being the lowest observed, and the mean number of finlets (5·120) being the highest observed.

If the mean values for the various British localities are correct, they ought to exhibit a similar correlation in regard to these characters; but, as will be seen from the following table, such a correlation between the local means does not exist. The localities are grouped in order of magnitude of the mean numbers of dorsal finlets; the inverse order of magnitude for the second dorsal values is given in brackets.

	Finlets.		2nd Dorsal.
1. Newport, U.S.A.	5·120	...	11·850 (1)
2. Kerry	5·016	...	11.947 (4)
3. North Sea	5·014	...	11·950 (6)
4. Kinsale	5·009	...	11·927 (2)
5. Plymouth	5·003	...	11·940 (3)
6. Scilly and Brest	4·994	...	11·948 (5)

It will be seen that there is a conspicuous lack of correlation between the mean values for the various local groups of European fish. Kerry and the North Sea, which have the highest average number of finlets, ought to have the lowest number of dorsal rays, instead of which these values are among the highest observed. On the other hand, the combined Brest and Scilly values occupy approximately their correct positions in the sequence.

It is clear, therefore, that the means cannot be regarded as correctly representative of the local groups of fish, and that no racial affinities or differences can be based on the figures as they stand. In view of the indubitable correlation between the two characters under discussion, I am inclined to attribute the inaccuracy of the means to the slight amount of variation in these characters among European fish, which renders necessary a much larger number of data than those at my disposal. A sufficient increase in the number of observations for each region would render the means more truly representative, and ought to reveal the correlation that must be exhibited before the values can be regarded as reliable.

Indirectly this explanation indeed can be shown to be correct by amalgamating those groups which we have already seen upon other grounds to be closely related. The order is the same as in the preceding list.

	Finlets.		2nd Dorsal.
1. Newport, U.S.A.	5·120	...	11·850 (1)
2. Ireland, S. and W.	5·011	...	11·934 (2)
3. North Sea and Plymouth	5·009	...	11·946 (3)
4. Brest and Scilly	4·994	...	11·948 (4)

This table shows that when the local groups of fish are amalgamated in the manner described, the means for finlets and second dorsal fin are distributed in the order demanded by the correlation of the two characters.

This result is not obtainable by any other mode of amalgamation. Thus, if the Kerry and North Sea groups are merged together, on the ground of the close resemblance they exhibit in regard to the high mean number of finlets, the resulting mean for the finlets becomes 5·015, and that for the finrays 11·948. *Each of these values would be the highest in its series, and therefore hopelessly wrong from the point of view of correlation.*

Similarly, if the Plymouth and Kinsale groups are amalgamated, the resulting means would both be among the lowest in their respective series, instead of displaying the inverse relation of high and low values which is demanded for accuracy.

I conclude from these facts that the grouping which fulfils the correlation test is the correct one; and, as this grouping is identical with that demanded by the variation of all the other characters examined, it would appear to rest upon the firm basis of real genetic affinity and racial differences.

XIV. Summary of Evidence concerning the Races of the Mackerel.

§ 1. *American Mackerel.*

The American mackerel have been shown in this report to differ very considerably from all samples of European mackerel examined.

The difference is exhibited in regard to every character the variation of which has been determined, and in every respect the American fish hold an extreme position among my samples. Thus the highest average is yielded by the American sample in regard to the following characters: (1) the number of transverse bars, (2) the number of spotty fish, (3) the number of spots per hundred fish, and (4) the number of dorsal finlets; whilst the lowest average is yielded by it in regard to the number of finrays in (1) the first dorsal, and (2) the second dorsal fin.

There can be no doubt as to the significance of these facts. The American mackerel constitute a distinct variety or race, whose most obvious characteristic is its high degree of spottiness.

It must remain for American or Canadian naturalists to determine the question as to the existence of minor local differences among the American fish. During the meeting of the British Association at Toronto last year, I examined a dozen mackerel which had been caught in the Gulf of St. Lawrence; and, although this number is insufficient to determine the existence of minute racial differences, I may state that it was the examination of these fish which first revealed to me the marked spottiness of the mackerel of the western shores of the Atlantic. In this respect, therefore, I have no doubt of the close agreement between the mackerel of Canadian and American waters.

§ 2. *European Mackerel.*

A subdivision of the mackerel which frequent the British coasts into two principal races, an Irish race and a race frequenting the English Channel and North Sea, appears to be demanded by the following facts which have been elucidated by my researches :—

(1) The identity of the Plymouth and North Sea fish, and the close agreement between the Kinsale and Kerry fish in regard to the variation in number of the transverse bars, and the emphatic difference between the two former and the two latter groups in regard to the same character;

(2) The close agreement between the Plymouth and North Sea fish in regard to the frequency of intermediate spots among the bars, and the emphatic difference between either of these groups and the Kerry fish in regard to the same character;

(3) The correlation of a relatively low average number of first dorsal finrays with a relatively high degree of spottiness in North Sea and Channel fish, and the correlation of the highest observed average number of finrays with the lowest observed degree of spottiness in the Irish fish. These correlated differences could not be expected to occur except in races of fish which had diverged to a different degree from the primitive condition;

(4) The correlated nature of the differences between the same two groups in regard to the number of second dorsal finrays and dorsal finlets.

The discrimination of these races has been made exclusively on the ground of structural differences and resemblances between the fish coming from a number of chosen localities. If the differences revealed by the present investigation should appear to some to be too small to be significant, it should be remembered that large differences could not in any case be expected to occur between the mackerel of any two regions in British seas, partly because of the relative smallness of the total area and the possibility of free intercourse between its different waters, and partly because of the known activity and wandering tendencies of the adult mackerel, in addition to its production of freely floating eggs. If, on the other hand, the differences should be regarded by others as accidental, this idea may be negatived at once by the general conformity of the results obtained for different characters, and by the important fact that those local groups which are shown to resemble one another most closely are exactly those which might have been expected to do so from geographical considerations. If there are no valid differences between any of the British groups of mackerel, it is in the highest degree improbable, when the number of observations is taken into account, that the data accumulated for North Sea and Plymouth fish should coincide so closely as they do, and differ to so considerable an extent from the data determined for the fish from Kerry.

Nevertheless, although certain differences between the Irish fish and those from the Channel and North Sea must, I think, be conceded, it would be a serious error to conclude that the division between these two races of mackerel is hard and fast. I have shown that the Kinsale fish are distinctly intermediate in character between the fish from the west coast of Ireland and those of the Channel in regard to the following features:—(1) number of transverse bars, (2) spottiness, and (3) number of first dorsal finrays. I have also shown that the mackerel caught off Brest and Scilly, though closely related to the Channel fish as a whole, also betray a certain approximation towards the Irish, especially the Kinsale, values in regard to the same characters; and, although the number of fish representing this region is relatively small, I see no reason for doubting that the consensus of evidence on this point is of some significance. These two intermediate cases, therefore, prevent the establishment of any rigid line of separation between the Irish and the Channel races; but they at the same time confirm in a most emphatic manner the one paramount conclusion of the whole inquiry, viz., *that the mackerel which frequent British waters are not exactly alike in all localities, but possess certain average peculiarities which distinguish one local race from another. These peculiarities are greatest between the races of localities which are geographically remote, and least between those which occupy areas that are geographically contiguous. Between the mackerel of the North Sea and English Channel there are no differences at all; but the Irish race is distinctly divisible into two stocks, one of which is restricted to the west coast, the other to the south. A considerable amount of mixture takes place between the southern Irish stock and the fish which frequent the mouth of the English Channel. The western Irish stock represents more closely than any other race the primitive type of mackerel, from which all, whether British or American, have been derived.*

XV. The Migrations of the Mackerel.

The establishment of geographical or local races of the mackerel settles a number of disputed points concerning the migrations of this fish. The theory of long migrations must be altogether given up. The mackerel certainly does not cross the Atlantic; the marked difference between American and European samples shows that at the present period of the earth's history there is no mixture between the two races.

Moreover, in view of the difference between Irish and Channel fish, it can no longer be maintained that the mackerel of these regions wander far in winter from their summer haunts. Each race of fish must possess its own winter habitat, and this must be situated close to the region where the fish make their first appearance in the spring. Indeed, the only migrations which can, for the most part, be conceded, are migrations from shallow to deeper water off the same coasts. The one exception to this rule concerns the North Sea fish. The racial identity of these fish with those of the Channel proper furnishes a conclusive proof of the accuracy of the view that the North Sea fish are derived from the English Channel in the spring, and return to it in the autumn, thus ensuring a complete mixture between the two groups during the winter period. By North Sea fish, however, are meant merely the fish which are taken off the east coast of England from Yarmouth southwards. How far to the northwards the spring migration extends must be settled by further investigation.

The relation between the autumn and spring fish of any locality is also elucidated by the same results. No racial differences between autumn and spring fish have been revealed by my inquiries for any locality which has been represented by samples taken at both periods; and the existence of differences between the fish of different localities renders it practically certain that each locality is frequented by one race only, viz., the race peculiar to the locality. So far as the Irish fish are concerned, the minor racial differences established between the fish of Kinsale and Kerry prevent a special pronouncement upon this matter on the present occasion, since the Kerry fish were exclusively spring fish, and the Kinsale fish almost entirely autumn fish. The evidence, so far as it goes, points to the conclusion that on the Irish coast the small autumn mackerel are young fish which will to a large extent form part of the breeding shoals in the following spring.

This matter, however, is being further investigated, and the same material will furnish a means of testing the accuracy of the conclusions which have here been submitted concerning the characters of the local races.

In conclusion, I may draw attention to the relation of the local races to the conformation of the sea-bed, which appears to me to be of considerable importance in any attempt to delimit the area normally frequented by each race. If reference is made to a properly contoured chart—*e.g.*, the charts of the fishing grounds in Cunningham's *Marketable Fishes of the British Islands* (Macmillan, 1896)—it will be seen that the mouth of the English Channel coincides with the 50-fathom line, that the same line bounds a large plateau of ground off the south coast of Ireland, but that off the west coast of Ireland it runs close to the coast-line. A moderately deep gully of more than 50 fathoms depth separates English from Irish territory.

Accordingly our division of British mackerel into an Irish and a Channel race coincides with the geographical division of the sea-bed by the 50-fathom gully which runs up St. George's Channel.

On the other hand, the 100-fathom line approaches the coast only off the south-west coast of Ireland and separates a considerable plateau of ground off the west coast of Ireland from the great quadrangular plateau which lies to the south of Ireland, and the southern boundary of which coincides with the latitude of Ushant.

Deeper contour lines, up to 1000 fathoms, leave the boundary of the southern plateau practically unaffected, but considerably increase the area of that off the west coast of Ireland, which at 200 fathoms includes the Porcupine Bank, a distance of 250 miles from the mainland. On the other hand, the study of deeper contour lines renders still more evident the geographical distinctness of the two plateaux, which are connected merely by a narrow shelf off the south-west coast of Kerry, 50 miles wide at 100 fathoms, and only 120 miles wide at 1000 fathoms. Thus the separation of the Irish race into a west coast and south coast stock coincides with the division of the Irish submarine plateau into a western and a southern portion by the deep 1000-fathom rift which has been described. As these banks probably form the winter quarters of the mackerel of the adjoining coasts, we can understand how the segregation of the Irish stocks has been induced, and how a certain amount of mixture between the Kinsale stock and the Channel race has taken place. The southern Irish stock is more closely related to the western Irish stock than to the Channel race on account of its proximity to the former during the breeding season. But it approaches the Channel race in character because it shares the same submarine plateau for its winter quarters; and, although this area is too large to bring about complete mixture of the two races, it is not large enough to prevent a certain amount of mixture from taking place. The annual amount probably depends upon the severity of the winter season, which determines the extent and depth to which the fish retire from the shore.

TABLE A. *Size of Fish (inches).*

Place.	Date.	No.	10	¼	½	¾	11	¼	½	¾	12	¼	½	¾	13	¼	½	¾	14	¼	½	¾	15	¼	½	¾	16	¼	½	¾	17	Most frequent size (ins.).
Newport	Oct. 18, 1897	100	—	—	—	—	—	—	—	2	10	16	15	12	9	11	10	3	4	2	3	1	0	1	0	0	0	0	1	—	—	12
Lowestoft	,, 7 ,,	100	—	—	—	—	—	—	1	0	3	1	3	7	13	14	19	11	9	9	8	1	1	—	—	—	—	—	—	—	—	13
,,	,, 12 ,,	50	—	—	—	—	—	—	—	1	3	6	5	2	15	12	4	1	1	—	—	—	—	—	—	—	—	—	—	—	—	13
,,	June 28, 1898	50	—	—	—	—	—	1	3	2	6	6	6	7	6	5	1	1	2	1	0	0	1	0	1	1	—	—	—	—	—	12
,,	July 12 ,,	100	—	—	—	—	—	—	—	—	7	7	7	8	9	9	11	13	9	11	4	5	—	—	—	—	—	—	—	—	—	13
,,	*(sum.)*	*300*	—	—	—	—	—	*1*	*4*	*3*	*19*	*20*	*21*	*24*	43	*40*	*35*	*26*	*21*	*21*	*12*	*6*	*2*	*0*	*1*	*1*	—	—	—	—	—	*13*
Ramsgate	Oct. 27, 1897	100	—	—	—	—	—	—	1	3	1	6	5	11	10	10	15	5	7	9	6	3	1	1	3	0	0	1	0	0	2	13
Plymouth	July to Oct., '97	76	—	—	4	9	6	7	10	10	8	6	1	1	1	3	3	0	2	3	0	0	0	0	1	1	—	—	—	—	—	11
,,	Nov. 16–20 ,,	100	—	—	—	—	—	—	—	2	15	12	14	12	12	12	5	7	4	1	1	0	0	2	0	1	—	—	—	—	—	12
,,	July 6, 1898	100	—	—	—	—	—	12	15	12	11	12	7	7	4	7	5	3	3	1	0	0	0	0	1	—	—	—	—	—	—	12
,,	,, 11 ,,	24	—	2	0	1	3	5	4	2	3	2	0	1	0	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11
,,	*(sum.)*	*300*	—	*2*	*4*	*10*	*9*	*24*	*29*	*26*	37	*32*	*22*	*21*	*17*	*23*	*13*	*10*	*9*	*5*	*1*	*0*	*0*	*2*	*2*	*2*	—	—	—	—	—	*12*
Scilly	May 8, 1898	12	—	—	—	—	—	—	—	—	1	2	0	4	1	1	0	3	—	—	—	—	—	—	—	—	—	—	—	—	—	12
,,	June 2 ,,	12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2	0	1	1	2	1	1	2	1	—	—	—	15
,,	,, 9 ,,	50	—	—	—	—	1	2	1	0	8	4	2	3	7	5	1	2	5	3	2	2	1	0	0	0	0	0	0	0	1	12–13
,,	*(sum.)*	*74*	—	—	—	—	*1*	*2*	*1*	*0*	9	6	*2*	7	*8*	*6*	*11*	5	*6*	*5*	*2*	*3*	*2*	*2*	*1*	*1*	*2*	*1*	*0*	*0*	*1*	*12–13*
Brest	June 20, 1898	100	—	—	—	—	—	—	—	1	0	0	1	1	3	9	14	10	12	13	12	5	4	4	5	1	1	1	1	1	1	14
Kinsale	July 30, 1897	119	—	—	1	1	3	12	27	35	23	8	5	1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	11
,,	Sept. 3 ,,	99	—	—	—	—	—	—	2	8	29	27	13	11	5	1	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	12
,,	,, 17 ,,	92	—	—	—	—	—	—	—	4	17	27	23	11	5	3	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	12
,,	July 1, 1898	100	—	—	—	—	1	1	1	2	3	9	10	9	7	17	9	6	12	5	1	3	3	0	1	—	—	—	—	—	—	13
,,	*(sum.)*	*410*	—	—	*1*	*1*	*4*	*13*	*30*	*49*	*72*	*71*	*51*	*32*	*20*	*21*	*12*	*8*	*12*	*5*	*1*	*3*	*3*	*0*	*1*	—	—	—	—	—	—	*12*
{ Smerwick	March 12, 1898	99	—	—	—	—	—	—	—	—	—	—	1	16	10	19	9	8	10	7	4	4	4	4	2	0	1	—	—	—	—	13
} Brandon	April 16 ,,	45	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	1	5	2	2	5	4	10	6	1	5	1	1	15
,,	,, 23 ,,	101	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	9	9	18	11	12	10	13	4	6	3	3	1	—	14
Co. Kerry	*(sum.)*	*245*	—	—	—	—	—	—	—	—	—	—	*1*	*16*	*10*	*19*	*10*	*10*	*20*	*17*	27	*17*	*18*	*19*	*19*	*14*	*13*	*4*	*8*	*2*	*1*	*14*
Irish, Autumn	*1897*	*310*	—	—	*1*	*1*	*3*	*12*	*29*	*47*	69	*62*	*41*	*23*	*13*	*4*	*3*	*2*	—	—	—	—	—	—	—	—	—	—	—	—	—	*12*
,, *Spring*	*1898*	*345*	—	—	—	—	*1*	*1*	*1*	*2*	*3*	*9*	*11*	*25*	*17*	36	*19*	*16*	*32*	*22*	*28*	*20*	*21*	*19*	*20*	*14*	*13*	*4*	*8*	*2*	*1*	*14*

TABLE B. *Transverse Bars—Entire series.*

Place.	Date.	Most frequent size (ins.).	Number of Fish.	Number of Bars. 23	24	25	26	27	28	29	30	31	32	33	Mean.
Newport, U.S.A.	Oct. 18, 1897 .	12	100	—	2	4	13	37	28	11	5	—	—	—	27·38
Lowestoft	,, 7 ,, .	13	100	—	2	5	30	36	20	5	2	—	—	—	26·90
,, ...	,, 12 ,, .	13	50	—	1	4	11	21	8	4	1	—	—	—	26·94
,, ...	June 28, 1898 .	12	50	—	—	7	17	20	6	—	—	—	—	—	26·50
,, ...	July 12 ,, .	13	100	1	2	7	36	37	12	5	—	—	—	—	26·62
,, ...	(*sum.*) .	*13*	*300*	*1*	*5*	*23*	*94*	114	*46*	*14*	*3*	—	—	—	*26·75*
Ramsgate	Oct. 27, 1897 .	13	100	—	—	7	22	52	15	3	1	—	—	—	26·88
Plymouth	July to Oct.,'97.	11	76	—	—	10	20	28	14	4	—	—	—	—	26·76
,, ...	Nov. 16-20 ,,.	12	100	—	—	4	35	47	11	3	—	—	—	—	26·74
,, ...	July 6, 1898 .	12	100	1	2	4	28	42	16	4	1	1	0	1	26·91
,, ...	,, 11 ,, .	11	24	1	0	2	7	10	3	0	1	—	—	—	——
,, ...	(*sum.*) .	*12*	*300*	*2*	*2*	*20*	*90*	127	*44*	*11*	*2*	*1*	*0*	*1*	*26·79*
Scilly	May 8, 1898 .	12	12	1	0	0	2	6	2	1	—	—	—	—	——
,, ...	June 2 ,, .	15	12	—	—	—	3	7	1	1	—	—	—	—	——
,, ...	,, 9 ,, .	12–13	50	—	1	2	19	18	7	1	2	—	—	—	26·78
,, ...	(*sum.*) .	*12–13*	*74*	*1*	*1*	*2*	*24*	31	*10*	*3*	*2*	—	—	—	*26·82*
Brest	June 20, 1898 .	14	100	—	—	5	32	40	19	4	—	—	—	—	26·85
Kinsale	July 30, 1897 .	11	119	—	—	6	18	52	34	6	3	—	—	—	27·21
,, ...	Sept. 3 ,, .	12	99	—	1	5	22	30	24	13	3	1	—	—	27·28
,, ...	,, 17 ,, .	12	92	1	1	2	17	40	21	7	2	0	1	—	27·19
,, ...	July 1, 1898 .	13	100	—	—	5	36	34	16	7	2	—	—	—	26·90
,, ...	(*sum.*) .	*12*	*410*	*1*	*2*	*18*	*93*	156	*95*	*33*	*10*	*1*	*1*	—	*27·15*
{ Smerwick	March 12, 1898.	13	99	1	1	1	19	36	26	11	4	—	—	—	27·32
{ Brandon	April 16 ,, .	15	45	—	—	1	6	14	17	5	2	—	—	—	27·56
,, ...	,, 23 ,, .	14	101	—	—	3	25	44	20	6	3	—	—	—	27·10
Co. Kerry	(*sum.*) .	*14*	*245*	*1*	*1*	*5*	*50*	94	*63*	*22*	*9*	—	—	—	*27.27*
PERCENTAGES				23	24	25	26	27	28	29	30	31	32	33	
Newport, U.S.A.	Oct., 1897 .	12	100	—	2	4	13	37	28	11	5	—	—	—	27·38
Lowestoft	1897 and 1898 .	13	300	$\frac{1}{3}$	$1\frac{2}{3}$	8	31	38	15	5	1	—	—	—	26·75
Ramsgate	Oct., 1897 .	13	100	—	—	7	22	52	15	3	1	—	—	—	26·88
Plymouth	1897 and 1898 .	12	300	$\frac{1}{3}$	1	7	30	42	14	4	1	$\frac{1}{3}$	0	$\frac{1}{3}$	26·79
Scilly	1898 . .	12–13	74	1	1	3	32	42	14	4	3	—	—	—	26·82
Brest	June, 1898 .	14	100	—	—	5	32	40	19	4	—	—	—	—	26·85
Irish : Kinsale ...	1897 and 1898 .	12	410	$\frac{1}{4}$	$\frac{1}{2}$	4	23	38	23	8	3	$\frac{1}{4}$	$\frac{1}{4}$	—	27·15
,, Kerry ...	Spring, 1898 .	14	245	$\frac{1}{2}$	$\frac{1}{2}$	2	21	38	25	9	4	—	—	—	27·27
,, Autumn..	1897 . .	12	310	$\frac{1}{3}$	1	4	18	39	26	8	3	$\frac{1}{3}$	$\frac{1}{3}$	—	27·23
,, Spring ...	1898 . .	14	345	$\frac{1}{2}$	$\frac{1}{2}$	3	25	37	23	8	3	—	—	—	27·17
North Sea and Eng. Channel..	1897 and 1898 .	13	700	$\frac{3}{7}$	1	7	29	42	15	4	1	$\frac{1}{7}$	—	$\frac{1}{7}$	26·79
Brest and Scilly .	1898 . .	13–14	174	$\frac{1}{2}$	$\frac{1}{2}$	4	32	41	17	4	1	—	—	—	26·84
Irish, S. and W.	1897 and 1898 .	12–13	655	$\frac{1}{3}$	$\frac{1}{2}$	4	22	38	24	8	3	$\frac{1}{6}$	$\frac{1}{6}$	—	27·20
Total, except Newport...	1897 and 1898 .	13	1529	$\frac{1}{3}$	$\frac{1}{2}$	5	27	41	19	5	2	$\frac{1}{6}$	$\frac{1}{10}$	$\frac{1}{10}$	26·97

TABLE C. *Transverse Bars which cross or touch the Lateral Line.*

Place.	Date.	Most frequent size (ins.).	Number of Fish.	Number of Bars. 12	13	14	15	16	17	18	19	20	21	22	23	24	25	Mean.
Newport, U.S.A.	Oct. 18, 1897	12	100	–	–	–	1	6	10	25	28	14	9	5	2	–	–	18·88
Lowestoft	,, 7 ,,	13	100	–	–	1	2	7	18	36	20	11	4	1	–	–	–	18·16
,,	,, 12 ,,	13	50	–	–	–	2	1	9	12	11	10	5	–	–	–	–	18·58
,,	June 28, 1898	12	50	–	–	–	—	1	10	18	12	7	2	–	–	–	–	18·40
,,	July 12 ,,	13	100	1	0	0	6	8	17	28	25	11	2	2	–	–	–	18·04
,,	(*sum.*)	*13*	*300*	*1*	*0*	*1*	*10*	*17*	*54*	94	*68*	*39*	*13*	*3*	–	–	–	*18·23*
Ramsgate	Oct. 27, 1897	13	100	–	–	–	1	6	16	31	27	13	4	1	1	–	–	18·43
Plymouth	July to Oct., '97	11	76	–	–	1	3	7	17	19	15	12	1	1	–	–	–	18·03
,,	Nov. 16–20 ,,	12	100	–	–	–	—	11	18	33	21	13	3	1	–	–	–	18·20
,,	July 6, 1898	12	100	–	–	–	3	7	13	26	36	10	2	2	0	1	–	18·40
,,	,, 11 ,,	11	24	–	–	–	1	3	4	7	6	1	1	1	–	–	–	——
,,	(*sum.*)	*12*	*300*	–	–	*1*	*7*	*28*	*52*	85	*78*	*36*	*7*	*5*	*0*	*1*	–	*18·21*
Scilly	May 8, 1898	12	12	–	–	–	1	0	0	5	4	2	—	–	–	–	–	——
,,	June 2 ,,	15	12	–	–	–	—	—	4	0	5	1	1	1	–	–	–	——
,,	,, 9 ,,	12–13	50	–	–	–	—	2	8	12	16	8	4	–	–	–	–	18·64
,,	(*sum.*)	*12–13*	*74*	–	–	–	*1*	*2*	*12*	*17*	25	*11*	*5*	*1*	–	–	–	*18·63*
Brest	June 20, 1898	14	100	–	–	1	0	6	9	29	30	18	5	1	1	–	–	18·65
Kinsale	July 30, 1897	11	119	–	–	–	1	7	16	31	36	17	9	1	0	1	–	18·62
,,	Sept. 3 ,,	12	99	–	–	1	3	7	15	32	28	7	5	1	–	–	–	18·19
,,	,, 17 ,,	12	92	–	–	–	—	9	15	23	19	17	6	1	1	1	–	18·58
,,	July 1, 1898	13	100	1	1	1	1	3	16	26	31	15	3	1	0	0	1	18·41
,,	(*sum.*)	*12*	*410*	*1*	*1*	*2*	*5*	*26*	*62*	*112*	114	*56*	*23*	*4*	*1*	*2*	*1*	*18·45*
Smerwick	Mar. 12, 1898	13	99	–	–	1	2	4	15	24	29	13	9	1	1	–	–	18·58
Brandon	Apl. 16 ,,	15	45	–	–	–	3	2	7	14	9	5	3	1	1	–	–	18·38
,,	,, 23 ,,	14	101	–	–	1	4	8	14	35	21	14	4	–	–	–	–	18·15
Co. Kerry	(*sum.*)	*14*	*245*	–	–	*2*	*9*	*14*	*36*	73	*59*	*32*	*16*	*2*	*2*	–	–	*18·37*
PERCENTAGES				12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Newport, U.S.A.	Oct., 1897	12	100	–	–	–	1	6	10	25	28	14	9	5	2	–	–	18·88
Lowestoft	1897 and 1898	13	300	$\frac{1}{3}$	0	$\frac{1}{3}$	$3\frac{1}{3}$	6	18	31	23	13	4	1	–	–	–	18·23
Ramsgate	Oct., 1897	13	100	–	–	–	1	6	16	31	27	13	4	1	1	–	–	18·43
Plymouth	1897 and 1898	12	300	–	–	$\frac{1}{3}$	3	9	17	28	26	12	$2\frac{1}{3}$	2	0	$\frac{1}{3}$	–	18·21
Scilly	1898	12–13	74	–	–	–	1	3	16	23	34	15	7	1	–	–	–	18·63
Brest	June, 1898	14	100	–	–	1	0	6	9	29	30	18	5	1	1	–	–	18·65
Irish: Kinsale	1897 and 1898	12	410	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{2}$	1	6	15	27	28	14	6	1	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{4}$	18·45
,, Kerry	Spring, 1898	14	245	–	–	$\frac{2}{3}$	4	6	15	30	24	13	6	$\frac{2}{3}$	$\frac{2}{3}$	–	–	18·37
,, Autumn	1897	12	310	–	–	$\frac{1}{2}$	1	7	15	28	27	13	6	1	$\frac{1}{2}$	1	–	18·47
,, Spring	1898	14	345	$\frac{1}{3}$	$\frac{1}{3}$	1	3	5	15	29	26	13	5	1	1	0	$\frac{1}{3}$	18·38
North Sea and Eng. Channel	1897 and 1898	13	700	$\frac{1}{7}$	0	$\frac{2}{7}$	3	7	17	30	25	13	3	$1\frac{2}{7}$	$\frac{1}{7}$	$\frac{1}{7}$	–	18·25
Brest and Scilly	1898	13–14	174	–	–	$\frac{2}{3}$	$\frac{2}{3}$	4	12	26	32	17	6	1	$\frac{2}{3}$	–	–	18·64
Irish, S. and W.	1897 and 1898	12–13	655	$\frac{1}{7}$	$\frac{1}{7}$	$\frac{1}{2}$	2	6	15	28	26	14	6	1	$\frac{1}{2}$	$\frac{2}{7}$	$\frac{1}{7}$	18·42
Total, except Newport	1897 and 1898	13	1529	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{1}{2}$	2	7	16	29	26	14	5	1	$\frac{1}{3}$	$\frac{1}{5}$	$\frac{1}{10}$	18·37

Table D. *Dorso-lateral Intermediate Spots.*

Place.	Date.	No. of Fish.	Number of Spots per Fish. 0	1	2	3	4	5	6	7	8	9	10	11	17	No. of Spotty Fish. Observed	%	Total No. of Spots. Observed	%
Newport, U.S.A.	Oct. 18, 1897 ...	100	34	23	13	9	5	6	1	5	0	0	2	1	1	66	66	215	215
Lowestoft	,, 7 ,, ...	100	81	12	4	1	1	1	–	–	–	–	–	–	–	19	19	32	32
,, ...	,, 12 ,, ...	50	37	11	0	2	–	–	–	–	–	–	–	–	–	13	26	17	34
,, ...	June 28, 1898 ...	50	44	4	2	–	–	–	–	–	–	–	–	–	–	6	12	8	16
,, ...	July 12 ,, ...	100	83	12	3	2	–	–	–	–	–	–	–	–	–	17	17	24	24
,, ...	*(sum.)* ...	*300*	*245*	*39*	*9*	*5*	*1*	*1*	–	–	–	–	–	–	–	*55*	*18*	*81*	*27*
Ramsgate	Oct. 27, 1897 ...	100	72	17	3	3	2	2	0	1	–	–	–	–	–	28	28	57	57
Plymouth	Sept. to Nov., '97	76	54	12	7	2	1	–	–	–	–	–	–	–	–	22	29	36	47
,, ...	Nov. 16–20, 1897	100	75	11	7	2	2	2	0	0	1	–	–	–	–	25	25	57	57
,, ...	July 6, 1898 ...	100	88	9	0	0	1	1	0	1	–	–	–	–	–	12	12	25	25
,, ...	,, 11 ,, ...	24	22	1	1	–	–	–	–	–	–	–	–	–	–	2	—	3	—
,, ...	*(sum.)* ...	*300*	*239*	*33*	*15*	*4*	*4*	*3*	*0*	*1*	*1*	–	–	–	–	*61*	*20*	*121*	*40*
Scilly	May 8, 1898 ...	12	10	0	1	0	1	–	–	–	–	–	–	–	–	2	—	6	—
,, ...	June 2 ,, ...	12	10	2	–	–	–	–	–	–	–	–	–	–	–	2	—	2	—
,, ...	,, 9 ,, ...	50	41	5	3	0	0	1	–	–	–	–	–	–	–	9	18	16	32
,, ...	*(sum.)* ...	*74*	*61*	*7*	*4*	*0*	*1*	*1*	–	–	–	–	–	–	–	*13*	*18*	*24*	*32*
Brest	June 20, 1898 ...	100	74	20	6	–	–	–	–	–	–	–	–	–	–	26	26	32	32
Kinsale	July 30, 1897 ...	119	98	17	3	1	–	–	–	–	–	–	–	–	–	21	18	26	22
,, ...	Sept. 17 ,, ...	92	71	14	4	2	0	0	0	0	0	1	–	–	–	21	23	37	40
,, ...	July 1, 1898 ...	100	84	10	3	2	0	1	–	–	–	–	–	–	–	16	16	27	27
,, ...	*(sum.)* ...	*311*	*253*	*41*	*10*	*5*	*0*	*1*	*0*	*0*	*0*	*1*	–	–	–	*58*	*19*	*90*	*29*
{ Smerwick ...	Mar. 12, 1898 ...	99	92	6	1	–	–	–	–	–	–	–	–	–	–	7	7	8	8
{ Brandon ...	Apl. 16 ,, ...	45	35	7	1	0	1	0	1	–	–	–	–	–	–	10	22	19	42
,, ...	,, 23 ,, ...	101	93	6	2	–	–	–	–	–	–	–	–	–	–	8	8	10	10
Co. Kerry	*(sum.)* ...	*245*	*220*	*19*	*4*	*0*	*1*	*0*	*1*	–	–	–	–	–	–	*25*	*10*	*37*	*15*
Percentages			0	1	2	3	4	5	6	7	8	9	10	11	17				
Newport, U.S.A.	Oct., 1897 ...	100	34	23	13	9	5	6	1	5	0	0	2	1	1	—	66	—	215
Lowestoft	1897 and 1898 ...	300	82	13	3	1⅓	⅓	⅓	–	–	–	–	–	–	–	—	18	—	27
Ramsgate	Oct., 1897 ...	100	72	17	3	3	2	2	0	1	–	–	–	–	–	—	28	—	57
Plymouth	1897 and 1898 ...	300	80	11	5	1⅓	1	1	0	⅓	⅓	–	–	–	–	—	20	—	40
Scilly	1898 ...	74	82	10	5½	0	1½	1	–	–	–	–	–	–	–	—	18	—	32
Brest	June, 1898 ...	100	74	20	6	–	–	–	–	–	–	–	–	–	–	—	26	—	32
Irish: Kinsale...	1897 and 1898 ...	311	81	13	3	2	0	⅓	0	0	0	⅓	–	–	–	—	19	—	29
,, Kerry ...	Spring, 1898 ...	245	90	8	1½	0	½	0	½	–	–	–	–	–	–	—	10	—	15
,, Autumn .	1897 ...	211	80	15	3	1½	0	0	0	0	0	½	–	–	–	—	20	—	30
,, Spring ...	1898 ...	345	88	8	2	1	⅓	⅓	⅓	–	–	–	–	–	–	—	12	—	19

TABLE E. *First Dorsal Fin and Proportion of Sexes.*

Place.	Date.	Most frequent size (ins.).	Number of Fish.	Sex. ♂	Sex. ♀	9	10	11	12	13	14	15	16	Mean.
Newport, U.S.A..	Oct. 18, 1897 ...	12	100	55	45	–	1	24	51	20	4	–	–	12·02
Lowestoft	,, 7 ,, ...	13	100	—	—	–	2	24	47	21	6	–	–	12·05
,, ...	,, 12 ,, ...	13	50	15 :	10 (?)	–	2	13	23	12	–	–	–	11·90
,, ...	June 28, 1898 ...	12	50	21	29	–	–	11	20	16	3	–	–	12·22
,, ...	July 12 ,, ...	13	100	39	61	–	1	15	49	30	5	–	–	12·23
,, ...	(*sum.*) ...	13	*300*	*75* :	*100* (?)	–	*5*	*63*	*139*	*79*	*14*	–	–	*12·11*
Ramsgate	Oct. 27, 1897 ...	13	100	55	45	–	4	22	44	26	4	–	–	12·04
Plymouth	July to Oct., '97.	11	76	—	—	–	1	15	40	17	3	–	–	12·08
,, ...	Nov. 16–20 ,, .	12	100	41	59	–	4	14	51	26	4	1	–	12·15
,, ...	July 6, 1898 ...	12	100	42	58	–	3	18	45	21	12	1	–	12·24
,, ...	,, 11 ,, ...	11	24	10	14	–	–	2	14	6	1	1	–	——
,, ...	(*sum.*) ...	12	*300*	*93* :	*131* (?)	–	*8*	*49*	*150*	*70*	*20*	*3*	–	*12·18*
Scilly	May 8, 1898 ...	12	12	6	6	–	–	1	5	6	–	–	–	——
,, ...	June 2 ,, ...	15	12	3	9	–	–	1	5	3	3	–	–	——
,, ...	,, 9 ,, ...	12–13	50	21	29	–	1	8	15	20	4	2	–	12·48
,, ...	(*sum.*) ...	12–13	*74*	*30*	*44*	–	*1*	*10*	*25*	*29*	*7*	*2*	–	*12·50*
Brest	June 20, 1898 ...	14	100	—	—	–	3	22	50	22	3	–	–	12·00
Kinsale	July 30, 1897 ...	11	119	—	—	–	3	28	67	19	2	–	–	11·91
,, ...	Sept. 3 ,, ...	12	99	—	—	1	5	34	43	14	2	–	–	11·65
,, ...	,, 17 ,, ...	12	92	—	—	1	0	18	51	22	–	–	–	12·01
,, ...	July 1, 1898 ...	13	100	44	56	–	1	20	50	23	6	–	–	12·13
,, ...	(*sum.*) ...	12	*410*	—	—	*2*	*9*	*100*	*211*	*78*	*10*	–	–	*11·94*
{ Smerwick	Mar. 12, 1898 ...	13	99	63	36	–	4	18	37	33	7	–	–	12·21
{ Brandon	Apl. 16 ,, ...	15	45	20	25	–	1	19	14	9	1	1	–	11·84
,, ...	,, 23 ,, ...	14	101	43	58	–	2	18	48	31	1	0	1	12·15
Co. Kerry	(*sum.*)	14	*245*	*126*	*119*	–	*7*	*55*	*99*	*73*	*9*	*1*	*1*	*12·12*
PERCENTAGES						**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	
Newport, U.S.A..	Oct. 18, 1897 ...	12	100	55	45	–	1	24	51	20	4	–	–	12·02
Lowestoft	1897 and 1898...	13	300	43 :	57 (?)	–	2	21	46	26	5	–	–	12·11
Ramsgate	Oct., 1897 ...	13	100	55	45	–	4	22	44	26	4	–	–	12·04
Plymouth	1897 and 1898...	12	300	42 :	58 (?)	–	3	16	50	23	7	1	–	12·18
Scilly	1898 ...	12–13	74	41 :	59	–	1	14	34	39	9	3	–	12·50
Brest	June, 1898 ...	14	100	?		–	3	22	50	22	3	–	–	12·00
Kinsale	1897 and 1898...	12	410	44 :	56 (?)	½	2	24	52	19	2½	–	–	11·94
Kerry	Spring, 1898 ...	14	245	51 :	49	–	3	22⅓	40	30	4	⅓	⅓	12·12
Irish: Autumn ...	1897 ...	12	310	?		1	2	26	52	18	1	–	–	11·87
,, Spring	1898 ...	14	345	49 :	51	–	2	22	43	28	4	½	½	12·12

Table F. *First Dorsal Fin.*

Distribution of Finray Numbers according to Sex and Size.

Place.	Size (ins.).	MALES. ♂								FEMALES. ♀								
		Number of fish.	Number of Finrays. 10	11	12	13	14	15	Mean.	Number of fish.	Number of Finrays. 10	11	12	13	14	15	16	Mean.
Ireland, S. and W.	11+	2	–	–	–	1	1	–	13·50	3	–	–	3	–	–	–	–	12·00
viz., Kinsale, 100	12+	25	–	5	9	8	3	–	12·24	23	2	3	6	9	3	–	–	12·35
Smerwick, 99	13+	52	–	8	23	19	2	–	12·29	36	–	7	14	12	3	–	–	12·31
Brandon, 146	14+	55	1	13	25	15	1	–	12·04	47	1	9	29	6	1	0	1	12 02
	15+	30	1	10	10	9	–	–	11·90	44	2	12	18	12	–	–	–	11·91
Total 345	16+	6	–	2	2	2	–	–	12·00	21	1	5	10	3	1	1	–	12·05
	17+	—	–	–	–	–	–	–	—	1	–	1	–	–	–	–	–	11·00
	Total	170	2	38	69	54	7	–	12·15	175	6	37	80	42	8	1	1	12·09
English Channel	10+	1	–	–	–	1	–	–	13·00	2	–	–	–	2	–	–	–	13·00
and North Sea.	11+	31	2	7	17	4	1	–	11·84	34	1	6	15	7	4	1	–	12·29
viz., Plymouth, 224	12+	79	–	14	31	28	5	1	12·34	104	–	18	50	24	11	1	–	12·30
Ramsgate, 100	13+	79	2	15	37	21	4	–	12·13	86	2	18	42	22	2	–	–	12·05
Lowestoft, 175	14+	26	1	2	16	6	1	–	12·15	42	3	8	19	11	1	–	–	11·98
	15+	6	–	2	3	1	–	–	11·83	6	1	0	2	3	–	–	–	12·17
Total 499	16+	—	–	–	–	–	–	–	—	1	1	–	–	–	–	–	–	10·00
	17+	1	–	–	–	1	–	–	13·00	1	–	–	–	1	–	–	–	13·00
	Total	223	5	40	104	62	11	1	12·17	276	8	50	128	70	18	2	–	12 17
PERCENTAGES.	...	♂	10	11	12	13	14	15	...	♀	10	11	12	13	14	15	16	...
Ireland, S. and W.	11+	2	–	–	–	50	50	–	13·50	3	–	–	100	–	–	–	–	12·00
	12+	25	–	20	36	32	12	–	12 24	23	9	13	26	39	13	–	–	12·35
	13+	52	–	15	44	37	4	–	12·29	36	–	20	39	33	8	–	–	12·31
	14+	55	2	24	45	27	2	–	12·04	47	2	19	62	13	2	0	2	12 02
	15+	30	3	33	34	30	–	–	11·90	44	5	27	41	27	–	–	–	11·91
	16+	6	–	33	34	33	–	–	12 00	21	5	24	48	14	5	4	–	12·05
	17+	—	–	–	–	–	–	–	—	1	–	100	–	–	–	–	–	11·00
	Total	170	1	22	41	32	4	–	12·15	175	3	21	46	24	5	½	½	12·09
English Channel	10+	1	–	–	–	100	–	–	13·00	2	–	–	–	100	–	–	–	13·00
and North Sea.	11+	31	6	23	55	13	3	–	11·84	34	3	18	44	21	12	2	–	12·29
	12+	79	–	18	39	36	6	1	12 34	104	–	17	48	23	11	1	–	12·30
	13+	79	2	19	47	27	5	–	12·13	86	2	21	49	26	2	–	–	12 05
	14+	26	4	8	61	23	4	–	12·15	42	7	19	45	26	3	–	–	11·98
	15+	6	–	33	50	17	–	–	11·83	6	17	0	33	50	–	–	–	12·17
	16+	—	–	–	–	–	–	–	—	1	100	–	–	–	–	–	–	10·00
	17+	1	–	–	–	100	–	–	13·00	1	–	–	–	100	–	–	–	13·00
	Total	223	2	18	47	28	5	(½)	12·17	276	3	18	46	25	7	1	–	12·17

TABLE G. *Second Dorsal Fin.*

Place.	No. of Fish.	NUMBER OF FINRAYS.														Mean.
		Frequency observed.							Frequency per cent.							
		9	10	11	12	13	14	15	9	10	11	12	13	14	15	
Newport, U.S.A. . . .	100	2	3	18	63	13	1	–	2	3	18	63	13	1	–	11·850
North Sea	400	–	3	37	337	23	–	–	–	1	9	84	6	–	–	11·950
Plymouth	300	–	–	37	244	19	–	–	–	–	12	82	6	–	–	11·940
Brest and Scilly . . .	174	1	2	15	143	13	–	–	½	1	9	82	7½	–	–	11·948
Kinsale	410	–	3	41	350	15	1	–	–	¾	10	85¼	3¾	¼	–	11·927
Kerry	245	*1	3	20	209	10	1	1	½	1¼	8	85¼	4	½	½	11·943
North Sea and English Channel	700	–	3	74	581	42	–	–	–	½	10½	83	6	–	–	11·946
Brest and Scilly . . .	174	1	2	15	143	13	–	–	½	1	9	82	7½	–	–	11·948
Ireland, S. and W. . . .	655	*1	6	61	559	25	2	1	⅙	1	9⅓	85	4	⅓	⅙	11·933

* Doubtful, owing to mutilation of fin. The number of rays *may* have been 10.

TABLE H. *Dorsal Finlets.*

Place.	No. of Fish.	NUMBER OF FINLETS; INCIPIENT FINLETS AS ½.										Mean.
		Frequency observed.					Frequency per cent.					
		4	4½	5	5½	6	4	4½	5	5½	6	
Newport, U.S.A. . . .	100	–	2	79	12	7	–	2	79	12	7	5·190
North Sea	400	3	5	378	6	8	¾	1¼	94½	1½	2	5·014
Plymouth	300	7	3	*277	7	6	2⅓	1	92⅓	2⅓	2	5·003
Brest and Scilly . . .	174	3	4	162	2	3	2	2	93	1	2	4·994
Kinsale	410	1	9	387	8	5	¼	2	94½	2	1¼	5·009
Kerry	245	2	3	231	3	6	1	1¼	94	1¼	2½	5·016
North Sea and English Channel	700	10	8	655	13	14	1½	1	93½	2	2	5·009
Brest and Scilly . . .	174	3	4	162	2	3	2	2	93	1	2	4·994
Ireland, S. and W. . . .	655	3	12	618	11	11	½	2	94½	1½	1½	5·011

* One of these specimens actually possessed only 4 finlets, but the position of the 5th was so clearly indicated, that it was almost certainly lost by accident.

Report on Trawling in Bays on the South Coast of Devon.

SUBMITTED FOR THE INFORMATION OF THE DEVON SEA FISHERIES COMMITTEE.

By

Ernest W. L. Holt.

THE investigations dealt with in this memorandum were commenced in the autumn of 1895, and have been carried on, as opportunity permitted, until July of the present year. The observations were made in 1895 and 1896 by Mr. F. B. Stead, in 1897 by Mr. S. D. Scott and myself, and in 1898 by myself. A preliminary memorandum, dealing with the observations made in 1895, has already been submitted to the Committee by Mr. Stead. As a matter of general convenience it is reprinted as an appendix to this Report.

The area included in our enquiry consists of Start Bay, Torbay, and Teignmouth Bay. By a bye-law of the Fisheries Committee, confirmed June 27th, 1893, it was made illegal to use a fish-trawl in these bays, and I presume that the assistance of the Marine Biological Association was invited in order that the Committee might learn to what extent their prohibition of trawling may be justified by the biological conditions of the grounds concerned.

Before proceeding to review our results I must advert to the inadequacy of our records, which is due to the insufficiency of the means at our disposal. The grounds lie at a considerable distance from Plymouth, and in order to carry out our work we have been obliged either to hire a Brixham sailing trawler, or to take round the Laboratory steam-launch, which cannot often be spared from her regular duties. If we hired a trawler, we had to take our chance of the weather, with the probability of finding the wind either too strong or too light for satisfactory working. Moreover, although it was possible at a good deal of personal inconvenience to accurately record the catch, subsidiary observations of great practical importance, such as the examination of the reproductive organs and food of fish taken, of the pelagic ova present in the water, and of the nature of the general fauna inhabiting the grounds, were only carried out with the greatest difficulty on account of the lack of accommodation and apparatus. The Laboratory steam-launch is well equipped, but she is only a 57 ft. boat, and cannot venture round the Start except in fine weather. Once on the ground, a change of wind is very apt to imprison her in Dartmouth or some other harbour. I trust that the above considerations may be held to explain the delay in furnishing the present Report, and its incomplete condition.

In considering the records before me, I do not see that it is possible to proceed except upon the assumption that the various hauls made at the same season, though in some cases in different years, were made under practically identical conditions. I do not suppose that this is really the case, since absolute seasonal regularity is not a characteristic of any fishery with which I am acquainted; but I do not see any possibility of tabulating the possible effects of weather with anything like accuracy, whether from the particulars furnished in the records or from the publications of the Meteorological Office. In so far as the work of the *Busy Bee* is concerned, it is fair to assume that the weather was reasonably fine before and during her operations, as otherwise they would have been prevented; but this takes no account of the general weather of the season, nor can I claim to possess the local knowledge indispensable to a just appreciation of the probable effect on the fishery.

On the whole, while I should be very loath to deduce from our records any positive opinion as to the abundance of fish at particular seasons, I believe that they furnish a fairly exact idea of the proportions of large and small fish likely to be met with; and, as I apprehend, it is chiefly with the question of possible destruction of undersized fish that the Committee is concerned.

It is proposed, whenever sufficient material shall be available, to discuss the general question of the distribution of fish and their migrations in the whole south-western district. It is a question which cannot fail to have an important bearing on practical fishery matters, but I do not think it can be conveniently dealt with in isolated parts. I shall therefore omit from consideration in this memorandum all details of life, history, food, migration, &c., and confine myself to a brief recapitulation of such facts as appear to be of immediate importance.

All food-fishes taken were measured by Mr. Stead to the nearest quarter of an inch, with the exception of skates and rays. The latter were considered by Mr. Scott and myself to be of economic importance, and are therefore included in our records, together with all fish whatsoever, and, in fact, all organisms brought up by the trawl, while efforts were made by us to ascertain what other forms, too small to be retained in the meshes, were present on the grounds over which we worked. In the subjoined lists I have, for the sake of brevity, grouped all food-fishes recorded under inches. It will be understood that a fish of, say, 8 inches may have been either 8, $8\frac{1}{4}$, $8\frac{1}{2}$, or $8\frac{3}{4}$ inches in actual length, measured from the tip of the snout to the end of the tail. Rays are treated exceptionally, the dimension given being the width of the disc, since some part of the comparatively unimportant tail is often missing. Except in the case of plaice, fish of less than 8 inches are grouped together, since I believe that no one will contend that such small creatures can be the object of a legitimate fishery.

In considering the proportional numbers of fish of different sizes, I have grouped together as "unsaleable" all plaice and dabs of *less than 8 inches*, a proceeding which appears to be in accordance with local market custom. The Sea Fisheries Bill of 1898 sought to prevent the sale, &c., of plaice, dabs, and soles *not exceeding 8 inches*, which is a slightly higher standard.

For convenience I have placed the standard of sexual maturity for plaice at 12 inches, though my colleague, Mr. J. T. Cunningham, who investigated the matter in this district, found that the average size at which female plaice, the larger and more numerous sex, begin to breed is slightly above 12 inches. Dabs are small fish, which may be mature even before they are saleable, so that the economic and biological limits sufficiently correspond. Soles are mature at about 12 inches, and until they reach such a length are only "slips" in the eyes of the fish-buyer, and as such do not command a very exalted price. The other species which figure in our records are so far from numerous that it is hardly necessary to discuss the question of their maturity. When taken in any number it will be found that the majority were so small as to be economically worthless, whether mature or not.

In the case of plaice I have introduced a standard of a purely arbitrary nature. Considering that fish reaches, even on the southern and south-western coasts, a length of 25 inches, I do not think that my standard of 15 inches for "large" fish will be held to be ridiculously high.

In reviewing the evidence afforded by our records, it has been unnecessary for me to deal, except very briefly, with the biological conditions affecting the question of the protection of small fish. The matter has already been discussed at some length by Mr. Stead, whose conclusions are in essential agreement with those which I have repeatedly put forward on previous occasions.

START BAY.

LIST OF HAULS.

In the subjoined list the details of locality, &c., entered in the records of the various naturalists who have had charge of the observations have been greatly condensed. For practical purposes the bay appears to be divisible into two parts, the line of demarcation being from the Start to the southern edge of the Skerries bank, along the bank, and from its northern end, marked by the bell buoy, to Combe Point. The area within this line is for the most part a smooth stretch of fine sand, from 6 to 10 fathoms. South of Torcross are a number of outlying rocks, and towards the Skerries the sand gets coarse. Extending the area a little to the north-west, we include all that part of the bay which appears to be of much interest to trawlers. The usual professional haul was made, according to my information, either parallel to the sands or along the inner edge of the Skerries and to some distance along the south edge. The coarse sand and shelly ground alongside of the bank is presumably rich in crabs, since numbers of crab-pots are set there; and it may be well understood that the prosecution of trawling and crabbing on the same ground did not tend to peace and harmony.

Such of our hauls as are described as "off the sands" were made parallel to the shore, usually between Torcross and Rockvale, at distances sufficiently indicated by the soundings. The initials "T." and "B.B." indicate that the hauls so marked were made by the smack *Thistle*, of Brixham, and the Association's steam-yacht *Busy Bee* respectively. The former carries a trawl of 40 ft. beam, the latter one of 27 ft. beam. The difference in the size of the mesh of the two nets is insufficient to require special attention. Sailing trawlers are generally held to catch more soles than steam vessels. Otherwise, given equal speed and equal skill, I suppose there is not much difference in catching power. Everyone knows that trawling is usually more successful by night than by day, but night-work offers great inconvenience when the catch has to be examined and measured. I do not know to what extent the difference of light affects the size as apart from the number of fish caught. With one exception all our hauls were made in the day-time.

I.	T.	Off the Sands .	7 fath.	3 h. 30 m.	20 x. '95
II.	T.	Inside the Skerries	15 to 5 fath.	3 h. 55 m.	29 x. '95
III.	T.	" " .	14 to 8 fath.	3 h. 50 m. (night)	31 x. '95
IV.	T.	Off the Sands .	10 fath.	3 h. 50 m.	4 xii. '95
V.	T.	" " .	9 fath.		12 xii. '95

VI.	T.	Off the Sands .	8½ fath.	2 h. 20 m. (bad weather)	27 i. '96
VII.	T.	,, ,, .	9 fath.	6 h.	28 i. '96
VIII.	B.B.	,, ,, .	7 to 9 fath.	3 h. 55 m.	11 iii. '96
IX.	T.	,, ,, .	9 fath.		21 x. '96
X.	T.	,, ,, .	8 fath.	55 m.	23 iii. '97
XI.	T.	,, ,, .	8 fath.	2 h. 50 m.	24 iii. '97
XII.	T.	,, ,, .	8 fath.	1 h. 15 m.	24 iii. '97
XIII.	B.B.	,, ,, .	7 to 6 fath.	2 h. 15 m.	26 v. '97
XIV.	B.B.	,, ,, .	9 to 6 fath.	2 h. 20 m.	26 v. '97
XV.	B.B.	,, ,, .	8 to 10 fath.	3 h. 5 m.	27 v. '97
XVI.	B.B.	Outer part of bay, off Dartmouth	14 to 17 fath.	1 h. 20 m.	27 v. '97
XVII.	B.B.	Outer part of bay, off Dartmouth	18 to 24 fath.	2 h. 25 m.	28 v. '97
XVIII.	B.B.	Off the Sands .	9¾ fath.	1 h. 10 m.	3 vi. '97
XIX.	B.B.	,, ,, .	7½ fath.	1 h. 45 m.	25 vii. '98
XX.	B.B.	,, ,, .	10 fath.	2 h.	26 vii. '98
XXI.	B.B.	Outer part of bay, off Dartmouth	20 to 22 fath.	1 h. 35 m.	28 vii. '98

Table I.

List of Fish caught in Start Bay.

PLAICE.

No. of Haul—	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii	xiv.	xv.	xvi.	xvii.	xviii.	xix.	xx.	xxi.
4 in.	—	—	—	—	—	—	—	9	—	1	—	—	—	—	—	—	—	—	—	—	—
5 ,,	—	—	—	—	—	—	—	22	—	4	7	—	2	5	1	—	—	2	—	—	—
6 ,,	—	—	—	1	1	—	—	9	—	4	13	4	3	6	4	—	—	13	6	3	—
7 ,,	—	—	1	—	—	—	4	14	1	2	11	12	10	7	3	2	—	10	3	5	—
8 ,,	1	1	9	2	1	—	4	26	9	3	21	10	6	12	2	3	—	4	2	5	—
9 ,,	6	1	18	3	10	—	2	21	7	2	25	10	3	8	1	2	1	6	2	5	—
10 ,,	11	10	31	9	20	—	—	29	27	1	7	2	3	2	—	1	—	1	4	5	—
11 ,,	36	13	42	28	26	—	—	23	52	3	22	5	4	1	—	—	1	5	—	6	—
12 ,,	14	14	48	37	29	—	1	17	92	—	12	3	2	2	1	1	2	2	2	—	1
13 ,,	10	7	40	36	29	—	1	8	57	—	11	2	—	2	—	2	1	—	2	2	—
14 ,,	4	9	21	27	15	—	1	5	30	1	10	6	1	1	—	1	—	1	—	2	—
15 ,,	4	4	13	11	11	—	—	5	15	1	3	1	—	—	—	—	—	1	—	3	—
16 ,,	3	1	10	5	4	—	—	2	6	—	4	—	—	1	—	—	—	—	—	1	—
17 ,,	2	—	4	1	4	—	—	1	2	—	2	—	—	—	—	1	—	2	—	—	—
18 ,,	—	—	2	2	—	—	—	1	—	—	2	—	—	—	—	1	—	—	—	—	—
19 ,,	—	—	3	—	—	—	—	1	1	—	—	—	—	—	1	—	—	—	—	—	—
20 ,,	—	—	2	1	—	—	—	1	1	—	1	—	1	—	—	—	—	—	—	—	—
21 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
22 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
23 ,,	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
24 ,,	—	—	2	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	91	60	246	163	150	0	13	195	301	22	151	55	35	48	13	14	5	48	21	37	1

DAB.

No. of Haul—	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	xix.	xx.	xxi.
(Under 8 in.)	92	24	271	14	10	—	7	72	7	41	160	70	16	22	28	6	4	36	33	48	—
8 ,,	52	8	198	10	15	—	2	18	18	18	34	19	1	9	4	2	—	5	5	9	—
9 ,,	21	1	132	48	13	—	1	6	32	4	14	8	1	3	2	1	2	5	2	10	—
10 ,,	12	12	47	31	7	—	—	4	15	1	3	3	4	1	—	3	—	3	1	—	—
11 ,,	7	10	14	28	6	—	3	—	6	—	3	1	2	2	3	1	—	3	—	—	—
12 ,,	4	9	6	13	4	—	1	—	3	—	1	—	1	—	1	—	2	1	—	—	—
13 ,,	—	3	—	8	1	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—
14 ,,	—	2	—	3	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—
15 ,,	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Totl.	188	69	668	155	57	—	14	102	82	64	215	102	25	37	38	13	8	53	41	67	—

FLOUNDER.

(Under 8 in.)	—	—	—	—	—	—	—	1	—	—	1	3	—	—	—	—	—	—	—	—	—
8 ,,	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
9 ,,	—	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—
10 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
12 ,,	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—
13 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Total	—	—	—	—	—	—	—	2	—	—	2	5	—	1	—	—	—	1	—	—	—

LEMON SOLE OR MERRY SOLE.

12 in.	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	1	—	—	—	—
13 ,,	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	1	—	—	—	—	2	—	—	1	—	—	—	—

SOLE.

(Under 8 in.)	—	—	—	—	—	—	—	—	—	—	—	1	—	9	—	—	—	—	—	2	—
8 ,,	—	1	—	1	—	—	1	—	1	—	—	—	—	3	—	—	—	—	—	3	—
9 ,,	—	1	3	1	—	—	—	—	1	1	—	—	1	2	—	—	—	—	2	4	—
10 ,,	2	1	10	—	—	—	2	—	9	—	—	—	—	—	—	—	—	—	3	3	—
11 ,,	3	2	12	—	—	—	1	—	11	—	—	—	—	3	—	—	—	—	1	1	—
12 ,,	—	1	7	—	—	—	—	—	3	—	—	—	1	—	—	—	—	—	1	—	—
13 ,,	1	1	1	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	2	—	—
14 ,,	—	—	—	—	—	—	—	1	2	—	—	—	—	—	—	—	—	—	—	—	—
Total	6	7	33	2	—	—	4	1	28	1	—	1	3	17	—	—	—	—	9	13	—

SAND SOLE.

(Under 8 in.)	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
8 ,,	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9 ,,	—	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10 ,,	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	9	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

U 2

TURBOT.

No. of Haul—	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	xix.	xx.	xxi.
10 in.	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—
11 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12 ,,	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13 ,,	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
14 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15 ,,	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	1	—	—	1	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—

BRILL.

	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	xix.	xx.	xxi.
11 in.	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12 ,,	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13 ,,	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	2	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

COD.

	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	xix.	xx.	xxi.
19 in.	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
20 ,,	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—

WHITING.

	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	xix.	xx.	xxi.
(Under 8 in.)	—	—	—	1	11	—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—
8 ,,	—	—	—	3	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9 ,,	—	—	—	4	6	—	—	—	1	—	—	—	—	—	—	—	—	1	—	—	—
10 ,,	—	—	—	25	18	—	—	—	7	—	—	—	—	—	—	—	—	—	—	—	—
11 ,,	—	—	—	26	14	—	—	—	4	—	—	—	—	—	—	—	—	—	—	—	—
12 ,,	—	—	—	13	4	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
13 ,,	—	—	—	3	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
14 ,,	—	—	—	2	2	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—
15 ,,	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	78	63	—	—	—	17	1	1	—	—	—	—	—	—	1	—	—	—

DORY.

	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	xix.	xx.	xxi.
(Under 8 in.)	—	—	2	—	1	—	—	—	—	—	—	—	—	—	1	2	1	—	1	—	—
8 ,,	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10 ,,	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
11 ,,	4	—	—	3	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
12 ,,	4	1	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13 ,,	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14 ,,	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	14	1	4	5	2	—	—	—	—	—	—	—	—	—	1	4	1	—	1	—	—

TUB OR LATCHET.

No. of Haul—	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	xix.	xx.	xxi.
(Under 8 in.)	—	—	—	—	2	—	—	—	—	6	14	8	2	5	3	—	—	5	1	2	—
8 ,,	—	—	—	—	—	—	—	—	—	—	2	1	—	—	—	—	—	—	1	6	—
9 ,,	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	1	—	—	—
10 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
11 ,,	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—
12 ,,	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
13 ,,	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
14 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
15 ,,	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	6	—	2	—	—	—	—	6	17	9	2	5	3	4	—	7	3	8	—

GREY GURNARD.

No. of Haul—	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	xix.	xx.	xxi.
(Under 8 in.)	—	40	—	—	—	—	—	2	—	1	9	1	3	6	55	2	1	15	17	12	—
8 ,,	24	—	15	1	1	—	—	—	—	—	1	1	—	—	—	—	—	—	1	—	—
9 ,,	—	—	—	1	—	—	—	—	1	—	3	—	—	—	—	—	—	—	—	1	—
10 ,,	—	—	—	1	—	—	—	1	8	—	—	—	—	—	—	—	—	—	—	—	—
11 ,,	—	—	4	5	2	—	—	—	2	—	—	—	—	—	—	—	—	1	—	—	—
12 ,,	—	—	3	7	1	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—
13 ,,	—	—	3	3	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14 ,,	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15 ,,	—	—	2	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	24	40	27	20	8	—	—	3	13	1	13	2	3	6	55	2	1	16	18	13	—

RED GURNARD.

No. of Haul—	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	xix.	xx.	xxi.
(Under 8 in.)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	9	—	—	—	—
8 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	1	—	—	—	—
9 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
10 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
11 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	10	—	—	—	—

PARROT GURNARD.

No. of Haul—	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	xix.	xx.	xxi.
9 in.	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—

THORNBACK (*Raia clavata*).

No. of Haul—	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	xix.	xx.	xxi.
(Under 8 in.)	—	—	—	—	—	—	—	—	—	1	—	—	8	6	8	—	—	1	—	—	—
8 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	2	1	—	—
9 ,,	—	—	—	—	—	—	—	—	—	—	—	—	1	—	2	—	—	—	—	—	—
10 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	2	1	—	—	1	2	—	—
11 ,,	—	—	—	—	—	—	—	—	—	—	—	—	1	—	2	—	—	—	—	—	—
12 ,,	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	1	—	—	—	—	—
13 ,,	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	1	—	—	—
14 ,,	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
15 ,,	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—
16 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
17 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
Total	?	?	?	?	?	?	?	?	?	2	1	3	10	10	13	1	—	5	5	—	—

PAINTED RAY (*R. microcellata*).

No. of Haul—	i.	ii.	iii.	iv.	v.	vi.	vii	viii.	ix	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	xix.	xx.	xxi.
11 in.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
12 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
13 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
14 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15 ,,	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
16 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17 ,,	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1	—	—
18 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
19 ,,	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—
20 ,,	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—
21 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
22 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
23 ,,	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Total	?	?	?	?	?	?	?	?	?	—	2	2	1	—	1	—	—	—	2	—	—

BLONDE RAY (*R. blanda*). *Large smooth spotted ray.*

No. of Haul—	i.	ii.	iii.	iv.	v.	vi.	vii	viii.	ix	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	xix.	xx.	xxi.
(Under 8 in.)	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	2	—	—	—	—	—
8 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
9 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
10 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—
11 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Total	?	?	?	?	?	?	?	?	?	—	1	—	—	—	—	3	1	1	—	—	—

HOMELYN (*R. maculata*). *Small smooth spotted ray.*

No. of Haul—	i.	ii.	iii.	iv.	v.	vi.	vii	viii.	ix	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	xix.	xx.	xxi.
(Under 8 in.)	—	—	—	—	—	—	—	—	—	1	—	—	8	7	13	5	1	—	1	1	—
8 ,,	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—	—	—	—	2?
9 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—
Total	?	?	?	?	?	?	?	?	?	1	—	—	9	7	14	7	1	—	1	1	2?

TABLE II.

Numbers and Percentages of Fish at given sizes at different seasons in Start Bay.

PLAICE.

	Season—March. Hauls—viii., x.-xii. Hours—9 hrs.	May, June. xiii.-xv., xviii. 8 hrs. 50 mins.	July. xix., xx. 3 hrs. 45 mins.	Oct. i.-iii., ix. 15 hrs. *ca.*	Dec. iv., v. 8 hrs. *ca.*
Unsaleable . .	112	66	17	2	2
Under 8 inches .	26%	46%	29%	0%	0%
Immature . .	322	124	46	276	101
Under 12 inches .	76%	86%	79%	39%	32%
Large . . .	26	8	4	76	31
15 inches and over	6%	6%	7%	11%	10%
Gross number . .	423	144	58	698	313

DABS.

	March	May, June	July	Oct.	Dec.
Unsaleable . .	343	102	81	394	24
i.e., under 8 inches	71%	67%	75%	39%	11%
Gross number . .	483	153	108	1007	212

Besides the species entered in Table I. our record includes, of marketable kinds, only a few small **pout** and an occasional **herring**.

In the later records, kept by Mr. Scott and myself, appear **spur-dogs, rough-dogs, angels** or buffoons (*Rhina squatina*), **dragonets**, locally known as miller's thumbs or sting-fish, **scald-fish** (*Arnoglossus laterna*), and **solenettes**. The dog-fish and angels, rapacious creatures all, would be of some importance if very numerous, which they were not. The solenette deserves a little attention, since this small fish, which hardly exceeds a length of five inches, is quite commonly regarded, even by fishermen, as the young of the marketable sole. Readers who, having experience of the bay, may not be familiar with the distinctive character of the several species of sole, will understand that the scanty number of small soles is accounted for by the elimination of solenettes.

Plaice are no doubt the most important fish found in the bay, since, although their individual value is far less than that of soles, turbot, or even brill, they are infinitely more abundant than those species. Glancing at Table II., we see that the proportion of unsaleable fish in October and December is less than 1 per cent. No reliable conclusions can be drawn from the two hauls made in January. The first haul (vi.) in bad weather was utterly blank, while the second (vii.) in six hours produced only 13 plaice. It is impossible to judge to what extent they may be normally present on the ground at this season. It is evident that they are difficult to catch in foul weather, and this, I believe, is the common experience of trawlers on similar shallow grounds. The explanation usually offered is to the effect that the fish bury themselves in the sand, and the little evidence which I have been able to collect on the subject does not contradict this view.

In March the percentage of unsaleable plaice rises to 26; in May and June to 46; while the general supply appears to be less in summer than in spring. In July, if two hauls give any reliable data, the supply remains about the same, but the percentage of unsaleable falls to 29.

Turning to the proportion of immature fish, this from March to July is never less than 76 per cent. In October it falls to 39, in December to 32 per cent.

Large fish, *i.e.*, those of 15 inches and above, appear to be never numerous. In October they stand at 11 per cent.; in the spring and summer at 6 to 7 per cent. only.

Dabs appear to be numerically more abundant than plaice at all seasons except during the month of December. From March to July the proportion of unsaleable is from 66 to 75 per cent., falling in October to 39, and in December to 10 per cent.

The number of **soles** entered in our records is too small to be reduced to percentages, but it is apparent that no "unsaleable" fish were taken except in May and July. A sole, as we have seen, ceases to be a "slip" at about the size at which it becomes capable of reproducing its species; and out of the total of 103 fish taken in all hauls we find only 23 mature. None of them exceed the very modest length of 14 inches. The best sole ground, according to my information, is along the inner edge of the Skerries. Hence our operations, mostly conducted over different ground, cannot be said to be fully representative. I shall have occasion to allude to this matter later on.

Sand soles (*Solea lascaris*) are of little importance unless taken in large numbers and of the full size of about 10 or 12 inches. The so-called lemon sole or **merry sole** (*Pleuronectes microcephalus*) is apparently too scarce in the bay to demand attention. The few **turbot** and **brill** taken were all immature, and too small to be very valuable. If **cod** ever form an important item of a trawler's catch in the bay our records furnish no evidence of the fact. **Whiting**, when encountered, were mostly immature, and nearly all so small as to be hardly worth catching. **Dories** were few and mostly immature and unsaleable, but the destruction of the young of this species appears to be much less here than on offshore grounds generally. **Tub gurnards** were hardly plentiful at any season, and, while the majority were unsaleable, the total does not comprise a single full-grown fish. **Grey gurnards**, abundant at times, were mostly unsaleable, except in December, when only a few were large enough to command the full price. These fish are addicted to rather sudden rovings, so that there is always some risk of error in results deducted from a small number of observations of their capture. Such as it is, our evidence suggests that large numbers of immature forms are liable to be destroyed by trawling in the bay in summer and autumn, without any adequate compensation in the capture of marketable material. **Red gurnards**, as might be supposed, are not found in the shallow part of the bay; **Parrot gurnards**, or "Polperro bull-dogs," only as occasional immigrants from the deeper water which they habitually affect.

With regard to rays, we have no evidence of the supply in October and December. **Painted rays** do not appear to be common in the spring and summer. **Homelyns** are only represented by small examples. **Blondes** are rarer, and, relative to the adult size, very small. **Thornbacks** are the most numerous, and some are of good size; but it may be said of all rays that while the supply in spring and summer appears hardly sufficient to be remunerative, the proportion of unsaleable specimens is very considerable.

TORBAY.

LIST OF HAULS.

According to my information, the best trawling ground in the bay is supposed to lie along the inner side of the Ridge, thence on towards Paignton, and round outside the Ridge towards Brixham. Hauls entered as "round the Ridge" will be understood to have been made as far as possible on these lines.

I.	T.	Across the bay from near Berry Head to ½ m. off Torquay pier . .	3 hrs. 20 min.	1 xi. '95
II.	T.	Inside the Ridge and on to Paignton . . .	2 hrs.	1 xi. '95
III.	T.	Same as II. . . .	1 hr. 50 min.	15 i. '97
IV.	T.	Round the Ridge . .	1 hr. 20 min.	26 iii. '97
V.	T.	" " . .	1 hr. 40 min.	26 iii. '97
VI.	B.B.	" " . .	1 hr. 25 min.	2 vi. '97
VII.	B.B.	" " . .	1 hr. 35 min.	2 vi. '97
VIII.	B.B.	" " . .	1 hr. 40 min.	27 vii. '98
IX.	B.B.	Central part of bay . .	45 min.	27 vii. '98

Table III.

List of Fish caught in Torbay.

PLAICE.

No. of Haul—	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.
1 inch	—	—	—	—	—	—	—	1	—
2 inches	—	—	—	—	—	—	—	—	—
3 "	—	—	—	—	1	—	—	—	—
4 "	—	—	11	8	16	8	19	—	—
5 "	—	—	5	7	21	18	108	—	2
6 "	—	—	5	5	16	10	81	1	12
7 "	3	1	4	3	7	1	16	—	12
8 "	5	2	6	5	15	2	7	2	9
9 "	9	5	6	10	19	6	16	2	15
10 "	7	1	8	13	25	9	14	2	20
11 "	17	4	5	24	34	5	20	3	16
12 "	21	7	5	26	30	6	21	5	3
13 "	7	3	2	19	31	3	18	2	—
14 "	3	1	1	1	10	2	7	—	—
15 "	—	2	—	2	7	2	4	1	—
16 "	—	1	—	4	—	6	—	2	—
17 "	1	—	—	1	1	—	—	—	—
18 "	—	—	—	—	—	—	—	1	—
19 "	—	—	—	—	—	1	—	—	—
20 "	—	—	—	—	1	—	—	—	—
Total	73	27	58	128	234	79	331	22	89

DAB.

No. of Haul—	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.
(Under 8 inches)	40	6	83	2	10	22	88	4	155
8 inches	2	—	—	3	6	1	23	—	6
9 ,,	10	1	1	—	3	2	4	—	1
10 ,,	2	3	2	—	—	2	2	—	—
11 ,,	4	2	—	—	—	1	—	—	1
12 ,,	1	—	1	—	—	1	—	—	1
13 ,,	1	—	—	—	—	—	2	—	—
Total	60	12	87	5	19	29	119	4	164

FLOUNDERS.

(Under 8 inches)	—	—	—	—	1	2	2	—	—
8 inches	—	—	1	—	2	—	5	—	—
9 ,,	—	—	1	—	2	—	1	—	—
10 ,,	—	—	1	—	1	1	4	—	—
11 ,,	—	—	2	—	3	—	5	—	—
12 ,,	—	—	2	1	4	—	3	—	1
13 ,,	—	—	—	1	3	—	2	—	—
14 ,,	—	—	—	—	—	—	—	—	—
15 ,,	—	—	1	—	—	—	—	—	—
Total	—	—	8	2	16	3	22*	—	1

* Noted as in bad condition.

SOLE.

(Under 8 inches)	—	—	—	—	—	—	1	—	—
8 inches	—	—	—	—	—	1	4	—	—
Total	—	—	—	—	—	1	5	—	—

BRILL.

(Under 10 inches)	—	—	—	—	1	—	1	—	—
Total	—	—	—	—	1	—	1	—	—

WHITING.

(Under 8 inches)	33	—	6	—	—	—	—	—	—
8 inches	7	—	8	—	—	—	—	—	—
9 ,,	5	—	1	—	—	—	—	—	—
10 ,,	4	—	—	—	—	—	—	—	—
Total	49	—	15	—	—	—	—	—	—

TUB.

(Under 8 inches)	—	—	—	—	8	4	10	—	—
8 inches	—	—	—	—	—	—	1	—	—
9 ,,	—	—	—	—	—	—	2	—	—
10 ,,	—	—	—	—	—	—	—	—	—
11 ,,	—	—	—	—	—	—	1	—	—
12 ,,	—	—	—	—	—	—	1	—	—
Total	—	—	—	6*	8	4	15	—	—

* Small fish ; actual sizes not recorded.

GREY GURNARD.

No. of Haul—	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.
(Under 8 inches)	—	—	—	—	—	—	—	—	7
Total	—	—	—	—	—	—	—	—	7

THORNBACK.

	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.
(Under 8 inches)	—	—	—	—	—	1	6	—	2
8 inches	—	—	—	—	—	1	1	1	—
9 ,,	—	—	—	—	—	—	—	1	—
10 ,,	—	—	—	—	—	—	—	—	—
11 ,,	—	—	—	—	—	—	—	1	—
12 ,,	—	—	—	—	—	—	1	—	—
13 ,,	—	—	—	—	—	1	—	—	—
16 ,,	—	—	—	—	—	—	—	—	1
25 ,,	—	—	—	—	—	—	—	—	1
Total	?	?	—	—	—	3	8	3	4

Table IV.

Numbers and Percentages of Fish at given sizes at different seasons in Torbay.

PLAICE.

Season—	January.	March.	June.	July.	November.
Hauls—	iii.	iv., v.	vi., vii.	viii., ix.	i., ii.
Hours—	1 hr. 50 mns.	3 hrs.	2 hrs. 55 mns.	2 hrs. 25 mns.	3 hrs. 20 mns.
Unsaleable . .	25	84	261	27	4
Under 8 inches .	43%	23%	64%	25%	4%
Immature . .	50	229	340	96	54
Under 12 inches	86%	63%	83%	87%	54%
Large . . .	0	16	13	4	4
15 ins. and over	0%	4%	3%	4%	4%
Gross number .	58	362	410	110	100

DAB.

	January.	March.	June.	July.	November.
Unsaleable . .	83	12	110	159	46
Under 8 inches .	95%	50%	74%	95%	64%
Gross number .	87	24	148	168	72

Our list contains a few kinds of fish not entered in Table III. As in the case of Start Bay, the deleterious kinds are not sufficiently numerous to demand attention, and the others need not here concern us.

It will be noticed that the proportions of plaice fluctuate throughout the seasons in a rather irregular manner. This may in part be due to the paucity of our material in January, only 58 fish being recorded. Another explanation, however, is forthcoming, viz., that January is the spawning season, when the bulk of the big fish are out on the spawning grounds, about 15 miles off Berry Head (if I am rightly informed on this point). If plaice spawn at all in Torbay it is contrary to anything that I know of the general habit of the species, so that during the spawning season one would expect to find there only immature fish and a few of the smaller mature ones, which, speaking broadly, ripen later in the season than their larger brethren. This, in effect, is the condition actually indicated by our record. To correspond with the numerical abundance in March, the January figures should be much higher, but the weather in the earlier month was not propitious. The fish taken were in good condition, but 43 per cent. were unsaleable.

In March the proportion of both unsaleable and immature fish falls considerably, though both remain high. The fall may be presumed to be in part accounted for by the return of spent fish from the spawning grounds. The mature fish were noted to be in very poor condition, "running away to water," as the skipper of the *Thistle* expressed it. In June the proportion of "unsaleable" rises very perceptibly, but it must be admitted that in haul vii. we gave the Ridge rather a wider berth, and so hauled closer to the shore than is usual with professional trawlers. The percentage of immature fish shows a corresponding rise in this month.

In July we found the Ridge unfit for trawling owing to the great quantity of drift weed, so made our second haul, a very short one, in the central part of the bay. Here plaice were numerous, but small and nearly all immature. The few that we got round the Ridge comprised a reasonable proportion of good fish, but the two hauls, taken together, put the proportion of immature rather higher than in June of the previous year. In November (1895) fish seem to have been scarce. More than half were immature, but few were unsaleable. I believe, from experience elsewhere, that it is not unusual for the big fish to draw away from the shore in this month to re-assemble later on in the spawning grounds.

Around the Ridge, as may be gathered from Table III., dabs are certainly less numerous than plaice, except (always ?) in January. In the central part of the bay this condition is reversed, but the proportion of unsaleable fish is very high throughout the year. It reaches its lowest point, 50 per cent., in March. Dabs are known to spawn, to some extent, in inshore waters, though I have little experience of their doing so in Devonshire bays.

Other marketable flat-fish require, unfortunately, but little consideration. **Soles** are represented by only two small specimens. **Merry soles** were never taken, though I believe that they sometimes, if not often, enter the bay. **Flounders** appear to be permanent inhabitants, or at any rate are to be taken in small numbers throughout the year. No **turbot** were taken, and only one **brill**, of unsaleable size, was observed. **Whiting, tub gurnard** and **grey gurnard** appear to be not only scarce, but too small to be worth catching. The same remark applies almost equally to **thornbacks**, during the months when the rays were recorded. No other kinds of ray were observed.

TEIGNMOUTH BAY.

LIST OF HAULS.

The trawling ground in this bay lies roughly parallel to the shore at depths ranging from 5 to 10 fathoms. Our experiments were made on courses which do not appear to differ from each other to such an extent as to require separate definition. The ground appears to be very liable to become covered with drift weed in the summer.

I.	T.	. . . . .	30 x.'95
II.	T.	. . . .	,,
III.	T.	4 hrs. 30 min.	2 xii.'95
IV.	T.	. . . .	,,
V.	T.	. . . . .	12 x.'96
VI.	T.	. . . .	,,
VII.	T.	. . . .	,,
VIII.	T.	. . . .	,,
IX.	T.	2 hrs. 25 min.	12 i.'97
X.	T.	2 ,, 30 ,,	,,
XI.	B.B.	2 ,, 50 ,,	25 iii.'97
XII.	B.B.	1 ,, 5 ,,	1 vi.'97
XIII.	B.B.	0 ,, 50 ,,	,,
XIV.	B.B.	1 ,, 40 ,,	,,
XV.	B.B.	2 ,, 20 ,,	,,

Table V.

List of Fish caught in Teignmouth Bay.

PLAICE.

Haul— Inches.	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.*
3	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—
4	—	—	—	—	—	—	—	—	—	—	45	3	5	—	8
5	—	—	—	—	11	3	—	—	2	6	102	12	10	5	46
6	1	7	2	—	26	11	1	2	29	26	152	21	7	4	17
7	10	46	14	2	38	29	8	5	35	11	91	2	10	6	15
8	14	72	12	6	24	31	12	8	17	12	38	1	1	4	6
9	55	80	18	24	26	64	19	16	6	25	18	—	—	4	1
10	90	124	31	70	27	101	30	25	9	22	15	—	4	6	3
11	47	78	13	81	11	76	29	12	6	21	11	3	3	2	3
12	25	34	8	58	11	52	24	17	2	15	11	1	4	3	—
13	10	9	3	18	7	12	9	10	—	3	3	2	4	2	1
14	1	3	3	6	5	2	2	3	1	1	1	1	—	1	2
15	3	—	—	6	3	2	3	2	—	2	1	2	2	—	2
16	—	—	1	2	2	—	—	—	—	—	—	3	—	—	2
17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
18	—	—	—	—	1	—	—	—	—	—	—	1	—	1	—
19	1	—	—	—	—	—	—	2	—	1	—	1	—	—	—
20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	257	453	105	273	192	383	137	102	107	145	490	53	50	38	106

* The net came up loaded with weed, which had to be removed by cutting the meshes. In this process many small flat-fish escaped.

DAB.

	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.
(Under 8)	53	45	118	94	—	112	4	16	47	101	56	6	4	9	20
8	29	34	28	26	—	26	5	16	—	—	3	—	2	5	2
9	14	24	11	19	—	29	23	13	—	2	—	—	—	1	3
10	—	16	4	12	—	16	9	4	—	1	2	—	—	—	—
11	—	4	4	1	—	1	4	—	—	1	—	—	—	2	—
12	—	1	—	4	—	—	3	—	—	2	—	—	—	—	—
13	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	97	124	165	156	?	184	48	49	47	107	61	6	6	17	25

FLOUNDER.

	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.
(Under 8)	—	—	—	—	—	—	—	—	1	—	2	1	—	—	—
8	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—
9	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Total	—	—	—	—	?	—	—	—	1	—	5	1	—	—	—

LEMON SOLE OR MERRY SOLE.

Haul— Inches.	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.
10	—	—	—	2	—	1	1	—	—	—	—	—	—	—	—
11	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
12	—	—	—	—	—	2	9	—	—	1	—	—	—	—	—
13	—	—	—	—	—	1	—	—	—	1	—	—	—	1	—
14	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—
Total	1	—	1	2	?	4	11	—	—	2	—	—	—	1	—

SOLE.

(Under 8)	—	—	—	—	—	—	—	—	—	1	—	—	—	—	1
8	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
9	—	—	1	—	—	1	—	4	—	—	—	—	—	1	—
10	—	—	1	—	—	4	—	2	—	—	—	—	—	—	1
11	—	—	1	—	—	1	—	1	—	—	—	—	—	—	—
12	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
13	1	—	1	1	—	—	—	—	—	—	—	—	—	—	1
14	—	—	—	—	—	1	—	—	—	—	—	—	—	—	1
15	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
Total	1	1	5	1	?	7	—	7	—	2	—	—	—	1	4

TURBOT.

12	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
13	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—
14	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Total	—	—	1	1	?	—	—	—	—	—	1	—	—	—	—

BRILL.

(Under 10)	—	—	—	—	—	—	—	—	1	—	2	2	3	2	1
10	—	—	—	1	—	—	1	—	—	—	1	—	—	—	—
11	—	1	—	—	—	1	—	—	—	—	—	—	—	—	—
12	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—
13	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
14	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
15	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
19	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
Total	—	1	—	1	?	2	1	—	1	2	3	4	3	2	1

COD.

Haul— Inches.	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.
13	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
14	—	—	—	—	—	1	2	—	—	—	—	—	—	—	—
15	—	—	—	—	—	3	—	—	—	—	—	—	—	—	—
16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
17	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—
Total	—	—	—	—	?	4	3	—	—	2	—	—	—	—	—

WHITING.

Haul— Inches.	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.
(Under 8)	—	16	30	—	—	—	—	—	1	—	—	—	—	—	—
8	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
9	—	—	1	1	—	1	1	—	—	—	—	—	—	—	—
10	—	—	5	2	—	—	5	1	—	—	—	—	—	—	—
11	—	—	2	—	—	3	2	—	—	—	—	—	—	—	—
12	—	—	1	—	—	1	1	—	—	—	—	—	—	—	—
13	—	—	1	—	—	—	2	1	—	—	—	—	—	—	—
14	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—
15	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—
Total	—	16	40	4	—	5	12	2	1	1	—	—	—	—	—

DORY.

Haul— Inches.	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.
Under 8	—	—	—	—	—	—	—	—	—	—	—	—	1	3	—
Total	—	—	—	—	?	—	—	—	—	—	—	—	1	3	—

GREY GURNARD.

Haul— Inches.	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.
(Under 8)	—	1	—	—	—	—	—	—	—	—	9	1	3	1	1
8	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
9	—	—	—	—	—	2	—	9*	—	—	1	—	—	—	—
10	1	—	—	—	—	10	4	—	—	—	—	—	—	—	1
11	—	—	—	—	—	3	—	—	—	1	—	—	—	—	—
12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	1	1	—	—	?	15	4	9	1	1	10	1	3	1	2

* Between 9 and 11 inches.

TUB GURNARD.

Haul— Inches.	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.
(Under 8)	—	—	—	—	—	—	—	—	1	—	33	4	6	3	3
8	—	—	—	—	—	—	—	—	—	—	—	1	1	1	1
9	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
10	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
11	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—
Total	—	—	—	—	?	—	—	—	2	—	33	5	7	7	4

THORNBACK.

Haul—	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.
Inches.															
(Under 8)	—	—	—	—	—	—	—	—	—	—	2	3	9	2	8
8	—	—	—	—	—	—	—	—	—	—	1	—	2	—	6
9	—	—	—	—	—	—	—	—	—	—	3	1	2	—	2
10	—	—	—	—	—	—	—	—	—	—	4	4	1	—	3
11	—	—	—	—	—	—	—	—	—	—	2	3	—	—	1
12	—	—	—	—	—	—	—	—	—	—	6	2	2	3	1
13	—	—	—	—	—	—	—	—	—	—	6	4	—	1	2
14	—	—	—	—	—	—	—	—	—	—	3	1	1	—	—
15	—	—	—	—	—	—	—	—	—	—	1	2	—	1	—
16	—	—	—	—	—	—	—	—	—	—	4	—	1	1	—
17	—	—	—	—	—	—	—	—	—	—	2	2	1	2	—
18	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—
19	—	—	—	—	—	—	—	—	—	—	3	2	—	3	—
20	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
21	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—
22	—	—	—	—	—	—	—	—	—	—	1	—	—	2	—
23	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
24	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—
Total	?	?	?	?	?	?	?	?	?	?	41	24	19	19	23

HOMELYN.

	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.
8	—	—	—	—	—	—	—	—	—	—	3	—	1	—	2
10	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
13	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Total	?	?	?	?	?	?	?	?	?	?	3	2	1	—	2

BLONDE.

	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.
(Under 8)	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—
8	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
13	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
15	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Total	?	?	?	?	?	?	?	?	?	?	—	6	—	—	—

Pout (*Gadus luscus* or *G. minutus*) are the only other marketable fish which appear in our records. Their numbers are quite unimportant. Of unmarketable species, solenettes, scald-fish, topknots (*Rh. unimaculatus*), dragonets, angels or buffoons, and various dog-fish appear in hauls subsequent to x. In Haul x. Mr. Scott has noted that dog-fish were abundant, but in subsequent hauls both dog-fish and angels, which may be regarded as deleterious forms, were not taken in any considerable number.

TABLE VI.

Numbers and Percentages of Fish at given sizes at different seasons in Teignmouth Bay.

PLAICE.

	January.	March.	May, June.	Oct.	Dec.
Season—	January.	March.	May, June.	Oct.	Dec.
Hauls—	ix., x.	xi.	xii.–xv.	i., ii., v.–viii.	iii., iv.
Hours—	4 hrs. 55 mns.	2 hrs. 50 mns.	5 hrs. 55 mns.	?	?
Unsaleable . .	105	392	171	198	18
Under 8 inches .	42%	80%	69%	14%	5%
Immature . .	227	474	212	1269	273
Under 12 inches .	90%	97%	86%	89%	72%
Large . . .	3	1	14	19	9
15 inches and over	1%	0%	6%	1%	2%
Gross number . .	252	490	247	1424	378

DAB.

Unsaleable . .	148	56	39	230	212
Under 8 inches .	96%	92%	72%	46%	66%
Gross number . .	154	61	54	503*	321

* The record of dabs in Haul 5 has been mislaid.

Fish of species not entered in Table V. were in no way important. Throughout the year it would appear that the **plaice** are for the most part immature, while the percentage of unsaleable is very high in spring and summer, and considerable even in January. In October and in December it is comparatively low. **Dabs** are evidently less abundant than plaice, and, except in October, most of them appear to be unsaleable. **Merry soles**, though not taken in large numbers, were saleable, and probably for the most part mature. **Soles** do not appear to be numerous, though a fair catch might perhaps be made at night, but would consist, as I infer, largely of immature "slips." The few **turbot** recorded are small, and probably all immature. Two mature **brill** were taken, but the rest were mostly unsaleable as well as immature. **Cod** are only represented by a few codling. **Whiting** may, perhaps, be taken in remunerative numbers by night, and appear to be mostly saleable (if rather small), except in October and December. Large **grey gurnard** appear to be scarce, while **tub gurnard** are much too small to be legitimately fished. **Thornbacks** seem to be an important item of the catch. Many are so small as to be comparatively worthless, while a fair number are quite unsaleable, but I cannot say that the proportion of the latter, having regard to the usual distribution of young and old in this species, is unusually high.

General Considerations.

I think it will be conceded that the preceding records indicate, in so far as they can be considered representative, that the three bays do not form a homogeneous area, characterised by similar conditions of fish supply throughout. Start Bay and Torbay show a certain similarity, if we restrict our attention to plaice, but there is a marked difference in the proportion of immature fish in the later months of the year. Thus in Start Bay these fish are 39 per cent. of the whole in October and 32 per cent. in December, while in Torbay they are 54 per cent. in November. Teignmouth Bay differs from either, in that the proportion of immature plaice never falls below 72 per cent. I imagine that the facts are of more interest to the Committee than their explanation, which may probably lie in the close proximity of the estuary of the Exe, apparently the chief nursery of young plaice in the district, to Teignmouth Bay.

Without undertaking the responsibility of suggesting legislative action, I think I may endeavour to indicate, in so far as my acquaintance with the local conditions permits, the probable effects of any modification of the existing bye-laws.

Any interference with the unrestricted prosecution by fishermen of their calling may be presumed to have for its object either the increase of the fish supply or the protection of one class of fishermen at the expense of another. The last case involves social considerations which I am not concerned to discuss, as they lie within the province of the political economist rather than that of the naturalist.

For the protection or increase of the supply a number of methods have been advocated, such as the prevention of the destruction of small fish (different standards of size being suggested), whether by prohibition of capture or prohibition of sale, the institution of a close season, etc. On the whole the imposition of a size limit, however enforced, seems to have found most favour, but opinions differ as to the size. The Sea Fisheries Bill of 1898 sought to make illegal the sale, &c., of plaice and soles not exceeding 8 inches in length. It must be supposed that the Parliamentary Committee, on the recommendations of which the Bill was based, held that the protection of fish of less size would in itself benefit the supply. A Fisheries Committee cannot deal with sales, but the Devon Committee has taken effectual means to prevent the destruction, at least by trawlers, of either large or small fish in the bays. If it be held that the limit proposed by the Parliamentary Committee is adequate, our tables show that the existing bye-law is superfluous in Start Bay, and probably in Torbay during the months of October, November, and December, while it is hardly necessary in Teignmouth Bay in December, since there are hardly any plaice under 8 inches to be caught. It is possible, however, that the Fisheries Committee may consider that the prohibition of sale of fish which are so small as to be practically unsaleable will not greatly alter existing conditions, and that an effort should be made to extend protection until the fish have reached a somewhat larger size. If this be the case the limit advocated will probably coincide with the size at which the fish becomes capable of reproducing its species, and so contributing to the up-keep of the stock. Plaice, the species with which we are almost entirely concerned, mature, as has been shown, at about 12 inches, and if this principle of protection be accepted it is obvious that no modification of the existing bye-law is advisable at any period of the year either in Teignmouth Bay or Torbay. In Start Bay it does not appear that the proportion of immature fish is higher in December than on offshore grounds. What may be the conditions in this bay in January and February the weather has never permitted us to ascertain.

Assuming that the protection of immature fish suffices, and that a proportion of 30 per cent. of such fish is that normally met with in company with large plaice on offshore grounds, it would appear that the bye-law might be relaxed in Start Bay in winter without much injurious effect in so far as the fish supply is concerned. It is not my business to recommend such a relaxation, and the Committee is probably aware that the southern edge of the Skerries, which appears to be a favourite trawling ground, is equally appreciated by the crabbers. Crabbing and trawling are industries little calculated to flourish on the same ground, especially by night. Supposing it to be possible to prevent interference with crabbing by restricting trawling to the northward of a line drawn from the Bell Buoy to Tinsey Head, and if this limit were respected (it is for the Committee to judge by what means respect could be enforced), the bay would remain in part a sanctuary for soles throughout the year. I take it that no one will be inclined to refuse to soles any sort of protection which can be afforded them, whether large or small.

I do not think that the proposal to establish a close time for sea fish has ever been seriously entertained, but I am by no means sure that beneficial results would not be achieved by diverting the attention of trawlers from fish of a given species at the time when the larger members of that species are engaged in spawning. It is well known that in any species the larger mature females yield more eggs than their smaller sisters, and that as a rule they are the earliest spawners. I myself believe that the larger fish produce not only more numerous but more vigorous offspring, capable, speaking generally, of attaining a larger size than the offspring of fish which have only just reached the mature condition. Large plaice are spawning, if I am correctly informed, in January. Means might be taken to tabulate the spawning period with greater exactitude, and I believe that the Committee might profitably consider to what extent the opening of Start Bay during this month (or during the earlier part of the spawning period) would have the effect of diverting the attention of trawlers from the large plaice when the latter are spawning. In this connection the weather is of great importance, since a gale of wind off the land is in itself a most efficient protector of spawning fish on distant grounds, while the opening of the bay would, under such meteorological conditions, submit the species to a persecution which they at present escape. In any modification of existing arrangements intended to protect large fish while spawning it would be essential to avoid any risk, by too early opening of inshore grounds, of molesting the breeders before they have hauled off the land, and I am certain that the date of the outward migration varies somewhat in different years.

A Fisheries Committee appears to have the power of dealing with trawling in inshore waters by various methods besides those already referred to, viz., by regulation of the hour and duration of hauls, and of the size of mesh, and by the prohibiting of the removal of fish from a fishery. It is a well-established fact that small fish, especially the hardier kinds of flat-fish, are not necessarily killed by being caught in the trawl, if the latter is only hauled for a short time and the ground is fairly clean. It is, of course, essential that the small fish, if they are to be saved, should be promptly returned to the sea. With regard to mesh, I doubt whether any alteration of size and pattern is practicable, since to restrict trawling in the bays to the use of a certain kind of net might be equivalent to closing them altogether, on account of the expense entailed by equipping the boats with two sets of gear. There can be no doubt as to the beneficial action of regulations dealing with duration of hauls and removal of small fish, if such can be effectually enforced; but I suppose that a man of affairs, before recommending any legislation on these lines, would consider how far the means at his disposal would be likely to render it effective.

In the above remarks I have directed my attention almost entirely to plaice, and only a few words appear to be necessary in respect of the other fish met with in the bays. Soles require no further notice. Merry soles and flounders appear to be unimportant. Turbot and brill are few and small, and, as such, may very well continue to enjoy the protection of the bye-law; nor can I find any reason to think that the closure of the bays is otherwise than beneficial to whiting and gurnards, which appear to be represented almost entirely by immature and unsaleable individuals.

Dabs require separate consideration. They are very abundant in the bays, and, except in Start Bay in December, a very large proportion of them is immature and unsaleable. But the dab is a small fish, which at no time enjoys a very exalted commercial value, while its flesh deteriorates very rapidly. Furthermore, it is commonly regarded by naturalists as a serious competitor in the matter of food with the more valuable kinds of flat-fish, in the company of which it is usually taken. Unlike the plaice, it is not by any means confined in its immature condition to any particular ground, and shows hardly any discrimination in the locality in which it spawns; while in addition to consuming large quantities of organisms, which might be more profitably employed in the architecture of young plaice and soles, it is practically omnivorous. Probably in virtue of this adaptability of feeding and habitat the dab continues to abound. At least, I have never heard it seriously contended by any responsible observer that the species has been greatly reduced in number by over-fishing. That it may have decreased in average size is quite possible, since although, as our records show, the length may occasionally reach 15 inches even in this district, 13 inches is much more frequently the size of the largest individuals met with. It is not unlikely that protection might result in slightly increasing the average size, and so in slightly raising the market value of the fish, but it is more than doubtful whether any useful end would be served by any sort of means specially directed to the preservation of this species. In giving evidence at an enquiry held during the present year with regard to a bye-law prohibiting the use of "tuck-nets" in Start Bay, I had occasion to speak of dabs in the same sense as appears above. Mr. Fryer, in his report to the Board of Trade, considered that my remarks with regard to dabs went a long way towards condemning the bye-law. The responsibility is his, not mine, for it is one thing to say that a dab needs and deserves no protection, and another to hold that small plaice ought not to be preserved for fear that the dabs should benefit by the same protection. The question of "tuck-nets" is outside the scope of our present enquiry. In the case of trawling in the bays our records sufficiently prove that all other considerations must be subordinated to the conditions affecting plaice. I should hesitate to advise that dabs are so deleterious that their extermination in the bays would justify the great destruction of small plaice that must ensue if the process were carried out in the course of ordinary professional fishing. In the good old days of which we hear, when valuable fish are said to have abounded, plaice must be supposed to have been able to maintain a successful competition with dabs, and food-fish generally with worthless or predatory forms. The balance appears to have been upset by the interference of man, but it is very difficult to advise how it may be satisfactorily adjusted again.

There is some risk even in the assertion that such worthless and predatory forms as sharks and dog-fish are wholly noxious, since their depredations among valuable fish may be partly compensated by the destruction which they inflict on each other and on small competitive forms. I am nevertheless inclined to think that the dog-fish commonly met with by trawlers, spur-dogs, nurse, rough-dogs, and angels or buffoons, do more harm than good, and may safely be killed when encountered. From the results of enquiries which I have made I doubt whether trawlers take any trouble in this matter. Spur-dogs, perhaps the most destructive of all, are likely enough to succumb to exposure on deck before they are shovelled overboard, but nurse, rough-dogs and buffoons are very tenacious of life, though easily disposed of by the judicious use of the heel of a sea-boot.

I have endeavoured to set forth above all the more important points raised by our enquiry, in so far as they can be limited to the single industry of trawling. I see no reason to change the opinion which I have long held, that the practical treatment of questions dealing with the supply of flat-fish cannot be limited to trawling alone, but must embrace all fisheries which are prosecuted on any part of the area tenanted, at different phases of their life history, by these fish.

APPENDIX.

Memorandum on the Results of Investigations into the Contents of Certain Bays on the South Coast of Devon.

Submitted for the Information of the Sub-Committee of Enquiry Appointed by the Devon Sea Fisheries Committee (September, 1896).

By

F. B. Stead, B.A.,

Assistant Naturalist on the Staff of the Marine Biological Association.

In the following Memorandum I propose to lay before the Sub-Committee of Enquiry, appointed by the Devon Sea Fisheries Committee, certain facts with regard to the contents of two of the bays on the South Coast of Devon, in which I have conducted trawling experiments, and then to point out the bearing of these facts on the practical questions before the Committee.

I. The experiments, to which reference will be made, were conducted at different times during the months of October to December of last year (1895); and the bays investigated were Start and Teignmouth Bays. The trawling smack *Thistle*, of Brixham, was engaged by the Association for the purposes of the investigation. All the food-fish which came on board were measured to the nearest quarter of an inch. The results of the several hauls were tabulated and compared with one another, and though these were not as many as I should have desired, the results obtained are such as to lead me to suppose that a fairly correct idea was gained of the relative numbers of fish of different sizes, belonging to the different species, which any similarly equipped vessel, fishing on the same grounds at that time of year, might be expected to catch. It is, of course, quite possible that there is a certain amount of variation in the numbers of fish of different sizes inhabiting these bays from year to year; and in considering the results which will be given below, this fact must be borne in mind.

The first fact which comes out clearly as the result of these experiments is, that *plaice* and *dabs* are far more numerously represented than any other species. Compared to the destruction of plaice and dabs effected by trawling, the destruction of other species is insignificant, and may, I think, for practical purposes, be left out of account.

The following table gives the actual numbers of fish of different species caught in four hauls in Teignmouth Bay (taken on October 30th and December 2nd and 3rd), and in three hauls in Start Bay (taken on October 31st and December 4th).

TABLE I.

Actual numbers of fish of different species caught in the Bays.

	Start Bay (3 Hauls).	Teignmouth Bay (4 Hauls).
Plaice	559	1088
Dabs	890	511
Common Sole	35	8
Merry Sole	—	4
Turbot	1	2
Brill	2	2
Whiting	144	61
Pouting	4	40
Cod	1	—
Grey Gurnard	57	2
Tub	8	—
John Dory	11	—

While plaice and dabs appeared in every haul in considerable numbers, the other species captured were obtained in relatively small numbers, and in most cases not in every haul.

In considering, then, the populations of the two bays in detail, we may confine our attention to the plaice and the dabs.

We may now proceed to set forth the results arrived at, by adding together the numbers of *plaice* of all the different sizes obtained in all the hauls taken in October and December in the two bays. The results are expressed in percentage of the total number of these fish caught in these hauls.

TABLE II.

Showing the relative numbers of plaice of different sizes taken in Start and Teignmouth Bays in columns I. Columns II. express the percentage number of plaice up to the corresponding size, e.g., "43·1 per cent. of all the plaice caught in Start Bay were 12 inches and under in size."

Start Bay. Inches.	I.	II.	Teignmouth Bay. Inches.	I.	II.
7	0·35	—	7	3·9	2·9
8	1·4	1·0	8	8·3	9·9
9	3·9	4·1	9	12·1	20·5
10	6·6	10·5	10	22·9	40·6
11	13·6	22·1	11	27·4	69·1
12	20·75	43·1	12	15·2	87·6
13	20·9	62·0	13	6·3	95·4
14	13·7	77·8	14	2·4	98·25
15	9·3	88·5	15	0·4	99·1
16	4·1	94·3	16	0·7	99·6
17	2·7	97·4	17	0·2	100·0
18	0·9	98·2	18	—	—
19	0·35	98·9	19	—	—
20	0·5	99·4	20	—	—
24	0·35	100·0			

We may now point out certain results which may be deduced from an inspection of this table. It will be seen that the plaice in Teignmouth are, on the whole, smaller than those in Start Bay; and that, whereas half the plaice in the former were 10½ inches or under, in the latter, the length on either side of which half the fish are found to lie is 12½ inches. It now remains to consider what percentage of the plaice in either bay fall below the limit of maturity.

Mr. Cunningham's investigations on the limit of maturity of plaice on the South Coast showed that the higher limit for plaice was 15 in.; that is to say, that if it was desired to impose such a size limit as to wholly prevent the capture of immature plaice, the limit we should impose would be as high, but no higher, than 15 in. On the other hand, it has been shown that—with only very occasional exceptions—no plaice under 9 in. is mature. A plaice between 9 and 15 in. in length may or may not be mature.

By imposing a size limit of 15 in. for plaice, we should, as I have just pointed out, wholly prevent the capture of immature plaice; but in so doing we should also prevent the capture of a certain number of plaice which have already arrived at maturity; and on the theory that the sole object to be kept in view is to permit the fish to spawn, it might be reasonably urged that the 15-in. limit is too high—since a considerable number of plaice under this length are mature. Acquiescing in this objection, we may accept 12 in. as a reasonably effective limit, and may now consider what proportion of the plaice in the bays examined fall below this limit of maturity. An inspection of Table II. will show that while 43·1 per cent. of the plaice in Start Bay were 12 in. or under, the percentage of plaice in Teignmouth Bay 12 in. or less in length was no less than 87·6. Or, in round numbers, two-fifths of the fish captured in Start Bay, and more than four-fifths of those captured in Teignmouth, were under the length which I have agreed to call a reasonably effective limit of maturity.

We may now turn to consider the facts ascertained for dabs. These may be best understood from an examination of the table given below :—

TABLE III.

Showing the relative numbers of dabs at the different sizes in all the hauls taken (October and December).

Start Bay. Inches.	No. per cent.	Teignmouth Bay. Inches.	No. per cent.
7¼ (and under)	28·7	6¼ (and under)	26·0
8	17·2	7	17·6
9	29·0	8	23·7
10	11·7	9	17·3
11	7·5	10	10·4
12	3·2	11	2·8
13	1·9	12	1·1
14	0·4	13	0·5
15	0·1	13	0·5

The limit of maturity for the common dab has been placed at 7 in. by one observer, and at 6 in. by another. It has not yet, so far as I am aware, been definitely ascertained for the South-west Coast; and it is known that in the case of the plaice, at least, the limit of maturity varies with the locality. I should hesitate, therefore, to deduce from the figures above what proportion of the dabs captured were "immature," nor is there the same necessity for doing so as in the other case. For if a case is to be made out for prohibiting fishing in the inshore, while permitting it in the offshore waters, it cannot be made to rest on facts connected with the distribution of the common dab. Investigations made in the North Sea have seemed to indicate that the dab "is found everywhere, and at all stages, in every part of the North Sea, both inshore and offshore, and that, except in estuaries, it seems to spawn anywhere, without regard to depth of water or proximity to land." It is far otherwise with the plaice; in the case of which fish it may be said with certainty that they remain for the most part in inshore waters during the period of their immaturity, undergoing a migration seawards when they are ready to spawn.

It follows that the practical question of whether these inshore waters which I have investigated should be closed or not, must depend on whether restrictive measures are necessary for the protection of the plaice.

In bringing this part of the memorandum to a conclusion, I can but express my regret that I have been unable to properly investigate the catches of the deep-sea trawlers in the areas adjacent to the two bays, with a view to making an exact comparison of the percentage of immature plaice among the plaice of the offshore waters with the percentage of immature plaice among those which are captured in the bays.

I have purposely omitted to deal with the relative merits of the pleas offered on behalf of the Start Bay longshoremen on the one hand and the trawlers on the other—partly because the case for the former admittedly rests, in part at least, on grounds which it does not come within my province to consider. I shall be willing to explain myself further on this point, in giving evidence before the Committee, should they desire it.

II. An examination of the figures given above will show that fishing in the two bays considered involves a considerable destruction of immature plaice and dabs. It will be seen also that the destruction of fish of all other species is insignificant. It now remains to consider the bearing of these facts on the practical question before the Committee.

The destruction of immature flat-fish has been held to be injurious to the fisheries for two different reasons by those who regard the question from two distinct points of view. The reason most commonly given for objecting to this destruction is that, by destroying an immature fish, you eliminate not the fish only, but its possible offspring. It is maintained on the other hand (and this view is held by some biologists) that the supply of larvæ is more than sufficient to maintain an adequate stock of large fish, and that the destruction of a certain number of immature fish is not to be deprecated on the ground that the number of eggs and larvæ produced at the next spawning season will be proportionately diminished. Those, however, who hold this view are no less anxious to put a stop to this destruction for quite a different reason.

It has been pointed out that a plaice 14 in. in length weighs twice as much as a plaice of 10 in., and that it would be more profitable to the fisheries if a 10 in. plaice was allowed to grow to 14 in. before being caught, doubling its weight in the process, than if it were destroyed at 10 in. And this statement certainly holds good, unless the mortality of plaice from natural causes is such as to reduce the number of 10 in. plaice by a half in the time they would take to grow to 14 in. And that this is the case is extremely improbable.

It will be seen, then, that the destruction of immature fish is objected to by some because these fish have not yet had a chance of reproducing their species, and by others because they have not yet grown to the size at which it would be most profitable to capture them; and it will be noticed that these two grounds of objection are not in themselves inconsistent with one another.

I have drawn attention to both these grounds of objection, because the criticism mentioned above—to the effect that the supply of larvæ is more than adequate, and that there is no reason for anxiety as to the consequences that may follow the destruction of a certain number of immature flat-fish—is not infrequently urged by those who have no special knowledge of the subject; and I am anxious to point out that whether this criticism be accepted or not, the position generally adopted still holds good—that the destruction of small flat-fish is to be deprecated.

It follows that, looking at the matter from a purely biological standpoint, we cannot regard with favour any proposal to effect a change in the bye-law which will permit the destruction of a greater number of under-sized flat-fish; and if such a change is to be advocated at all, it must be on grounds which it does not come within our province to consider.

It may, however, be reasonably asked whether, and if so to what extent, the fisheries in which the Committee is especially interested are likely to be benefited from a continuance of the restrictions now in force. Granting that an abolition of the restrictions against trawling within the areas under consideration would be detrimental to the fisheries as a whole by decreasing the number of flat-fish, have we any right to expect a material improvement, supposing that these restrictions remain in force? This question does not admit of a simple answer. Looking at the fisheries as a whole, it may, of course, be rightly said that the preservation of young flat-fish will be beneficial for reasons mentioned above; but if I am asked by the Committee to say whether restrictions enforced by them in a particular area will lead to an increase in the number and size of the flat-fishes in that area, I shall be unable to answer the question. I may be allowed to refer in this connection to certain experiments and observations made by the Naturalists under the Scotch Fishery Board.

The experiment of closing certain bays (part of the Firth of Forth and St. Andrew's Bay) to trawlers has been tried since 1886: and hauls have been regularly made in the closed areas, at intervals since that date, to test the effect of the closure. The results show that there have been fluctuations in the number of flat and round fishes in these closed areas, but no steady increase since the dates when the areas were first closed. This statement holds good, not only for the closed areas, but for the open areas adjacent to them.

It might, of course, be urged that this is enough to show that it is useless to close a particular area to trawlers, inasmuch as no increase in the number of fishes results from such a proceeding. But, granting that, as time goes on, the condition of the bays remains what it is—and no increase in the number of flat-fishes they contain is seen to result from the closure—the above conclusion would still, in my opinion, be unjustifiable. It would, in fact, only be justifiable if the flat-fishes inhabiting such a bay at any time were confined to that bay during the whole of their lives. But this is not what happens in Nature. Plaice, for instance, which, as a rule, are confined to inshore waters during the period of their immaturity, go out into deep waters to spawn. But it by no means follows that their offspring will return to the areas whence their parents came. I may quote Dr. Fulton (of the Scotch Fishery Board) on this point:—

"The floating eggs and larvæ derived from a particular spawning area may be carried considerable distances in a definite direction in a comparatively short space of time, and may hence form the source of supply, not to adjacent parts of the coast" (whence, presumably, the spawners came), "but to parts situated a considerable distance from it."

It will be seen, then, that before we can know what will be the effect of closing particular inshore waters, it is necessary to discover the spawning ground to which the fish from these waters resort, and then to determine the direction of the prevailing surface currents. Not till this has been done is it possible to say where the beneficial effect of closing any particular inshore waters is likely to be felt.

In the case of the areas in which I have conducted experimental trawlings, no information at present exists, so far as I am aware, on these points. It is not, therefore, possible to say whether the preservation of immature plaice and dabs in Start and Teignmouth Bays will lead to an increase in the number of these fish in the bays in question, or even in their immediate neighbourhood; but the general proposition still holds true, that the destruction of immature flat-fish is detrimental to the fisheries at large.

Further, it is impossible to give any answer to the question *to how great an extent* are the fisheries likely to benefit from the continuance of the present restrictions, or *what amount* of damage is likely to result from their abolition. It is impossible to make any quantitative estimate of the effect of closing a particular bay, unless we know among other things the proportion which the number of immature fish in the bay bears to the total number of fish of that species in the neighbouring district. And further, though of course it is true that the preservation of the immature fish in such a bay will result directly—and perhaps also indirectly—in an increase in the numbers of the species, the admission has to be made that we cannot be certain that the catches of any individual fishermen will be materially improved in consequence.

Before bringing this memorandum to a close, it is, I feel, necessary to point out that the considerations offered above are an attempt to set forth the view which I think must be taken by those who are interested in the welfare of the fisheries as a whole, of any proposal to remove restrictions which were designed for the preservation of the immature flat-fish. But I am aware that the question before the Committee may be complicated by considerations with which I have not attempted to deal.

The question which the Committee has immediately to consider—whether a particular change in the law should or should not be enacted—is not one which ought, in my opinion, to be directly put to any scientific authority. The immediate effect of such a change—the sudden imposition, for instance, of a size-limit, or the closure of certain inshore waters—may entail great hardship on particular "local communities." The Committee will be cognisant of the fact that a proposal in favour of a restrictive bye-law has been definitely opposed on the ground that particular local interests would be thereby endangered. An argument of this kind can only be dealt with by those who are acquainted with the nature and extent of the local interests involved; and it is possible that the disturbance caused to particular communities by a restrictive measure may be such as to render its enactment undesirable. Whether it is so or not, in any case before the Committee, I am not qualified to judge; and I am here only concerned to point out that, inasmuch as considerations of this kind lie outside the province of a biologist, but may properly be brought to the notice of the Committee, the responsibility of definitely advising the retention or abolition of a bye-law is one which I should do wrong to accept.

Notes on *Pontobdella muricata.*

By

The Hon. Henry Gibbs.

A *Pontobdella* lived in my tanks for about six months of the present year. I first placed it in a wide shallow tank with a variety of Actiniæ and a few Hermit Crabs, but no fish of any sort. When first introduced the leech was very restless, and wandered all over the tank. After a day or so, however, he took up his abode on the glass, close to the surface. He remained in this spot about three months, and if disturbed would always go back to it. He never noticed any of the other animals, and did not appear in the least sensitive to the stinging power of the tentacles of the Actiniæ. I have frequently seen him plunge his head and neck in amongst the tentacles of a large *Anthea cereus* who lived near him, and he treated *T. crassicornis* with a like disrespect.

So soon as the weather grew warm, the leech displayed signs of uneasiness, and finally left his place on the glass, and retired to a cool corner formed by the slate back and side of the tank, close to the syphons of the aerating apparatus, where he remained two months and a half.

He never appeared to notice sticks or nets moving near him in the water, but would remain in his usual position, viz., the base fixed to the wall of the tank, the body sticking out horizontally for about half its length, and the fore part doubled under, so that the mouth was pressed against the under side.

If, however, I placed my hand near him in the water he always displayed excitement; he would raise his head and most of his body completely out of the water and wave himself in the air, or more frequently he would feel about with his head in the water, going over the rocks and sand at the bottom of the tank, as if searching for food. He never detached his base on these occasions, and always drew sharply back if he touched my hand, so that he did not intend to bite me, as I at first suspected.

In *The Aquarium Naturalist* Professor Rymer Jones writes that the skate-leech becomes more active at the approach of evening, and that it rejects all subsistence when in confinement, though extremely voracious in the natural state. My *Pontobdella*, however, was neither more nor less active in the evening than at other times in the twenty-four hours. He certainly abstained from food during the first four months of his residence with me, not decreasing in size or appearing at all out of health during the whole of that time, so that I began to think he must have some miraculous power of fasting. I tried him with all sorts of food, such as raw meat, live shell-fish, live earthworms, live and dead wrasse, etc., but he would have none of them. At last, one day a flounder and a skate (both young) died within a day of each other in another tank, so I placed the flounder, who was only just dead, in the leech's tank, just under the latter's head. As usual, when the leech became aware of my hand being in the tank he began moving his head about, and in doing so touched the flounder several times; however, he took no more notice of it than if it had been a piece of rock, so I gently detached him from his place, and put him on the back of the flounder; the leech, however, instantly got off it and returned to his corner. I therefore concluded that live flat-fish were essential to him if he would feed at all in captiviy, for I did not think that one species of flat-fish would be less acceptable to him than another.

However, the skate died the next day, and I dropped him into the leech's tank, without expecting the latter to take any notice, any more than he had of the dead flounder. To my surprise, the skate had hardly touched the bottom of the tank when the leech detached his base and cast himself upon the skate's body, where he immediately fixed his base and sat upright with his head doubled down in the usual way; after a few minutes, he bit the skate's back in several places, evidently making vigorous but unsuccessful efforts to extract blood. His labours lasted about half an hour, and he then returned to his old corner, and took no further notice of the skate.

I observed that when about to attack his prey he did not move in his usual way, which is that of a fresh-water leech, viz., by first fixing his head and then drawing up his base after it. He simply detached his base, fell to the bottom of the tank, and extended himself till he was over the skate's body, then drew up the rest of his body till it lay sideways in a loose coil on the skate, and then fixed his base, *not* his head, on the lower part of the skate's wing.

Probably this method of attack is less alarming to a live fish than if the leech first seized with his head.

After this episode with the dead skate, I moved the leech into a much larger and deeper tank, wherein were many blennies, gobies, wrasse, etc., thinking that he might secure a wrasse when lying half on its side asleep at nights, as is the frequent custom of these fish.

The fish displayed no fear of the leech; on the contrary, several of them bit at him when he was first put in.

The leech, however, seemed extremely alarmed at the fish, and at once secreted himself between two large stones at the bottom of the tank, where he remained hidden for about a week without moving. I then introduced three young live skate into the tank, and extracting the leech from his hiding-place, put him on the back of one of them; he took no notice of it however, but immediately escaped to a rock fixed to the side of the tank. I left him there for the night, but in the morning the leech was fixed, as to his base, on the lower part of the wing of one of the live skate, in exactly the same place where he had settled on the dead skate.

There were traces of blood on the skate's back, and about an hour later the leech had fixed his mouth on the wing, and immediately in front of the leech's mouth there was a semi-circular mark of blood.

The two other skate died in the course of the day, but the third skate lived on for about twenty-four hours with the leech on his back. The latter must have extracted a quantity of blood, but he did not swell as does a fresh-water leech when gorged.

When *Pontobdella* had had enough he would raise himself upright in his usual position, and with his base still fixed to the skate, until he felt ready for another attack.

Finally he got off the skate, and hid himself completely under a stone, and a quarter of an hour after the leech had disappeared the skate died. The latter would probably have borne the leech's attack longer, had it not been enfeebled by a recent journey from Plymouth to London.

The leech remained in hiding for about a month after his meal, and I then removed him and the other animals from London to the country.

He had always appeared to dislike heat, and unfortunately, on arriving in the country, he was placed in a shallow vessel, the water in which had been greatly heated by the sun. He at once lost the power of attaching his base, and lay for three or four days on his side, coiled like a watch-spring, and then died. Given a live skate or so a year and cool water, I believe *Pontobdella* could be kept alive for an indefinite period.

Notes on the Reproduction of Teleostean Fishes in the South-Western District.

By

Ernest W. L. Holt and L. W. Byrne.

Morone labrax. *Linn.* Bass.

Towards the end of May a large female bass in one of the Aquarium tanks appeared to be approaching ripeness, and constantly swam round the tank followed by one or more of its companions, probably of the opposite sex. A fine-meshed net was accordingly placed over the overflow from the tank in question, and on the morning of the 29th May was found to contain a very large number of eggs, undoubtedly attributable to this species, the only other Teleostean inmates being turbot, congers, pollack, rocklings, and two species of wrasse.

All the eggs proved to be unfertilised, or, at most, showed only an approach to segmentation, which may have been due to the spermatozoa of a rockling. Circumstances seemed strongly to point to the fact that the eggs are not all shed at once, but owing to an unfortunate series of accidents with the net it is impossible to speak on this point with absolute certainty.

Although the bass is a common British fish, its ova find no place in the records of British naturalists, and are only known from the descriptions of Raffaele,* who obtained them both from parents living in the tanks of the Naples Laboratory and from the neighbouring sea.

The eggs observed by us at Plymouth are spherical, and, while living but unfertilised, measure from 1·25 to 1·34 mm. in diameter. Raffaele gives 1·155 to 1·2 mm. as the diameter of Naples examples. The latter have an oil-globule of ·332 to ·366 mm. The Plymouth eggs have often two or more oil-globules, which soon coalesce to form a single globule of ·39 or ·40 mm., pale yellowish to the naked eye, but perfectly colourless by transmitted light under the microscope.

* *Mittheil. Zool. Stat. Neap.*, viii., 1888.

Raffaele's ova are thus smaller than those which we have seen at Plymouth, and have a smaller oil-globule. This difference may perhaps be correlated to the size of the parent fish (as noted by one of us in the case of another species*), but Raffaele does not mention the dimensions of the Naples spawners. The Plymouth female measures about 28 inches, 70·2 cm., so far as we can judge. It is impossible to catch her without emptying the tank, a proceeding at present inconvenient. Bass, according to Risso† and Faber‡, grow, or used to grow, to a larger size than this in the Mediterranean and Adriatic, but Raffaele's examples may have been smaller.

The ova of the bass being easily recognisable, whether from the dimensions and proportionate size of the oil-globule, or from the pigmentation of the embryo, as described by Raffaele, it is somewhat remarkable that they should never have been found in British waters. Raffaele suggests that spawning may take place indifferently in either fresh or salt water, the ova in the former case developing at the bottom. In this district and at Newquay, young bass, from about two inches upwards, are found in the estuaries, and not, so far as we know, in the open sea, and we have taken a large female, with advanced ovaries, in the Tamar estuary. If spawning takes place in the estuary it is not remarkable that the ova should have escaped notice. Those deposited in the Plymouth tanks floated buoyantly in the Aquarium water, which is of somewhat lower specific gravity than that of the open sea, while Raffaele seems to have obtained all his specimens, other than those from the Naples tanks, at the surface. Experiments which he describes suggest that perfectly fresh water is deleterious to the ova (of parents that have been living in sea-water?), while brackish water is rather beneficial than otherwise to the larvæ, and does not injure the ova. As has been indicated by one of us,§ *Motella mustela,* a fish with typically pelagic eggs, almost certainly spawns to some extent in the Plymouth estuary. The local fishermen strenuously assert that the same is true in the case of the flounder, and may be quite correct in their opinion. It is, therefore, by no means impossible that the spawning of the bass takes place, in so far as concerns this district, rather in the estuaries than in the open sea.

Observations of spawning in an Aquarium give no reliable evidence as to the spawning season under natural conditions, since when both periods have been noted they have not been found to coincide. Our

* *Journ. M. B. Assoc.*, N.S., v., 1897, pp. 113 and 117.
† *Ichth. Nice*, p. 300.
‡ *Fisheries of the Adriatic*, p. 71.
§ *Journ. M. B. Assoc.*, N.S., v., No. 2.

large bass are very old members of the Laboratory staff, and, since no reproductive activity has been observed in previous years, it is quite probable that they may have lost count of the seasons.

Gobius niger. *Linn.*

In so far as concerns the neighbourhood of Plymouth, this species appears to be chiefly estuarine in distribution, being common throughout the year in the Hamoaze and in the lower reach of the Lynher river. We have little doubt but that spawning takes place to a large extent in the estuary, though, as a matter of fact, we have only found the ova, identified from Petersen's description and figures,* on an old tin trawled in Cawsand Bay on the 14th July.

Gobius paganellus. *Gm. Linn.*

In Plymouth Sound this Goby is common enough, between tide-marks and elsewhere, on rather rough ground, but has not been taken, to our knowledge, in any part of the estuaries. During the present spring a number of specimens were kept in a large table-tank in the Laboratory. In April two males assumed the breeding livery, which may, for the present, be sufficiently described as a deep purplish madder all over the head and body, and nearly black on the anterior parts, while the border of the anterior dorsal fin is cream-colour or orange. Nests were chosen under a flat stone leaning against the side of the tank, and under the convex valve of a scallop, *Pecten maximus.* Ova were deposited, in all probability by several females, but it is not possible to give the size of the parent of the specimens measured. The latter are from 1·84 to 1·90 mm. in length. The shape is rather regularly fusiform, the greatest width, rather less than half the length, occurring about the middle. The base is about one-tenth to one-twelfth of the length; the apex is in all cases somewhat pointed, in most examples most distinctly so, and never broadly rounded as in *G. niger.* The fixing apparatus differs in no important particular from that of *G. niger.* The yolk is opaque, and yellowish in colour.

Petersen (*op. cit.*, p. 7) has criticised a drawing given by one of us, which purports to represent the ova of *G. niger.* As appears from the text, the drawing and identification are those of Professor M'Intosh. In the light of our present observation it becomes evident that the parent species was *G. paganellus*, and not *G. niger.* In future, where the matter is not complicated by the occurrence of other large Gobies, such as *G. Friesii*, it should be easy to distinguish the ova of *G. niger*

* "On the eggs and breeding of our Gobiidæ." From the Danish Biological Station. 1891 (1892), p. 2, Tav. i. b.

and *G. paganellus* by the apex, which is bluntly rounded in the former and more or less acutely pointed in the latter. Spawn, evidently that of *G. paganellus*, has been found on several occasions, at Easter and in the early summer of 1897, attached to various objects between tide-marks on Drake's Island.

Gobius pictus. *Malm.*

The ova of *G. minutus* and *G. Ruthensparri* have been frequently observed at Plymouth, but require no further description than is afforded by the admirable memoirs of Guitel* and Petersen.† It is, perhaps, worthy of remark that males and females of the former species have been taken by one of us in full breeding condition during the first week of September of this year at Newquay, Cornwall. At Plymouth *G. minutus* begins to spawn at least as early as April.

So far as we are aware Mr. A. O. Walker is the only observer who has noticed (in Colwyn Bay) the occurrence of *Gobius pictus* in British waters (*cf.* Day, *Fish. Gt. Brit.*, i., p. 168), although it is quite possible that the species may have been recorded under other names. It is by no means rare on sandy and muddy ground, and among algæ and zostera in Plymouth Sound (Cattewater, Jennycliff Bay, N.E. of Drake's Island), and in Cawsand Bay. A single specimen has been taken in Bigbury Bay, and probably a little attention would show that the species occurs on many parts of our coasts.

We have not observed ova taken directly from the parent, but consider that this species is probably responsible for some spawn attached to a Pecten shell trawled near the Batten Breakwater on the 12th May, 1898. In dimensions and shape the ova approach the condition of *G. microps* (*cf.* Petersen, *op. cit.*, p. 3, tav. i. b., Fig. 11), a form closely allied to *G. pictus*, but unrepresented, so far as we can determine, in our district. The egg measures ·81 mm. in height. As in *G. microps*, it is swollen near the base, the greatest breadth being ·63 mm. Distally the lateral outline is somewhat compressed, while the apex, sometimes rounded, is usually very slightly acuminate. The shape is, therefore, intermediate between that of *G. Ruthensparri* and that of *G. microps*, but nearest to the latter. A newly-hatched larva measured 2·68 mm. in total length. The pigment differs from that of *G. minutus* in that yellow and black chromatophores extend in almost unbroken series along the dorsum and ventrum, to a point near the caudal extremity. Petersen gives no detailed description

* *Arch. Zool. Exper.*, S. II., x., 1892; S. III., iii., 1895.

† *Op. cit.* The ova and larva of *G. minutus* have also been described by one of us in *Ann. Mag. Nat. Hist.*, S. VI., 1890, p. 30.

of the larva of *G. microps;* but his drawing of the embryo indicates that the pigmentation of the two forms must be rather similar at the time of hatching.

Gobius Jeffreysii. *Günther.*

An old oyster shell, presumably dumped down with other rubbish by a harbour mud-hopper, was dredged on the 3rd July, 1898, about two miles S. by E. of the Plymouth Mewstone in about twenty-three fathoms of water. It was found to be coated on one side by the eggs of a Goby. The shell did not appear to be a recent contribution to the Mewstone ground, while the spawn was in an early stage of development, and may be supposed to have been deposited where found. No Goby was found in the net, but *G. Jeffreysii* is commonly taken on the same ground, where it is the only representative of its genus. In shape the ova differ from those attributed to *G. pictus,* chiefly in that the apex is always rounded and never acuminate. The height varies from ·72 to ·78 mm., the greatest breadth from ·55 to ·58 mm. The yolk is practically colourless. We have no observations of more advanced stages.

Gobius scorpioides. *Collett.*

According to Smitt (*Hist. Scand. Fish.*, Ed. II., i., p. 260) this Goby has hitherto been known from three specimens, of which two, 28 and 37 mm. long, were taken by G. O. Sars at twenty to sixty fathoms outside Stavanger and Hardanger fjords, while the third, 18·5 mm. long, was found by Winther at six fathoms in the S.W. of the Cattegat.

We are able to extend the range of the species to the British area, having taken a specimen on the 13th July, 1897, in the mouth of Falmouth Harbour at about eighteen fathoms, N. by W. of Anthony point, in a dredge full of dead shells, etc. It is a female measuring 21 mm. in total length. The ovaries are much distended, and contain apparently ripe ova loose in the lumen, with the outer layer of the zona everted.

The ova are mostly oval or ovoid in shape, but some show an approach to the shouldered condition common to other small species of the genus. Two measure ·52 and ·60 mm. in height by ·42 and ·39 mm. in greatest breadth, but these measurements do not allow for the expansion which probably takes place when the spawn is deposited in the ordinary way in sea-water, the specimen having been preserved in weak formol before its viscera were examined. The everted outer layer of the zona is similar to that of other Gobies, except that it shows hardly any perforations near the micropylar region, the numerous recticulo-radiate ridges being mostly united by a thin membrane.

G. scorpioides is certainly the smallest British Goby so far recorded. If common it is not likely to be often retained in the meshes of an ordinary net.

Aphia pellucida. *Nardo.*

We cannot find a description of the ova of this fish, though in other respects, thanks to Collett,* the cycle of its life-history is fairly well known. In the early part of July of the present year, adults of both sexes were rather numerous on the zostera and weed beds of the inner part of Cawsand Bay, the females being full of roe. They became scarce towards the end of the month, and none have been since taken. The abundance of this species in the estuary of the Lynher in April has already been noticed by one of us. (*Journ. M. B. A.*, vol. i., p. 89.)

None could be found there on the 21st July of the present year. If the fish is a permanent inhabitant of the estuary this would seem to indicate that the brood of last year, offspring of the half-grown examples met with in April, had already died off, having fulfilled the life-span of a single year allotted to them by Collett.† It is, however, possible that individuals move seawards from the estuary at the approach of maturity, while the larvæ in turn migrate to the estuary.

Though breeding adults were numerous, we failed to find the spawn attached to any object trawled or dredged in Cawsand Bay. Examination of the ovary of a female, 1¾ inches long, taken in the Bay on the 14th July, indicates that the ova are certainly demersal. The yolk, probably not quite mature, was transparent, colourless, and almost free from granulations. It consisted at this stage of an outer layer, enclosing an inner and more refractive part. After 15 hours in sea-water the ovum was evidently dead. It had become opaque and yellowish, the refractive part having been apparently broken up into a number of globules, bearing a general resemblance to those of Gobius. Under natural conditions it is probable that the yolk is not essentially different from that of Gobius, but less opaque and without conspicuous colouration. The zona is thin and without special markings. As in Gobius, it is enveloped in the ovarian condition by an outer membrane, which is everted when the follicle is ruptured, and forms the fixing apparatus. This outer membrane is, however, divided into a number of

* *Proc. Zool. Soc.*, 1878, i., p. 318.

† The brood of 1898, if present, would be too small to be retained in the net employed. It is possible that some larvæ, taken at the mouth of the Lynher in 1897, may have belonged to these species; they were not preserved.

fine threads which may spring directly in a single series from around the micropyle, or may be united for a very short distance proximally. In this respect the condition of Blennius is approached rather than that of Gobius, but the divergence from the latter type is only one of degree.

When freshly removed from the ovary the zona was spherical, and about ·44 mm. in diameter, the perivitelline space being small, but soon expanding in sea-water. About 15 hours after extension, such ova as were at all regular in outline had acquired a broadly oval shape, the yolk mass remaining round. One example measured 1·06 mm. by ·78 mm.; another, 1·25 mm. by ·95 mm. We cannot say how far either dimensions or shape conformed to the natural condition, as we were unable to effect fertilisation.

Crystallogobius Nilssonii. *Düb and Kor.*

This fish is exceedingly abundant on the Eddystone grounds and in the deeper part of Falmouth Bay, forming in these localities, as probably on all offshore grounds in the district, the chief food of half-grown dories (*Zeus faber*) and large scald-fish (*Arnoglossus laterna*). The latter is essentially a bottom fish, and all records with which we are acquainted tend to confirm Collett's opinion that Crystallogobius is an inhabitant of the lower strata of the water, if not actually a bottom fish to the same extent as the Gobies. However, on the 8th of May of last year a female was taken in a surface net near the Eddystone. It measures 22 mm. in total length. The ovaries contain eggs (transparent, like the rest of the animal, in the fresh condition) of which the largest measure about ·12 mm. in diameter. They are spherical, and not sufficiently mature to justify any conclusion as to their appearance in the ripe condition.

CORRIGENDA.

Capros aper (vol. v., pp. 44, 121). Advanced larvæ of about 5 to 6·5 mm., taken off Fowey, have been referred in my previous papers to Capros, chiefly on account of the pigmentation, since the specimens were not in the best state of preservation. This year I have had several opportunities of observing in the living condition a larva which certainly belongs to the same species, and is without doubt a young *Ctenolabrus rupestris.* It would be difficult to find a better illustration of the difficulty of determining a Teleostean larva at a stage when the skeletal characters are insufficiently developed for exact diagnosis, and especially when the conformation has been more or less obscured by post-mortem distortion, since it would appear that the larvæ of Capros, Crenilabrus, and several species of Lepadogaster all pass through phases characterised by one and the same pigmentation pattern. The identity of the pattern seems to be explicable neither by the taxonomic propinquity of the genera nor by protective adaptation.

Caranx trachurus. My attention has been drawn to several errors in my notes on this species (vol. v., p. 116). The yolk in *Temnodon saltator* is actually described by Agassiz and Whitman as having only cortical segments, instead of becoming segmented throughout as in the ova which I attribute to Caranx. The difference is one of degree, since yolk segments when present in ripe eggs seem to be the survivors of the yolk spherules of ovarian stages (*cf.* Raffaele, *Mitth. Zool. Stat. Neap.*, viii., 1888, p. 21), although it is only in the supposed Caranx eggs that these segments have been seen to divide and to encroach upon, and finally occupy all parts of the yolk after deposition. I have also spoken of Raffaele's species, No. 3 (*loc. cit.*, p. 64) as doubtfully assigned by its discoverer to Coryphæna, whereas Raffaele really says that, while recognising the resemblance to Coryphæna, he considers that No. 3 probably belongs to a family nearly related to the Clupeidæ. If this view were correct one would expect to see at the larval stage, depicted in Tav. iv., Fig. 9, some trace of transverse folds in the lining membrane of the intestine.

The young Caranx, mentioned in vol. v., p. 119, were taken between Puffin Island and Bray Head, Co. Kerry. In recording them from the Irish Sea I was misled by a similarity of names in the two localities.

E. W. L. H.

The Great Silver Smelt, *Argentina silus*, Nilss. An Addition to the List of British Fishes.

By

Ernest W. L. Holt.

By the kindness of Mr. J. Jacobs, to whom the Laboratory is already indebted for many specimens of interest, I received on the 15th June a fine example of the species mentioned above, which had been trawled off the south coast of Ireland. The fish weighed 1 lb. 5 oz., and measured 42 cm., or 16½ inches. Though taken at least a day previously, it was in excellently fresh and firm condition. I have already recorded its capture in a letter to the *Field* and at a meeting of the Zoological Society, but the locality was inexactly given in each of these communications. I have since learned that the correct locality is 50° 20′ N., 8° 25′ W., or about seventy-five miles true S. of the Old Head of Kinsale, depth seventy-four fathoms. A number of the same species were trawled, and some were found to be excellent eating. I have no means of deciding whether the occurrence of *A. silus* on the ground indicated is normal or exceptional. If it can be taken in any quantity it should prove a valuable addition to our list of food-fishes.

I can find no previous record of *A. silus* in British waters, since Edward, according to Day, acknowledged that his specimen was identical with the species figured and described by Day, which is the lesser silver smelt, *A. sphyræna*, Linn. Other European records are from the Scandinavian and Jutland coasts, always in water of considerable depth. The species is also known from the Atlantic coasts of North America. A good figure is given by Smitt (*Hist. Scand. Fish.*, Ed. 2, II.), who states that all the examples of which he has acquaintance had the stomach everted by the expansion of the air-bladder, and so yielded no evidence as to the nature of the food. In my specimen the air-bladder was not abnormally dilated, and the œsophagus and stomach were filled with a mass of finely triturated animal matter, which appeared, judging from experience in similar cases, to be the muscular tissue of shrimps or prawns. A much macerated telson, the only hard part found, appeared to belong, most probably, to a shrimp, certainly to that section of the *Crustacea macrura* which embraces the shrimps and prawns. I also found a single copepod, identified by Mr. T. V. Hodgson as *Calanus finmarchichus.* The latter is often met with at the bottom, and has been found by myself in the stomachs of pleuronectids, while all available evidence seems to indicate that *A. silus* is a bottom-haunting fish.

Ichthyologists will observe that this record sensibly extends the range of *A. silus* in a southerly direction. Comment on the matter may well be withheld until we possess even an elementary knowledge of the fauna of the deeper parts of our own region. It is hardly necessary to add that the specimen has been handed over to the custody of the British Museum.

Notes and Memoranda.

Callionymus maculatus. *Bonap.* Since the species was added to the English fauna in the last number of this journal, three specimens have been taken in the neighbourhood of Plymouth. One of these lived for two months in the Aquarium, remaining for the most part half buried in fine gravel. It was only once observed to take a *Nereis diversicolor,* the favourite food, in our tanks, of *C. lyra,* but showed considerable liking for Gammarids.

Phrynorhombus unimaculatus. *Risso.* A male, measuring $4\frac{5}{8}$ inches, was taken four miles south of the Plymouth Mewstone on the 9th May, 1898. It appears to be the only specimen that has been taken near Plymouth since the Laboratory has been in existence.

Motella cimbria. *Linn.* A specimen taken from the stomach of a hake trawled in or off the Bristol Channel, was sent to the Laboratory on the 16th September, 1898. It measures 21·7 cm. ($8\frac{1}{2}$ in.) in total length, and differs from described members of the species in the great length of the first dorsal ray. The length of this structure is 5·2 cm., that of the head being 3 65 cm. I have since seen an Irish specimen with the first ray similarly prolonged. E. W. L. H.

Sepia elegans. *d' Orb.* (Jatta, "Fauna u. Flora d. Golfes v. Neapel, Cefalopodi" = *S. biserialis,* Verany; Gwyn Jeffreys, Brit. Conch.). During the summer of last year (1897) this species was taken not infrequently on the trawling grounds inside the Eddystone. This year three examples have been brought to the Laboratory. The largest of these, measuring in length 7·5 cm., including the sessile arms, was obtained on the trawling ground off Plymouth, while the others were taken off Bolt Head ($3\frac{1}{2}$ m. S., 33 fms.).

Since there appears to be some confusion with regard to the species of this genus, especially in the use of the name *Sepia elegans,* it is necessary to state that our specimens agree with the figures and description of *S. elegans* given by Jatta in the Naples monograph (the shell in particular is characteristic). They also agree with Gwyn

Jeffreys' description of *S. biserialis*, Verany, which is considered by Jatta to be synonymous with *S. elegans*, d'Orb., as is also *S. rupellaria*, d'Orb., these two latter having no sufficiently important characters to entitle them to separate specific rank. On the other hand, the *Sepia elegans*, de Blainville, of Gwyn Jeffreys' Brit. Conch., is a distinct species equivalent to the *S. orbignyana*, Férussac. This, according to Jatta, is the *S. elegans* of Norman's Revision of the Brit. Moll. (*Ann.* and *Mag.*, 1890) also. Previous British records for our species are Polperro and Mawgan Porth in Cornwall, Swansea, North Coast of Ireland, and Northumberland. Apparently in some, if not most, cases dead shells only were obtained. E. W. L H. and W. I. B.

Mysis longicornis. *Milne Edwards.* This species, which we believe to be an addition to the known fauna of the Atlantic area, was found to be somewhat abundant in Start Bay, S. Devon, at the end of July last (1898). It was taken on fine gravel and sandy ground off Blackpool and Slapton Sands in from 5 to 8 fathoms, in company with *Mysidopsis gibbosa* and *M. Angusta*, these in comparatively small numbers, and single specimens of *Siriella armata*, and of a form approaching, though not agreeing exactly with, *S. Clausii.*

So far as we have been able to ascertain, *M. longicornis* has not previously been obtained outside the Mediterranean, and therein only at Naples (M. Edwards, G. O. Sars, &c.), and according to Carus (*Prod. Faunæ Mediterr.*), at Algiers (Lucas).

This species can hardly be assigned to any of the genera of Mysinæ, as defined by Norman ("British Mysidæ," *Ann.* and *Mag.*, 1892). It would appear to come near to *Neomysis*, with which it agrees in having the third pair of pleopods in the male unmodified, and like the first, second, and fifth pairs differing in no material respect from those of the female.* Were Norman's definition of the sub-family strictly enforced, both would, as a matter of fact, be excluded from the Mysinæ by this character.

Mysidopsis angusta. *G. O. Sars.* This species was found in Start Bay on the same ground as *Mysis longicornis* in July, 1898, as noted above. It was taken in the same locality in the early part of the summer of the previous year.

The finding of *Mysidopsis angusta* on the South Devon coast adds considerably to the known range of the species in North-Western European waters, where it had not previously been taken further south than the Dogger Bank (Scott, "Crustacea from the Dogger Bank,

* Compare the figures of Sars: *Middelhavets Mysider*, Pl. X., Fig. 13, and *Monograph over Mysider*, Pl. XXXIV., Fig. 17.

collected by Ernest W. L. Holt," *Ann.* and *Mag.*, 1894). It was, however, known to occur at Naples (G. O. Sars, *Middelhavets Mysider*).

We hope to prepare a further publication on the Schizopoda of the Plymouth district shortly.

NOTE.—Since the above was written we have found that *Mysidopsis angusta* is recorded from Valencia Harbour, on the west coast of Ireland, by A. O. Walker. (*Trans. Liverpool Biol. Soc.* xii. 1898, p. 164.)

E. W. L. H. and W. I. B.

Malformation of the Mouth in the Common Sea-Bream.— Yarrell has published in his work on British Fishes (vol. i., p. 110) a sketch of Couch's, which represents an abnormal condition of the mouth in the Common Sea-Bream (*Sparus centrodontus*), caused, according to Yarrell, by the "want of intermaxillary bones." The effect is to give the fish a characteristic "short-nosed" appearance, and to cause the lower jaw to protrude considerably in front of the head. At the same time the mouth is reduced to a small tubular orifice, which leaves the anterior half of the lower jaws permanently exposed. Mr. Dunn, of Mevagissey, recently forwarded to the Laboratory a Bream which exhibited this same abnormality. It was caught in a seine at Mevagissey on September 30th, and in all other respects was in good condition. Its length, from the tip of the lower jaw to the fork of the tail, is 9½ inches; its maximum depth, 3¼ inches. The puzzle propounded by Mr. Dunn was how a fish with such a mouth could manage to eat anything, especially as in his specimen the aperture of the mouth is reduced to an even greater extent than in Couch's, the fleshy cheek and nasal membranes having grown forwards and downwards, so as to leave only the teeth on the anterior extremity of the lower jaw exposed, the lateral teeth being completely covered. The aperture of the mouth is spoon-shaped, and measures ¼ inch in long diameter, and slightly more than ⅛ inch across. It is quite incapable of closure or of expansion. As I had seen a similar "short-nosed" Bream at Plymouth earlier in the summer, it would appear that this extraordinary abnormality is curiously common in this species and in this locality—a matter which seemed to merit enquiry. I have, therefore, carefully compared Mr. Dunn's specimen with a normal Bream, and, with Mr. Dunn's assistance, am able, I think, to offer a complete explanation.

The stomach of the abnormal fish was greatly distended with food, which consisted principally of pieces of green algæ, both *Ulva* and *Enteromorpha*, among which were to be found a small number of

Amphipod Crustaceans and the late larva of a shrimp or prawn, which was too much digested to admit of closer identification. The stomach also contained, remarkably enough, the cleanly excised stomach of another fish, which contained Copepods and other small plankton organisms in a sufficiently fresh state to admit of easy identification. The stomach was clearly that of a Clupeoid, with a characteristic tough, gizzard-like pyloric portion, and it is, in fact, the stomach of a pilchard, as I have found by comparison. Mr. Dunn tells me that, along with the abnormal Bream, there were taken in the seine about a dozen other Bream, about 30 Red Mullets, a few flat-fishes, and about 3000 pilchards. He says that the fishermen were very anxious to see if the pilchards were fat or not, and that, in order to see their condition, the men may have unmeshed and opened one before tucking the seine, and thrown its stomach in the sea. There can be no doubt that this explanation is correct, but it is curious that this bit of jetsam should have fallen to the lot of the fish which was worst provided with organs of prehension. Although, however, the abnormality described undoubtedly deprives the fish of all power of using its teeth, it does not affect its powers of suction; and, as observations in the Aquarium have shown that this means of catching small prey is very commonly employed by fishes, it is no doubt by this means that the abnormal Bream succeeded in securing its supply of Amphipods and other booty.

As regards the structure of the abnormal mouth, Yarrell is right in attributing its main peculiarity to the absence of the intermaxillary (or premaxillary) bone. But in the specimen examined by me this is not the only defect, for one of the maxillary bones, viz., the right, is also wanting, while the left persists. This asymmetry in the abnormality suggests the result of injury rather than a congenital malformation, and confirms a view as to the origin of the abnormality which has been communicated to me in a letter from Mr. Dunn. I will quote his remarks *verbatim*:—

"It is known to our people, when they anchor on certain high rocks, that the Sea Bream, in all its stages, is the most pertinaceous, persistent, and obdurate enemy that our Pollack fishers have, never leaving the bait rest one moment, if the Pollack is not in the immediate neighbourhood of the end of the line. This vexes the fisherman very much, and when he feels them tearing and mangling his bait, and making it unfit for Pollack food, in his excitement he often jerks the line with all the might of his arm. Sometimes one of the batch (for there are generally several there) will be hooked on the outside, but if hooked on the top of the mouth his top jaw is sure to be pulled away. This I have seen done more than once."

Mr. Dunn adds that the specimen forwarded to us was by no means unique, as similar ones occur at Mevagissey from time to time, one of which, caught in 1896, he still preserves. He concludes that the deformity is caused by the fishermen in the above-mentioned way, the injury to the mouth being gradually repaired, although its structure is permanently modified, by the forward growth of the soft cheek tissues, as already described. My observations entirely support this view of the origin of the abnormality.

There is one point to which I will draw attention in conclusion. Hitherto, to the best of my knowledge, this deformity has not been recorded as occurring elsewhere than on the Cornish coast. I should be glad, therefore, if fishermen and sea-anglers generally would be good enough to forward to the Director of this Laboratory any similarly abnormal specimens of the Sea Bream which they may come across, in order that the distribution of the abnormality may be recorded. It would appear to be possible to make use of the facts as evidence in connection with the winter movements of the fish, especially if such specimens should be captured in the early part of the season. In such a case the injury must have been produced in the preceding season, before the winter migration.

WALTER GARSTANG.

Marine Biological Association of the United Kingdom.

Report of the Council, 1897–98.

The Council and Officers.

Four ordinary meetings of the Council have been held during the year, at which the average attendance has been 9.

The Council records with regret the death of Lord Revelstoke, who for the past eight years has been one of the Vice-Presidents of the Association, and rendered it much valuable assistance in connection with dredging and oyster culture in the river Yealm, near Plymouth.

The Council has again to acknowledge the courtesy of the Royal Society in granting the use of its rooms for the meetings of the Association.

The Plymouth Laboratory.

The buildings, fittings, and machinery have been maintained in good condition.

An apparatus designed for the purpose of keeping pelagic animals alive in small aquaria, by maintaining a constant movement in the water, has been fitted up in the Laboratory, and has given satisfactory results. This apparatus was originally designed by Mr. E. T. Browne, in conjunction with the Director of the Laboratory, for keeping medusæ in a healthy condition, and amongst the animals which have been successfully reared through their larval stages to the adult form are *Chætopterus*, *Cladonema radiatum* (hydroid reared from the medusa), *Syncoryne sp.* (from the medusa), *Nika edulis*, and *Capitella capitata*.

The Boats.

The *Busy Bee* has been constantly at work, and a great deal of dredging and trawling has been satisfactorily done in the immediate neighbourhood of Plymouth, especially around the Eddystone. In addition to this, expeditions have been made to the eastward to

Dartmouth and Exmouth, and to the westward to Fowey and Falmouth. The sailing boat *Anton Dohrn* has also been used for collecting in Plymouth Sound.

The Staff.

No change has taken place in the staff during the year.

The Council would again draw attention to the fact that the equipment of the Laboratory and boats is now sufficiently complete to allow of a very much larger amount of scientific work being done, if the services of more naturalists could be retained for lengthened periods. It is in this direction that the Council looks forward to the development of its work, although any such development is impossible without an adequate increase in the income of the Association.

The Library.

The thanks of the Association are due to Mr. J. P. Thomasson for a donation of £20 for the purchase of books for the Library and for binding, and to the Zoological Society of London for an almost complete set of their publications from the year 1832. With the help of Mr. Thomasson's donation Smitt's valuable work on Scandinavian fishes has been purchased, and the publications of the Zoological Society have been bound.

It has been necessary to fix a number of new shelves in the Library in order to accommodate the increasing number of books.

The Council has again to thank the Royal Society, the Zoological Society, the United States Commissioner of Fish and Fisheries, the Royal Microscopical and many other societies, for copies of their current publications, as well as those authors who have presented separate copies of their works.

General Report.

In compliance with the requirements of H.M. Treasury, mentioned in last year's Report of Council, special attention has been given to investigations relating to the habits and migrations of the mackerel. In addition to the preparation of the report on the subject forwarded to H.M. Inspectors of Irish Fisheries, which has since been published in the Journal of the Association, Mr. Garstang has been specially engaged in studying the characteristics of mackerel captured in various localities and at different seasons of the year, in order to determine whether distinct races of this fish can be recognised. Samples have been obtained from the western portion of the English Channel, the west coast of Ireland (through H.M. Inspectors of Irish Fisheries), the North Sea, from America, and from other localities, and a report on the subject is in preparation. At the same time systematic investigations are in progress with reference to the general question of the movements of the migratory fishes, more especially of the mackerel, in connection with the periodic movements of the floating organisms upon which these fishes, directly or indirectly, depend for their food supply, and also with the changes in the physical conditions of the sea, especially with regard to density and temperature.

Mr. Holt has paid much attention to questions connected with the reproduction and development of the fishes living in the neighbourhood of Plymouth, and their distribution at different ages. A memoir dealing with these questions has been published in the Journal of the Association, and Mr. Holt has also given evidence on the subject at an enquiry, held by the Board of Trade, having reference to a bye-law proposed by the Devon Sea Fisheries Committee.

The experiments with floating bottles for determining the surface-drift in the English Channel have been continued, and a report upon the results of the first year's work in this direction has been published.

The systematic dredging and trawling of the grounds between the Eddystone and Start Point have been proceeded with, and the results are now being prepared for publication.

A collection of specimens of fishes, and other marine animals which serve as food for fishes or are used as bait, was arranged and exhibited by the Association at the Yachting and Fisheries Exhibition, held during the summer of 1897 at the Imperial Institute. This collection has since been on view at the Laboratory at Plymouth.

Occupation of Tables.

The following naturalists have been engaged in research work at the Plymouth Laboratory during the year:—

W. I. Beaumont, B.A., Cambridge (Nudibranchiata).
F. P. Bedford, B.A., Cambridge (Myriothela).
G. Brebner, University College, Bristol (Algæ).
E. T. Browne, B.A., University College, London (Medusæ).
L. W. Byrne, B.A., Cambridge (Teleosteans).
A. H. Church, B.A., Oxford (Algæ).
J. T. Cunningham, M.A., Penzance (Crabs).
G. Duncker, Ph.D., Kiel (Variation of Fishes).
F. W. Gamble, M.Sc., Owens College, Manchester (Nervous System of Polychætes).
E. S. Goodrich, B.A., Oxford (Polychætes).
N. B. Harman, M.B., Cambridge (Eyes of Fishes).
T. V. Hodgson, Plymouth (Crustacea).
J. W. Jenkinson, B.A., Oxford (Larvæ of Crustacea).
W. F. Lanchester, B.A., Cambridge (Phoronis).

M. Lubbock, M.D., London (Fishes).
E. W. MacBride, M.A., Montreal (Development of Echinodermata).
E. A. Minchin, M.A., Oxford (Protozoa).
S. D. Scott, B.A., Cambridge (Ascidians).
T. H. Taylor, M.A., Yorkshire College, Leeds (Polyzoa).
W. F. R. Weldon, F.R.S., University College, London (Variation of Crabs).
N. Wylde, London (Variation of Galathea).

Prof. Hickson, F.R.S., of Owens College, Manchester, sent his assistant to the Laboratory, to collect material for his researches on the development of Alcyonium.

Mr. Garstang again conducted a vacation class in Marine Biology, which was attended by eight students from Oxford, Cambridge, and the Yorkshire College.

Published Memoirs.

Amongst the papers, either wholly or in part the outcome of work done at the Laboratory, which have appeared elsewhere than in the Journal of the Association, are the following:—

Bethe, A.—*Das Nervensystem von Carcinus Mænas*, i., ii., and iii. Archiv für Mikroskopische Anatomie, l., 1897, pp. 460-546, 589-639; and li., 1898, pp. 383-452.

Browne, E. T.—*On British Medusæ.* Proceed. Zool. Soc. London, Nov. 16, 1897, pp. 816-835.

Brumpt, E.—*Sur un Copépode nouveau parasite de Polycirrus aurantiacus, Grube.* Comptes rendus, June 21, 1897.

Church, A. H.—*The Polymorphy of Cutleria multifida.* Annals of Botany, xii., No. 45, pp. 75-109.

Cunningham, J. T.—*On the Early Post-Larval Stages of the Crab (Cancer pagurus), and on the Affinity of that Species with Atelecyclus heterodon.* Zoological Society, March 15, 1898.

Garstang, W.—*On some Modifications of Structure subservient to Respiration in Decapod Crustacea which burrow in Sand.* Quart. Journ. Micr. Sci., vol. 40, pp. 211-232.

Harmer, S. F.—*On the Development of Tubulipora, and on some British and Northern Species of this Genus.* Quart. Journ. Micr. Sci., vol. 41, pp. 73-157.

Holt, E. W. L.—*On the breeding of Callionymus lyra in the Marine Biological Association's Aquarium at Plymouth.* Zoological Society, April, 1898.

Donations and Receipts.

The Receipts for the year include the Annual Grants from H.M. Treasury (£1000), and the Worshipful Company of Fishmongers (£400), Composition Fees (£30), Annual Subscriptions (£144), Rent of Tables in the Laboratory (£84), Sale of Specimens (£232), Admission to the Aquarium (£76), Special Donations (£35). The total receipts for the year amount to £2039.

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1898–99:—

President.

Prof. E. Ray Lankester, LL.D., F.R.S.

Vice-Presidents.

The Duke of Argyll, K.G., K.T., F.R.S.
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 Tweedmouth.
Lord Walsingham, F.R.S.
The Right Hon. A. J. Balfour, M.P., F.R.S.
The Right Hon. Joseph Chamberlain, M.P.
The Right Hon. Sir John Lubbock, Bart., M.P., F.R.S.
Prof. G. J. Allman, F.R.S.
Sir Edward Birkbeck, Bart.
Sir Wm. Flower, K.C.B., F.R.S.
A. C. L. Günther, Esq., F.R.S.
Prof. Alfred Newton, F.R.S.
Rev. Canon Norman, D.C.L., F.R.S.
Sir Henry Thompson.
Rear-Admiral Sir W. H. L. Wharton, K.C.B., F.R.S.

Elected Members.

F. E. Beddard, Esq., F.R.S.
Prof. F. Jeffrey Bell, F.Z.S.
G. C. Bourne, Esq., F.L.S.
Sir John Evans, K.C.B., Treas. R.S.
G. Herbert Fowler, Esq.
S. F. Harmer, Esq., F.R.S.
Prof. W. A. Herdman, F.R.S.
Prof. S. J. Hickson, F.R.S.
J. J. Lister, Esq.
Sir John Murray, F.R.S.
P. L. Sclater, Esq., F.R.S., Sec. Z.S.
D. H. Scott, Esq., F.R.S.
Prof. Charles Stewart, F.R.S.
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. Burdon Sanderson, F.R.S. (Oxford University).
Prof. Michael Foster, F.R.S. (Cambridge University).
Sir William Flower, K.C.B., F.R.S. (Brit. Assoc. for Advmnt. of Science).

Dr. *Statement of Receipts and Expenditure for the Year ending 31st May, 1898.* Cr.

Receipts.	£ s. d.	£ s. d.
To Balance from last year, being Cash in hand, less Overdraft at Bank		198 11 4
,, H.M. Treasury		1000 0 0
,, Fishmongers' Company		400 0 0
,, Composition Fees and Donations—		
J. P. Thomasson	20 0 0	
J. Straker	15 15 0	
W. F. Lanchester	15 0 0	
W. F. Sinclair	10 10 0	
W. J. Adams	3 3 0	
L. W. Byrne	1 1 0	
		65 9 0
,, Annual Subscriptions		143 17 0
,, Rent of Tables	84 3 0	
,, Sale of Specimens	232 3 0	
,, Sale of Journal	17 19 9	
,, Admission to Tank Room	76 3 9	
		410 9 6
,, Interest on Investment		19 6 8
		£2237 13 6

Expenditure.		£ s. d.	£ s. d.
By Salaries and Wages—			
Director		200 0 0	
,, Allowance for Assistant		5 11 0	
Naturalist		239 11 8	
Wages		485 1 6	
			930 4 2
,, Stationery, Office Printing, Postages, &c.			170 12 8
,, Printing and Illustrating Journal			98 13 6
,, Sundry Expenses—			
Gas, Water, Coal, Oil, &c.	£100 11 6		
Coal and Water for Steamer	40 17 6		
		141 9 0	
Insurance of Steamer		12 7 6	
Stocking Tanks, Feeding, &c.		76 12 10	
Glass, Chemicals, Apparatus, &c.	£104 10 2		
Less Sales of Glass	15 13 8		
		88 16 6	
Maintenance and Renewals of Buildings, Boats, and Nets	£270 0 2		
Less Sales of Nets and Gear	17 16 5		
		252 3 9	
Rates and Taxes		4 6 0	
Boat Hire		10 0 0	
Travelling Expenses		31 0 6	
Expenses of Exhibition of Specimens		37 0 6	
Library		80 18 9	
			734 15 4
,, Balance forward, being Cash at Bank and in hand, 31st May, 1898			303 7 10
			£2237 13 6

Investment held May 31st, 1898, £500 Forth Bridge Railway 4% Guaranteed Stock.

Examined and found correct,

(Signed) EDWIN WATERHOUSE,
STEPHEN E. SPRING RICE,
W. F. R. WELDON,
G. HERBERT FOWLER, } *Auditors.*

June 23rd, 1898.

Director's Report.

The paper by Mr. Garstang in the present number of the Journal contains a full account of his researches, so far as they have at present proceeded, on the question of the different races of the mackerel. In addition to this work Mr. Garstang has been investigating the food of the mackerel, for which purpose a large number of the stomachs of the fish have been preserved and their contents examined. At the same time the distribution in the sea of the various floating and free-swimming organisms, which constitute the greater part of the food of the mackerel and other migratory pelagic fishes is being investigated, and an attempt is being made to correlate the movements of these organisms with changes in the physical conditions of the sea-water, as indicated by observations of its temperature and density. The experiments with floating bottles for determining the direction and rate of the surface drift are also being continued.

At the beginning of September, Mr. Garstang attended the International Fisheries Congress at Dieppe, and there submitted a proposal for a joint Anglo-French investigation of the physical and biological conditions of the English Channel during the year 1899. This proposal met with the support of the French naturalists, and a resolution was passed expressing the desirability of forming an Anglo-French committee to co-operate with the Marine Biological Association in the matter. At the meeting of the British Association in Bristol, a grant of £100 was made towards carrying out the suggested scheme of investigation, and Mr. H. N. Dickson promised his assistance in carrying out the physical parts of the work.

Mr. Holt, who during the summer continued his observations on the distribution of young stages of fishes in this neighbourhood, has now proceeded to the west coast of Ireland, where he is taking charge of the fishery investigations, which are being resumed by the Royal Dublin Society in that district.

On p. 296 will be found the report on the trawling experiments in the Bays on the South Coast of Devon, which were carried out at the instance of the Devon Sea Fisheries Committee. These experiments were commenced by Mr. Stead in 1895, and have since been continued by Mr. Scott and Mr. Holt. The present report, drawn up by Mr. Holt, deals with the experiments in their more immediately practical aspect, as affecting those problems which the Sea Fisheries Committee has had under consideration. The investigations have at the same time furnished valuable material for the discussion of general questions relating to the distribution of fishes at different ages, and of the food upon which they live in the various localities. It has been thought better however not to include this material in the present report, but to reserve it, together with much similar material collected in the neighbourhood of Plymouth, until sufficient observations have been brought together to form the basis for a comprehensive discussion of these subjects.

The following is a list of the naturalists who have occupied tables at the Laboratory since the publication of my last Report, and of the subjects which have specially engaged their attention:—

Beaumont, W. I., B.A., May 2nd to October 5th (*Mollusca and Nemertina*).
Brebner, G., April 2nd to April 19th, and July 26th to August 6th (*Marine Algæ*).
Browne, E. T., B.A., April 4th to June 4th (*Hydrozoa*).
Byrne, L. W., B.A., May 27th to June 3rd (*Pisces*).
Church, A. H., M.A., D.Sc., March 30th to April 16th (*Marine Algæ*).
Gamble, F. W., M.Sc., March 28th to April 29th (*Nervous system of Polychæta*).
Gemmill, J. F., Ph.D., August 30th to September 6th (*Polychæta*).
Gilson, Prof., August 29th to September 6th (*General*).
Goodrich, E. S., B.A., April 2nd to April 19th (*Polychæta*).
Gurney, E., July 1st to July 25th (*Echinodermata*).
Harman, E. B., M.B., March 19th to April 2nd (*Pisces*).
MacBride, Prof., M.A., May 17th to June 30th (*Echinodermata*).
MacMunn, C. A., M.D., June 7th to June 18th (*Aplysia*).
Moore, J. E. S., September 6th to September 14th (Collecting).
Pethybridge, G. H., B.Sc., Sept. 5th to October 8th (*Marine Algæ*).
Scott, S. D., B.A., April 18th to April 26th (*Tunicata*).
Taylor, T. H., M.A., March 26th to April 9th, and August 3rd to September 30th (*Polyzoa*).
Todd, R. A., B.Sc., September 19th to October 8th (*Mollusca*).
Weldon, Prof., F.R.S., July 12th to August 22nd (*Variation of Crabs*).
Woodward, M. F., August 2nd to September 14th (*Mollusca*).

In addition to the above, eight students from Oxford, Cambridge, and Yorkshire College, Leeds, attended Mr. Garstang's class during the Easter vacation.

A party of members of the International Congress of Zoology, which met this year in Cambridge, visited the Laboratory, and took part in two dredging excursions in the *Busy Bee* on August 31st.

During the Bristol meeting of the British Association a number of marine tanks were exhibited by the Marine Biological Association at the Zoological Gardens, Clifton.

Some alterations have been made in the arrangement of the Aquarium, which have proved advantageous in rendering the tanks more attractive, and in effectively exhibiting some of the smaller fishes and invertebrates. Additional storage room, which has long been badly needed, has been added to the Laboratory by the erection of a galvanized-iron shed at the back of the building.

E. J. ALLEN.

October, 1898.

LIST

OF

Governors, Founders, and Members.

1st OCTOBER, 1898.

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* £4705
The University of Oxford £500
Bayly, Robert, *Torr Grove, Plymouth* £1000
Bayly, John (the late) £600
Thomasson, J. P., *Woodside, near Bolton* £970

II.—Founders.

* Member of Council. † Vice-President. ‡ President.

1884 The Corporation of the City of London £210
1888 The Worshipful Company of Drapers, *Drapers' Hall, E.C.* £315
1884 The Worshipful Company of Mercers, *Mercers' Hall, Cheapside* ......£341 5*s.*
1884 The Worshipful Company of Goldsmiths, *Goldsmiths' Hall, E.C.*....... £100
1889 The Worshipful Company of Grocers, *Poultry, E.C.* £120
1884 The Royal Microscopical Society, 20, *Hanover Square, W.* £100
1884 The Royal Society, *Burlington House, Piccadilly, W.* £350
1884 The Zoological Society, 3, *Hanover Square, W.* £100
1884 Bulteel, Thos., *Radford, Plymouth* £100
1884 Burdett-Coutts, W. L. A. Bartlett, 1, *Stratton Street, Piccadilly, W.*.... £100
1888 Bury, Henry, M.A., *Trinity College, Cambridge* £100
1884 Crisp, Frank, LL.B., B.A., Treas. Linn. Soc., 17, *Throgmorton Avenue, E.C.* £100
1884 Daubeny, Captain Giles A., 30, *Cornwallis Crescent, Clifton, Bristol* ... £100
1884 Eddy, J. Ray, *The Grange, Carleton, Shipton, Yorkshire* £100
1884 Gassiott, John P., *The Culvers, Carshalton, Surrey* £100
‡*1884 Lankester, Prof. E. Ray, F.R.S., *British Museum (Natural History), South Kensington, S.W.* £100
1885 Derby, the Rt. Hon. the late Earl of £100
1884 Lister, S. Cunliffe, *Swinton Park, Masham, Yorkshire* £100

†1884 Lubbock, The Rt. Hon. Sir John, Bart., M.P., F.R.S., *High Elms, Bromley, Kent* £100
1884 Poulton, Prof. Edward B., M.A., F.R.S., *Wykeham House, Oxford* ... £100
1889 Revelstoke, The late Lord £100
1890 Riches, T. H., B.A., *Kitwells, Shenley, Herts.* £130
1884 Romanes, G. J., LL.D., F.R.S. (the late) £100
†1889 Thompson, Sir Henry, 35, *Wimpole Street, W.* £110
*1887 Weldon, Prof. W. F. R., F.R.S., 30A, *Wimpole Street, W.* £100
1884 Worthington, James (the late) £100

III.—Members.

ann. signifies that the Member is liable to an Annual Subscription of One Guinea.
C. signifies that he has paid a Composition Fee of Fifteen Guineas in lieu of Annual Subscription.

1897 Adams, W. R., 59, *Fleet Street, E.C.* .... *ann.*
1884 Alger, W. H., *Manor House, Stoke, Devonport* .... *C.*
†1884 Allman, Prof. G. J., F.R.S., *Ardmore, Parkstone, Dorset* £20
*1895 Allen, E. J., B.Sc., *The Laboratory, Plymouth* .... *ann.*
1889 Anderson, Dr. John, 71, *Harrington Gardens, S.W.* £20
†1884 Argyll, The Duke of, K.G., *Argyll Lodge, Kensington, W.* .... *C.*
1885 Armstrong, Lord, C.B., F.R.S., *Crag Side, Rothbury* .... *C.*
1893 Ascroft, R. L., 11, *Park Street, Lytham, Lancs.* .... *ann.*
1892 Assheton, R., *Birnam, Cambridge* £20

1884 Bailey, Charles, F.L.S., *Ashfield, College Road, Whalley Range, Manchester* *ann.*
1893 Bailey, W. E., *Porth Enys Museum, Penzance* .... *C.*
1884 Balfour, Prof. Bayley, F.R.S., *Royal Botanic Gardens, Edinburgh* ...... *C.*
1893 Bassett-Smith, P. W., Staff-Surgeon, R.N., 118, *North Side, Clapham Common, London, S.W.* .... *ann.*
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, B.Sc., *St. Cuthberts, West Heath Road, Hampstead.* *ann.*
1884 Bayly, Miss, *Seven Trees, Plymouth* £50
1884 Bayly, Miss Anna, *Seven Trees, Plymouth* £50
1897 Baynes, R. W., 4, *Saltram Place, Plymouth* .... *ann.*
1884 Beaumont, W. I., B.A., *The Laboratory, Plymouth* .... *ann.*
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, F. P., B.A., 326, *Camden Road, London, N.* .... *ann.*
*1884 Bell, Prof. F. Jeffrey, 35, *Cambridge Street, Hyde Park, W.* .... *ann.*
1887 Berrington, A. D., *Pant-y-Goitre, Abergavenny* .... *ann.*
1890 Bidder, George, B.A., *Ravensbury Park, Mitcham, Surrey* .... *C.*
1885 Bignell, Geo. Carter, F.E.S., *The Ferns, Home Park Road, Saltash, Cornwall* .... *ann.*
†1885 Birkbeck, Sir Edward, Bart., 10, *Charles Street, Berkeley Square, W.* ... *ann.*
1893 Bles, A. J. S., *Palm House, Higher Broughton, Manchester* .... *ann.*
1889 Bolitho, T. B., M.P., *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, Henry, M.P., *Forty Hall, Enfield* .... *ann.*
1895 Bridge, Prof. T. W., D.Sc., *Mason College, Birmingham* .... *ann.*
1890 Brindley, H. H., M.A., 9, *Richmond 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.*
1886 Bullar, Miss Anna K., *Westbourne Hill, Southampton* .... *ann.*
1896 Bulstrode, H. P., M.D., 4, *The Mansions, Earls Court, S.W.* .... *ann.*
1887 Burd, J. S., *Cresswell, Higher Compton, Plymouth* .... *ann.*
1889 Burnard, Robert, 3, *Hillsborough, Plymouth* .... *ann.*
1897 Byrne, L. W., B.A., 33, *Lancaster Gate, London* .... *ann.*

1884 Caine, H. T., 5, *Upper Wimpole Street, London, W.* .... *C.*
1884 Caine, W. S., *The Terrace, Clapham Common, S.W.* £21
1887 Caldwell, W. H., *Birnam, Cambridge* .... *C.*
1884 Canterbury, His Grace the Archbishop of, *Lambeth Palace, S.W.* .... *ann.*
†1884 Chamberlain, Rt. Hon. J., M.P., 40, *Princes Gardens, S.W.* .... *ann.*
1884 Christy, Thomas Howard, *Malvern House, Sydenham* .... *ann.*
1887 Clarke, Rt. Hon. Sir E., Q.C., M.P., 5, *Essex Court, Temple, E.C.* £25
1884 Clay, Dr. R. H., *Windsor Villas, Plymouth* .... *ann.*
1885 Clerk, Major-Gen. H., F.R.S., 40, *St. Ermin's Mansions, Caxton Street, S.W.* £21
1886 Coates and Co., *Southside Street, Plymouth* .... *C.*
1885 Collier Bros., *Old Town Street, Plymouth* .... *C.*
1890 Cook, C. H., M.A., *Elmlea, South Stoke, Reading* .... *ann.*
1889 Crossman, Major-General Sir William, K.C.M.G., *Goswick House, Beale, R.S.O., Northumberland* .... *ann.*

1885 Darwin, Francis, F.R.S., *Botanical Laboratory, Cambridge* .... *C.*
1885 Darwin, W. E., *Ridgemount, Bassett, Southampton* £20
1889 Davies, H. R., *Treborth, Bangor* .... *ann.*
1884 Dewick, Rev. E. S., M.A., F.G.S., 26, *Oxford Square, Hyde Park, W.* ... *C.*
1885 Dixey, F. A., M.A., Oxon., *Wadham College, Oxford* .... £26 5*s.* *and ann.*
1890 Driesch, Hans. Ph.D., *Stazione Zoologica, Napoli* .... *C.*
†1889 Ducie, The Rt. Hon. the Earl of, F.R.S., *Tortworth Court, Falfield, R.S.O.* £50 15*s.*
1884 Dunning, J. W., 4, *Talbot Square, W.* .... £26 5*s.*
1884 Dyer, W. T. Thiselton, M.A., C.M.G., F.R.S., *Director of the Royal Gardens, Kew* .... *C.*

1893 Edward, S. Stanley, F.Z.S., *Kidbrook Lodge, Blackheath, S.E.* .... *ann.*
1898 Eliot, C. N. E., *The British Embassy, Washington, U.S.A.* .... *ann.*
1891 Ellis, Hon. Evelyn, *Rosenais, Datchet, Windsor* .... *C.*
1893 Enys, John Davies, *Enys, Penryn, Cornwall* .... *ann.*
*1884 Evans, Sir John, D.C.L., Treas. Roy. Soc., *Nash Mills, Hemel Hempstead* £20
1885 Ewart, Prof. J. Cossar, M.D., *University, Edinburgh* £25

1894 Ferrier, David, M.A., M.D., F.R.S., 34, *Cavendish Square, W.* .... ann.
1884 Fison, Frederick W., *Greenholme, Burley-in-Wharfedale, Leeds* .... C.
*†1884 Flower, Sir W. H., K.C.B., F.R.S., 26, *Stanhope Gardens, London, S.W.* C.
1897 Foster, Richard, *Windsworth, Looe, R.S.O.* .... ann.
*1885 Fowler, G. Herbert, B.A., Ph.D., 12, *South Square, Gray's Inn, W.C.*... ann.
1884 Fox, George H., *Wodehouse Place, Falmouth* .... ann.
1886 Freeman, F. F., *Abbotsfield, Tavistock, S. Devon* .... C.
1884 Fry, George, F.L.S., *Carlin Brae, Berwick-on-Tweed* £21
1884 Fryer, Charles E., *Board of Trade, S.W.* .... ann.

1898 Ganz, C., 5, *Kildare Terrace, Bayswater, London* .... ann.
1892 Galton, F., F.R.S., 42, *Rutland Gate, S.W.* .... ann.
1885 Gaskell, W. H., F.R.S., *The Uplands, Shelford, Cambridge*.... .... C.
1885 Gaskell, E. H., *North Hill, Highgate, N.* .... C.
1893 Gatty, Charles Henry, LL.D., F.L.S., *Felbridge Place, East Grinstead* ... C.
1897 Gibbs, Hon. Henry, 10, *Lennox Gardens, S.W.* .... ann.
1884 Gibson, Ernest, F.Z.S., c/o Fraser, Stoddart, and Ballingall, 16, *Castle Street, Edinburgh*.. ann.
1885 Gordon, Rev. J. M., *St. John's Vicarage, Redhill, Surrey* .... ann.
1885 Gotch, Prof. F., F.R.S., *University Museum, Oxford* .... ann.
1888 Goulding, F. H., *George Street, Plymouth* .. .. C.
1884 Grove, E., *Norlington, Preston, Brighton* .... ann.
1884 Groves, J. W., *Wargrave Lodge, Wargrave-on-Thames* .... ann.
†1884 Günther, Dr. Albert, F.R.S., 2, *Lichfield Road, Kew Gardens* .... ann.

1884 Haddon, Prof. Alfred C., M.A., *Innisfail, Hills Road, Cambridge* ...... ann.
1884 Halliburton, Prof. W. D., M.D., B.Sc., 9, *Ridgmount Gardens, Gower Street, W.C.* .... ann.
1884 Hannah, Robert, 82, *Addison Road, Kensington, W.* .... C.
1897 Hargreaves, P., *The Fishery, North Hayling, Hants.* .... ann.
*1885 Harmer, S. F., D.Sc., F.R.S., *King's College, Cambridge*.................... C.
1889 Harvey, T. H., *Cattedown, Plymouth* .... ann.
1888 Haselwood, J. E., 3, *Lennox Place, Brighton*.. C.
1884 Haslam, Miss E. Rosa, *Ravenswood, Bolton* £20
1884 Hayne, C. Seale, M.P., 6, *Upper Belgrave Street, S.W.* .... ann.
1884 Head, J. Merrick, F.R.G.S., J.P., *Ardverness, Reigate*....................... .. ann.
1884 Heape, Walter, *Heyroun, Chaucer Road, Cambridge*............................ C.
*1884 Herdman, Prof. W. A., F.R.S., *University College, Liverpool* .... ann.
1884 Herschel, J., Col., R.E., F.R.S., *Observatory House, Slough, Berks.* ...... C.
1884 Heywood, James, F.R.S., 26, *Palace Gardens, W.* .... C.
1889 Heywood, Mrs. E. S., *Light Oaks, Manchester* .... C.
*1884 Hickson, Prof. Sydney J., M.A., D.Sc., F.R.S., *Ellesmere House, Wilenslow Road, Withington, Manchester*.. ann.
1897 Hodgson, T. V., 7, *Addison Road, Plymouth*.. ann.
1884 Holdsworth, E. W. H., F.L.S., F.Z.S., *Lucerne House, Dartmouth* . .... ann.
1893 Holt, Mrs. Vesey W., 104, *Elm Park Gardens, S.W.* .... ann.
1887 Howes, Prof. G. Bond, F.R.S., F.L.S., *Science and Art Department, South Kensington* .... ann.
1884 Hudleston, W. H., M.A., F.R.S., 8, *Stanhope Gardens, South Kensington, S.W.* .... ann.

1891 Indian Museum, *Calcutta* .... ann.
1888 Inskip, Capt. G. H., R.N., 22, *Torrington Place, Plymouth* .... ann.

1885 Jackson, W. Hatchett, M.A., F.L.S., *Pen Wartha, Weston-super-Mare* *ann.*
1893 Jago, Edward, *Menheniot, Cornwall* .... *ann.*
1887 Jago-Trelawny, Major-Gen., F.R.G S., *Coldrenick, Liskeard* .... *C.*
1890 Johnson, Prof. T., D.Sc., F.L.S., *Royal College of Science, Dublin*......... *ann.*
1892 Joshua, Mrs., 57, *Cadogan Square, S.W.* .... *ann.*
1894 Justen, F. W., F.Z.S., c/o Dulau and Co., 37, *Soho Square, W.* .... *ann.*

1884 Kellock, W. B., F.L S., F.R.C.S , 94, *Stamford Hill, N.*......... *ann.*

1897 Lanchester, W. F., B.A., *King's College, Cambridge*......... *C.*
1885 Langley, J. N., F.R.S., *Trinity College, Cambridge* .... *C.*
1885 Lea, A. S., M.A., *Caius College, Cambridge* .... *ann.*
*1895 Lister, J. J., M.A., *St. John's College, Cambridge* .... *ann.*
1888 Lopes, The Rt. Hon. Sir Massey, Bart., *Maristow, Roborough, South Devon* .... *ann.*

1885 Macalister, Prof. A., F.R.S., *St. John's College, Cambridge* .... *ann.*
1884 Mackrell, John, *High Trees, Clapham Common, S.W.* .... *C.*
1886 MacMunn, Charles A., *Oak Leigh, Wolverhampton* .... *ann.*
1889 Makovski, Stanislaus, *Fairlawn, Red Hill* .... *ann.*
1885 Marr, J. E., M.A., *St. John's College, Cambridge* .... *C.*
1884 Mason, Philip Brookes, *Burton-on-Trent* .... *ann.*
1884 McAndrew, James J., *Lukesland, Ivybridge, South Devon* .... *ann.*
1884 McIntosh, Prof. W. C., F.R.S., 2, *Abbotsford Crescent, St. Andrews, N.B.* *C.*
1884 Michael, Albert D., *Cadogan Mansions, Sloane Square, S.W.*......... *C.*
1885 Mocatta, F. H., 9, *Connaught Place, W.* .... *C.*
1886 Mond, Ludwig, F.R.S., 20, *Avenue Road, Regent's Park, N.W.*......... *C.*
1884 Morgan, Prof. C. Lloyd, *University College, Bristol*......... *ann.*
1891 Morgans, Thomas, 60, *Queen Square, Bristol*......... *ann.*
†1889 Morley, The Rt. Hon. the Earl of, 31, *Prince's Gardens, S.W.* .... *ann.*
1885 Morrison, Alfred, 16, *Carlton House Terrace* ....£52 10*s.*
*1896 Murray, Sir John, K.C.B., F.R.S., *Challenger Lodge, Wardie, Edinburgh* *ann.*

†1884 Newton, Prof. Alfred, M.A., F.R.S., *Magdalen College, Cambridge* £20
†1884 Norman, Rev. Canon, M.A., D.C.L., F.R.S., *The Red House, Berkhamsted, Herts.* .... *ann.*

1884 Ommanney, Admiral Sir Erasmus, K.C.B., F.R.S., 29, *Connaught Square, W.* .... *ann.*

1885 Paget, Sir James, Bart., F.R.S., 5, *Park Place, W.*......... *C.*
1898 Parkinson, J., 251, *Camden Road, London, N.*......... *ann.*
1884 Parsons, Chas. T., *Norfolk Road, Edgbaston, Birmingham* .... *ann.*
1888 Pennsylvania, University of, *Philadelphia, U.S.A*......... *ann.*
1885 Phillips, Chas. D. F., M.D., 10, *Henrietta Street, Cavendish Square, W.* *C.*
1887 Phipson, Mrs., *Cumballa Hill, Bombay*......... *ann.*
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.*

1897 Quentin, C., *Milland, Liphook, Hants.* .... *ann.*
1893 Quintin, St. W. H., *Scampstone Hall, Rillington, Yorks* .... *ann.*

1884 Radford, Daniel, *Mount Tavy, Tavistock* .... *ann.*
1884 Ralli, Mrs. Stephen, 32, *Park Lane, W.* £30
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.*
1898 Row, J. H., 26, *Strand Road, Calcutta* .... *ann.*
1892 Rüffer, M.A., M.D., *Bacteriological Institute, Cairo* .... *ann.*

1897 Sandeman, H. D., 4, *Elliot Terrace, Plymouth* .... *ann.*
1888 Scharff, Robert F., Ph.D., *Science and Art Museum, Dublin* .... *ann.*
*1884 Sclater, P. L., F.R.S., Sec. Zool. Soc., 3, *Hanover Square, W.* .... *ann.*
1884 Sclater, W. L., *The Museum, Cape Town* .... *ann.*
*1885 Scott, D. H., M.A., Ph.D., F.R.S., *Old Palace, Richmond, Surrey* .... *C.*
1884 Sedgwick, A., M.A., F.R.S., *Trinity College, Cambridge* .... *C.*
1888 Serpell, E. W., 19, *Hill Park Crescent, Plymouth* £50
1898 Seyd, Ernest, 87, *Edith Road, West Kensington, London, S.W.* .... *ann.*
1885 Sheldon, Miss Lilian, *The Murmurs, Exmouth* .... *ann.*
1884 Shipley, Arthur E., M.A., *Christ's College, Cambridge* .... *C.*
1886 Shore, T. W., M.D., *The Warden's House, St. Bartholomew's Hospital, E.C.* .... *ann.*
1894 Simpson, F. C., J.P., *Maypool, Churston Ferrers, R.S.O.* .... *ann.*
1885 Sinclair, F. G., *New Museums, Cambridge* .... *C.*
1891 Sinclair, William F., 102, *Cheyne Walk, Chelsea, S.W.* .... *C.*
1884 Skinners, the Worshipful Company of, *Skinners' Hall, E.C.* £42
1889 Slade, Commander, E. J. Warre, *Milton Heath, Dorking* .... *C.*
1884 Sladen, W. Percy, 13, *Hyde Park Gate, S.W.* .... *ann.*
1893 Sorby, H. C., LL.D., F.R.S., *Broomfield, Sheffield* .... *ann.*
1888 Spencer, Prof. W. Baldwin, M.A., *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.*
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.*
1897 Travers, J. A., *Dorney House, Weybridge* .... *ann.*
1888 Tripe, Major-General, 3, *Osborne Villas, Stoke, Devonport* .... *ann.*

1888 Vallentin, Rupert, 1, *Melville Road, Falmouth* .... *ann.*
1891 Vaughan, Henry, 28, *Cumberland Terrace, N.W.* .... *ann.*
1884 Venning, Mrs., 3, *Wingfield Villas, Stoke, Devonport* £50
1884 Vines, Professor Sydney H., M.A., D.Sc., F.R.S., *Botanical Gardens, Oxford* .... *ann.*

1884 Walker, Alfred O., *Nant-y-glyn, Colwyn Bay, N. Wales* .... *ann.*
1884 Walker, P. F., 36, *Princes Gardens, S.W.* .... *ann.*
†1884 Walsingham, Lord, F.R.S., *Merton Hall, Thetford* £20
1890 Waterhouse, Edwin, *Feldmore, near Dorking* .... *ann.*
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OBJECTS

OF THE

Marine Biological Association of the United Kingdom.

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

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

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

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

The Association has received some £30,000, of which £14,000 has been granted by the Treasury. The annual revenue which can be at present counted on is about £1,820, of which £1,000 a year is granted by the Treasury, the remainder being principally made up in subscriptions.

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

The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

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On the Fauna and Bottom-Deposits near the Thirty-Fathom Line from the Eddystone Grounds to Start Point.

By

E. J. Allen, B.Sc.

Director of the Plymouth Laboratory.

With Charts I. to XVI.

INDEX OF CONTENTS.

Section I.

INTRODUCTION.

The investigation described in the present paper was commenced in 1895, with the aid of a grant of £100 from the Government Grant Committee of the Royal Society to meet the expenses of boat-hire, and a further grant of £25 has been made by the Society to assist in the production of the charts by which the paper is illustrated. The object of the investigation has been to gain an accurate knowledge of the distribution of the fauna on the sea-bottom over a continuous area, in order to ascertain and where possible to explain the changes which take place in the animal population when the nature of the bottom-deposit changes. At the same time it was hoped that fresh light would be thrown upon the general question of the distribution of life on the sea-bottom and the principles upon which it depends. It appeared that an investigation of this character gave promise of serving the double purpose for which the Marine Biological Association was founded, namely, to increase our scientific knowledge of marine animals, and to obtain information having a direct bearing upon problems connected with sea-fisheries. It does not, I think, require any elaborate argument to demonstrate what is brought out clearly in detail in the present report, that the inter-relations between the different animals living in one neighbourhood are so intimate and complex that one cannot hope to understand the natural history of any particular group, such as the fishes, without a knowledge of the whole fauna of which that group forms a part.

Since the principal object of the investigation was to study the relation of the fauna to the bottom-deposit, the area selected for examination was so chosen that the general physical conditions prevailing over the whole of it were uniform, and showed no very marked differences in any feature beyond the changes in the nature of the deposits. The hauls were all made at nearly similar depths, the thirty-fathom line being roughly followed from the Eddystone to Start Point. (See Charts I.–XVI.) Probably the only variable factor which is of any importance at all, in addition to the bottom-deposit, is the amount of disturbance of the bottom water due to the action of waves, which is discussed on p. 375.

On the western portion of the area the Eddystone Lighthouse, standing as it does upon a reef which rises abruptly with water of thirty fathoms depth all round it, forms a valuable landmark, and enables one to determine without much difficulty the positions of the different stations.

The instrument used in making the collections has been for the most part an ordinary naturalist's dredge, the mouth of which was from 2 ft. 6 in. to 3 ft. long and 6 to 8 inches deep. On the finer grounds a small otter-trawl and a small beam-trawl (27 ft. beam) have also been employed. For obtaining actual samples of the bottom-deposits a dredge fitted with a canvas bag inside the ordinary net was used.

About 100 hauls of the dredge or trawl were made altogether, and so far as practicable every species captured was identified and recorded, note being made of its relative abundance, and in the case of fixed species, of the objects to which the specimens were generally attached. It was afterwards found possible to group together many of these hauls, which having been made close to one another showed a similar fauna and bottom-deposit, and these groups have been called *grounds*. In all eighteen grounds have been recognised.

As already stated, the investigation was commenced in 1895, and it was continued each year till 1898, the hauls having been made at different seasons, but for the most part during the summer. At these depths there appears to be little change in the fauna at different times of the year, excepting in the case of the migratory fishes.

In the identification of the species I have received very great assistance from my colleagues, as well as from many naturalists who have from time to time worked in the Laboratory, and without this assistance it would have been impossible to have attempted to give so full an account of the fauna of the grounds as I am now able to do. I would therefore express my great indebtedness to Prof. Weldon, Messrs. W. Garstang, E. W. L. Holt, T. V. Hodgson, E. T. Browne, W. I. Beaumont, T. H. Riches, and T. H. Taylor for the help which has been so readily given. The particular groups in which each naturalist has assisted will be found mentioned in Section VI. It must be understood, however, that the responsibility for the statement that a species occurs upon any particular ground is in all cases my own.

My thanks are also due to Mr. R. H. Worth for the geological examination of the samples of bottom-deposits, and for the determination of the amounts of carbonate of lime which they contain. Mr. Worth's principal contribution will be found at page 381: others are enclosed in square brackets, and are followed by his initials.

With regard to the names adopted for the different species, my one object has been to make my meaning understood as readily as possible. For most of the groups therefore some standard monograph has been made use of, the name of which is stated in each case, and the nomenclature there given has been employed. In a few cases old and well-established names have been retained in place of later but less known ones.

It will, I think, be clear to anyone studying the results of this investigation that information of great value would result from a comparison of the faunas of these grounds with those found in similar situations around the British coasts. Although a great deal of dredging has been done, very little information has as yet been published in a form available for making such comparisons, and as will be again pointed out (see p. 377), the accounts of the nature and texture of the bottom-deposit require to be much more definite and detailed than those which have generally been given.

Even when one seeks for knowledge of the true centre of distribution of a species, either of its geographical or of its bathymetric distribution, it is remarkable in how few instances this can be ascertained from the published accounts. If we are ever to obtain an accurate knowledge of the adaptation of species to their environment they must be studied at their centres of distribution, in those localities where they are exceptionally abundant, for it is there that the species is kept true, and it is to the conditions there prevailing that the species is most perfectly adapted. So much attention has in the past been devoted to the rarer species occurring in any district that the exact conditions under which the common and prevailing forms exist have often received but little attention. Yet the fact that a species is rare in any locality no doubt in most cases means that it is only imperfectly adapted to the conditions there prevailing, and that if the locality were cut off from communication with the real centre of distribution the species would soon cease to exist in it. Illustrations of this could be almost indefinitely multiplied. One case in point is referred to in some detail on p. 473.

It is clear, therefore, that much yet remains to be done all round our coasts in the way of dredging work. A number of detailed surveys in the different districts and in water of different depths is what is really required. Continuous areas should where possible be examined, samples of the bottom-deposits obtained, and all the physical conditions observed. The nature of the fauna should in each case be described in such a way that the common and characteristic species are clearly indicated and given due prominence, and the inter-relations of the different species pointed out. Special attention should be directed to all spots where any one species is exceptionally plentiful, in order to ascertain as exactly as possible the conditions under which it is best able to flourish.

Section II.

THE CAUSES WHICH INFLUENCE THE DISTRIBUTION OF LIFE ON THE SEA-BOTTOM.

In this section I propose to give a brief summary of some of the more important causes influencing the distribution of the animals and plants which live on the sea-bottom, as it will be necessary to constantly bear these causes in mind in considering the nature of the fauna on the various grounds to be described. This summary is based largely on the writings of Forbes, Gwyn Jeffreys, Wyville Thompson, Norman, Berthold, Herdman, M'Intosh, Petersen, and Walther.

The definite distribution of animals and plants in the sea, as on the land, is due to causes some of which are obscure, whilst others, and perhaps the most important ones, are sufficiently obvious. They may, as a matter of convenience, be divided into two classes, the physical causes and the biological causes. The physical causes are the result of those physical conditions which immediately affect the life of the individual members of a species. The biological causes include, in addition to such as are due to the structure and activity of the organism itself, all those influences to which a species is subjected in consequence of the existence at the same time of other living organisms. Such influences may be spoken of as the result of the *external biological conditions* to which the species is subjected. In ultimate analysis, however, the external biological conditions affecting the distribution of a species in any locality are themselves largely, if not entirely, due to physical conditions acting in the same or in neighbouring localities.

Since the assemblage of animals and plants forming the fauna and flora of any particular area is merely a collection of a number of individual species, the causes determining its nature will be the same as those which determine the distribution of species. In the present paper we are more particularly concerned with the distribution of a portion of the bottom fauna and flora of the sea, of those organisms which live in intimate relation with the bottom-deposit and are captured by the use of the naturalist's dredge or of the trawl.

I. Physical Conditions.

Those physical conditions, the variations of which influence the life of bottom-living species, are capable of definite statement, and for the most part of accurate measurement. They are—

1. The constitution of the sea-water.
2. The nature of the bottom-deposit.
3. The movements of the water, due to
    (*a*) wave action,
    (*b*) currents,
    (*c*) tides.
4. The temperature of the sea-water.
5. The pressure, varying with the depth of water, to which the organisms are exposed.
6. The amount of light which penetrates to the sea-bottom.

1. *The Constitution of the Sea-water.* Variations in the constitution of the sea-water of sufficient importance to have any marked effect upon the bottom-living animals and plants are only met with in the neighbourhood of the land. These variations are (1) the addition of fresh-water, indicated by a lowering of density, which is the result of the land-rainfall; (2) the presence of soluble substances derived from the drainage of the land; (3) the presence of solid substances in suspension either brought down directly by the land-water, or stirred up by the action of waves on the coast and in shallow parts of the sea, and (4) in all probability the amount of oxygen and carbonic acid dissolved in the sea-water.

Of these four variable factors the second, the presence of soluble substances derived from the drainage of the land, has never, so far as I am aware, received any attention, although in many localities, especially in enclosed estuaries, it is probably of considerable importance in influencing the distribution of animal and plant life.

The incursion of fresh-water is a factor which is liable to great variation. At times of exceptional flood the influence of a river will be felt at a much greater distance from shore than at other times. In considering the physical conditions of any particular ground it is necessary to bear this in mind, and to know whether it is or is not subject to such periodic incursions of water of low density at regular or irregular intervals. It is a well-known fact that marine animals are liable to be injured by a *sudden* change in the density of the water of a much smaller amount than that to which they can quite well become accustomed, provided the change takes place gradually.

2. *The Nature of the Bottom-deposit.* Since the time of the earliest marine naturalists it has been fully recognised that one of the principal factors in determining the distribution of marine animals and plants is the nature of the bottom-deposit or substratum upon which they live.

The nature of the substratum varies both as to the kind of material of which it is composed and as to the texture of that material. The kind of material forming the bottom-deposit may be either inorganic, when it varies with the geological formation of the particular locality, or it may be organic, consisting of the skeletal remains of marine organisms, in which case it varies according to the fauna of the locality. Deposits composed almost entirely of organic remains have been termed *neritic deposits* by Herdman. The texture of the bottom-deposit varies from solid rock or large stones to gravel, sand, and the finest mud. Amongst marine animals and plants, especially amongst the former, a great variety of adaptations are found for fixing, for boring, for burrowing, and for locomotion, specially suited to the particular kind of bottom upon which the organism generally lives. In very few cases, however, have the different kinds of bottom-deposit, upon which a particular species can live, been accurately ascertained, and one of the results of such investigations as that detailed in the present report is to obtain additional evidence on such questions.

3. *The Movements of the Water.* (*a*) *Wave action.* The important influence exerted by the action of the waves on animals and plants living between tide-marks, or in water of only a few fathoms depth, has always been recognised by naturalists, and many of the adaptations of structure and habit, by means of which this action is combated, have been pointed out. It was not, however, until the appearance of Hunt's paper (No. 54) on the influence of wave currents that the atten-

tion of naturalists was directed to the fact that this factor was in all probability of great importance to animals living even at such depths as 30 or 40 fathoms, at any rate in those seas which are subject to large waves and to strong tidal currents. Even since the publication of this suggestive paper the subject does not appear to have received the attention which it deserves. Hunt bases his conclusions not only upon his own observations of objects trawled from a depth of 40 fathoms in the English Channel, but he publishes a letter from Sir George Stokes, in which the subject is treated from a mathematical standpoint, the conclusions being such as to entirely agree with those which had been drawn from observation. Hunt points out in detail some of the adaptations of animals living in shallow water to resist this movement of the waves.*

(*b*) *Currents.* From the point of view of the distribution of bottom-living marine organisms currents are important (1) as the bearers of a large and important food-supply; (2) as a means of distribution of the larvæ of many animals and the spores of plants; (3) as influencing in many places the nature of the bottom-deposit; (4) from the alterations which they may produce in the density and temperature of the water, and (5) from their power of sweeping away such organisms as are insufficiently fixed.

(*c*) *Tides.* It would be beyond the scope of the present paper to enter into a discussion of the peculiar conditions found within the belt of sea-coast which is alternately exposed to the air and covered by the sea with the ebb and flow of the tide. The highly special character of the fauna and flora due to this cause is well known, and has often been described.

The currents produced in shallow seas, such as those around the English coasts, by the action of the tidal wave, influence the bottom-fauna in the same ways as do currents due to other causes.† These have already been sufficiently indicated, but in the case of the tidal current one important difference must be noted. In the great majority of instances the tidal current runs alternately in opposite directions, and it would not therefore be likely to bring such an abundant food-supply as a steady current progressing at the same rate, nor would it tend to distribute larvæ over a very large area.

This equal alternation of the tidal current is often greatly modified in the immediate neighbourhood of the coast, especially where bays and inlets of the sea abound. In such localities the current may run for a much longer time in one direction than in the other.

* For a further discussion of this subject see pp. 375 and 457.

† The strength of the bottom tidal current, as indeed of all bottom currents, in the seas around the British Isles is a subject about which definite information is very much needed.

4. *Temperature of the Sea-water.* There seems to be some difference of opinion amongst recent writers as to the extent to which temperature is a determining cause in the distribution of marine species.

The following general principles appear to be beyond dispute.

Change of temperature, having regard both to the amount of the change and to the rapidity with which the change takes place, is of greater importance in its influence upon marine life than the actual degree of temperature, though at the same time the latter must not be considered to be without effect.

For each species there is a maximum rate of change of temperature which the species is able to endure without injury, and this rate of change differs greatly for different species.

Each species is specially adapted to flourish within a particular range of temperature, which differs both in actual degree and in extent of range for different species.

It also seems probable that, provided the change takes place sufficiently slowly, the particular range of temperature to which a species is adapted may alter, and a race of the species may arise adapted to a temperature range different to that of the species in general. Whether or not selection plays a part in the formation of such races it is impossible in the present state of knowledge to say.

5. *Pressure.* The range of many species in depth is very great, so that it is evident—and the fact has been sufficiently recognised since the time of Forbes and Gwyn Jeffreys—that pressure in itself has little influence on the distribution of marine animals, unless the differences of pressure are very great indeed.

6. *The Amount of Light which penetrates to the Sea-bottom.* The extent to which light penetrates the sea-water is one of the most important factors in determining the distribution of marine life, since on it depends the existence of the plant life upon which animals ultimately depend for their food supply.

Berthold has shown that different species of marine algæ require different light-intensities in order to flourish at their best. Some grow only where the light is very strong, the majority, however, attain their maximum development in situations which are to some extent shaded, or in which the intensity of the light is modified by the depth of water through which it has to pass.

The amount of light which penetrates the sea-water and becomes available for bringing about the assimilation of plants depends, in the first place, upon the amount of light which strikes the surface of the sea, and will vary therefore with the particular climate and meteorological conditions prevailing in each locality. The depth at which marine algæ will be found will be greater in localities where the sky remains clear and the light of the sun intense for long periods, than in those where the opposite conditions prevail. The clearness of the water, which depends upon the amount of solid matter in suspension, will also be a factor of importance.

In addition to the indirect effect of light upon the distribution of animal life in the sea, owing to the dependence of the latter upon plant life, there is also a direct effect, which, however, appears to be of importance only within somewhat wide limits. The distribution of those animals which seek their food chiefly by the aid of sight will evidently be limited by the amount of light which penetrates, whilst the safety of those which serve them as food will be correspondingly increased as the amount of light diminishes.

II. External Biological Conditions.

The external biological conditions influencing the distribution of any bottom-living organism (animal or plant), due to the existence at the same time of other living organisms, are often of a complicated nature.

1. One organism may exert an advantageous influence upon another.
   - (*a*) By serving as its food-supply;
   - (*b*) By serving as a fixed base to which it may attach itself;
   - (*c*) By serving as a movable base, and thus extending the area over which a fixed organism can collect its food-supply;
   - (*d*) By bringing supplies of food to the other organism as well as to itself, either by setting up a current, or in some other way;
   - (*e*) By affording the other organism means of protection or concealment from its enemies.
2. One organism may exert a disadvantageous influence upon another.
   - (*a*) By preying upon it;
   - (*b*) By fixing upon it in such a way as to destroy it;
   - (*c*) As a competitor for a limited food-supply, or for a limited amount of fixing space.
3. The biological conditions by which the organisms on any particular patch of ground are influenced depend not only upon the organisms living on that ground itself, but also upon the nature and abundance of the organisms living upon neighbouring grounds.

The meaning of the latter statement can perhaps be best explained by supposing that a particular patch of ground could be cleared of all the organisms living upon it, and then allowed to remain until it had acquired a new population. The nature of this new population would depend upon the physical conditions of the ground, upon the nature of the larval animals which were brought to it by the moving water above, and upon the wandering animals which entered it from other grounds. The nature of the larval forms would depend upon the nature of the grounds over which the water had previously passed, and it would appear that the supply of larvæ from grounds in the immediate neighbourhood would be much greater than that from those which were more distant. In this connection the tidal current, running alternately in opposite directions, will evidently be an important factor. It will be shown in the present report that in many cases the nature of the fauna at a particular spot is distinctly influenced by the fauna of grounds in the immediate neighbourhood.

The principle just discussed may be extended to the fauna of any particular district, which will be influenced by the nature of the fauna in surrounding districts. The fact, which has long been well known, that the fauna in the western portion of the Channel is composed of a mixture of northern and southern species is, to some extent, a result of the principle enunciated.

Section III.

THE PHYSICAL CONDITIONS PREVAILING ON THE GROUNDS INVESTIGATED.

The grounds have been so chosen that, with the exception of changes in the nature of the bottom-deposit, the differences in their physical conditions are probably only slight and not of great importance. Under the present heading those conditions, which are nearly the same for all the grounds, will be described, whilst the nature of the changes which the bottom-deposit undergoes will be reserved for an independent section.

The grounds lie in the immediate neighbourhood of the 30-fathom line (Charts I. to XVI.), all of them being between the 25- and 35-fathom lines. In the neighbourhood of the Eddystone the 30-fathom line is from eight to nine miles distant from the coast, and within about a mile of the exposed Eddystone rocks. Near Bolt Head and Prawle Point, on the other hand, it approaches to within $1\frac{1}{4}$ miles of the shore.

The Composition of the Water. The density of the water on all the grounds may be taken, for the purposes of the present inquiry, to be that of normal Atlantic water, any variation from this figure being so small as to be without importance in influencing the distribution of the bottom fauna.

This appears to be the case even for the Bolt Head and Prawle Grounds, which lie close to the entrance of the Salcombe estuary, as is shown by the observations made by Mr. H. N. Dickson (No. 21, pp. 166–169) in 1891. Dickson's stations I. and XV. are sufficiently near to be of value.

Station I.	Bolt Head N.E. by E. 1½ miles. June 15th, 1891.		
	Density ($_4S_{15\cdot56}$).	Surface	1·02601
		19 fathoms	1·02599
Station XV.	Bolt Head N.N.E. 1½ miles. June 17th, 1891.		
	Density ($_4S_{15\cdot56}$).	Surface	1·02598
		19 fathoms	1·02602

In November, 1891, and March, 1892, samples were also taken by Dickson at the above Station I., as well as at other stations in various parts of the Channel, and he reports (No. 21, p. 273) that "the examination of these samples has shown that the water over the area under consideration is normal Atlantic water throughout."

No accurate data can be given as to the amount of solid matter in suspension in the water at various times, as no attempts have been made either to determine this directly or to measure the degree of transparency of the water. It is possible, owing to the nearer proximity of the coast in the neighbourhood of Prawle Point, that the water there at the 30-fathom line may at times be somewhat more muddy than that in the neighbourhood of the Eddystone.

The Movements of the Water. 1. *Wave Action.* No satisfactory method has yet been devised for measuring directly the amount of wave action at various depths. There is, however, considerable evidence to show that a certain amount makes itself felt on the grounds under consideration, and that although the amount is small it is appreciably different on the different grounds.

That the amount of wave action extending to the bottom is generally slight is shown by the abundance of the hydroids *Antennularia antennina* and *Aglaophenia myriophyllum*, which fix themselves in the sand or fine gravel by a felt-work of root-fibres in such a way that they would certainly be torn up by any violent movement of the water, and on the fine sand grounds *Cellaria* is abundant fixed in a similar way. On the gravel also to the west and south-west of the Eddystone the ascidian *Polycarpa varians* (Heller) is very plentiful, and is generally attached only to the gravel itself, for nearly all the specimens which come up in the dredge are found to have their bases covered with pieces of gravel to which they are firmly fixed.

The distribution of *Alcyonium digitatum* (see p. 457), on the other hand, seems to indicate that the amount of movement of the bottom water is appreciably less on the grounds where the depth is greater than 33 fathoms than it is upon those from 28 to 33 fathoms.

The evidence for considerable wave action is strongest on Grounds XIV. and XVI., immediately to the west of the Eddystone reef, where it is probably increased by the rebound of the Atlantic swells from the rocks. On Ground XVI. (see Charts) the bottom-deposit is a shell gravel, which is remarkably clean and free from silt,* as will be seen from the figures in Table II., p. 525, which shows the texture of the samples taken from the different grounds. There is also on this ground an almost entire absence of such species as fix directly to the bottom-deposit.

The sample of the bottom-deposit on Ground XIV. (haul 85) is unique amongst all the samples obtained, in having the fine sand grains rounded and highly polished (see p. 385), and on this ground the number of hydroids is also very small.

There is evidence (see p. 425) that Ground XIII., which lies south-east of the reef, is more sheltered from wave disturbance than the grounds to the westward of the Eddystone.

2. *Currents and Tides.* Practically nothing is at present known as to the strength or even as to the prevailing direction of the bottom currents of the Channel. It is well known, however, that the surface currents are especially strong around the various headlands, and it is probable that these will still be felt on the bottom. If this be so the currents on the Bolt Head and Prawle Grounds may be more rapid than those in the neighbourhood of the Eddystone.

Temperature. The Laboratory records of bottom temperatures at depths of about 30 fathoms show a range from 7·1° C. (48° F., March, 1898) to 13·9° C. (57·1° F., Nov. 17th, 1898). The records at this depth are not, however, very numerous, and the above observations probably do not quite represent the maximum and minimum temperatures. The temperature changes very slowly, generally not more than 1° C. in a month, and the total yearly range may be safely put at about 7° or 8° C.

Pressure. The depth of water on all the grounds varies only from 25 to 35 fathoms, which represents a difference of pressure too slight to affect the bottom animals.

Amount of light which penetrates. This is sufficient only for the lowest forms of vegetable life, such as diatoms, coccoliths, etc. None of the branched red or brown sea-weeds are found on any of the grounds.

* Wave action in itself would not of course be able to remove silt which had been deposited ; it would, however, tend to keep the silt in suspension, so that it would be carried away by the prevailing currents.

SECTION IV.

THE BOTTOM-DEPOSITS.

THE question of the changes in the nature of the fauna which take place in shallow waters with changes in the character of the bottom-deposit is one to which considerable attention has recently been paid. More especially Marion (No. 74) in the Gulf of Marseilles, Petersen (No. 95) in the Kattegat, Herdman (Nos. 40–44) in the Irish Sea, and Pruvot (No. 98) in the Mediterranean and in Brittany have dealt specially with the subject. At the instigation of these naturalists chemical analyses of the bottom-deposits have been made and their geological characters have been described.

In considering the relation between the nature of the bottom-deposit and the fauna living upon it, the factor which appears to be of primary importance is the *texture* of the deposit rather than its geological character. This is fully recognised by the authors named, and it is a point to which the attention of marine naturalists has always been directed.

The terms rock, stone, gravel, coral or nullipore, shell, sand, fine sand, mud, muddy gravel, muddy sand, etc., have generally been used to express differences in the nature and texture of the deposits. These designations are adopted from navigators, and are the terms used on Admiralty and other charts to express the nature of the material brought up on the tallow placed for the purpose at the end of the ordinary sounding-lead. But a very slight study of the accounts of dredgings given by various authors is sufficient to show that these terms are used in very different senses by different individuals. The term sand especially seems to be employed in a very broad sense to include deposits having a wide range of texture. Several of the other terms are also much confused.

After the present investigation had proceeded for some time it seemed necessary that an attempt should be made to actually measure the texture of the deposits found in different places, so that accurate and consistent descriptions might be given. The readiest method of doing this is to separate the particles of different sizes by means of a series of sieves of standard meshes, and then to determine the percentage of material of each size in the sample. Since my results were obtained I have found that three or four of Petersen's samples were examined in the same way, though, unfortunately, he does not give the numbers of the hauls from which they were obtained, and it is impossible, therefore, to discover the fauna connected with them.

The method of procedure which has been adopted will now be described.

Obtaining the Sample. In order to get a correct idea of the nature of the deposit it is not sufficient to take a sample of so much of it as happens to come up in the ordinary dredge. Samples obtained in this way have lost much of the finer portions of the deposit, and generally give a very incorrect idea of its nature. The samples, the composition of which is here described, have always been taken with a moderate-sized dredge (about 2 ft. 8 in. long),* fitted with a bag of stout canvas inside the ordinary net. At the end of a haul of the ordinary dredge it was our custom to steam back a little way over our course and then work this dredge with the canvas bag, leaving it down only for two or three minutes. In this way a good sample of the deposit was obtained, and the haul often yielded interesting species not obtained in the usual way of dredging.

Examination of Samples for Texture. The samples were brought back to the Laboratory, and for their examination a series of sieves made of zinc and with perforated zinc bottoms was employed, through which the samples were washed. The sieves had a diameter of 15 centimetres and six of them were used, the sizes of the (circular) perforations being 15 mm., 5 mm., 2·5 mm., 1·5 mm., 1 mm., and 0·5 mm.† The material passing through the 0·5 mm. sieve was further subdivided into two parts, one of which was regarded as fine sand and the other as silt. This separation was made by stirring the material up with a considerable quantity of sea-water, allowing it to settle for one minute, and then pouring the water off. The process was generally repeated a second time, the material remaining in suspension being regarded as silt, whilst that which settled in one minute was regarded as fine sand.

In this way eight grades of material were obtained altogether, and it was found that these could conveniently be distinguished by the following nomenclature:—

I. Stones. All inorganic material which will not pass through 15 mm. sieve.
II. Coarse Gravel. Material left on 5 mm. sieve.
III. Medium Gravel „ „ 2·5 mm. „
IV. Fine Gravel „ „ 1·5 mm. „
V. Coarse Sand „ „ 1 mm. „
VI. Medium Sand „ „ 0·5 mm. „

* The size of the dredge is important, as a smaller and lighter one would probably not dig so deeply into the deposit. A strong net is retained outside the canvas bag in order to take some of the strain when the dredge is brought up.

† Perforated zinc with holes of these diameters can be obtained from Messrs. J. Staniar & Co., Manchester Wire Works, Manchester.

VII. Fine Sand. Material which passes through 0·5 mm. sieve and when stirred up with sea-water settles in one minute.

VIII. Silt. Remains in suspension at the end of one minute.

The designations here adopted seem to agree very well with the ideas generally connected with the respective terms, and it would be a great advantage if these terms could in future be used in the exact senses proposed.

In determining the texture of a sample by the use of a series of sieves it is necessary, in order to obtain constant results, that a considerable quantity of material be examined, especially in the case of coarse and mixed deposits. My practice was to sieve the quantity which was contained in a bottle of about 800 cc. capacity.

After trials of various methods the following was adopted as the readiest and most convenient way of obtaining satisfactory results. The finest sieve was placed in a vessel somewhat larger and deeper than itself, so large in fact that the sieve could be conveniently worked about with the hand. Sea-water was then poured into the surrounding vessel until the sieve, standing in it, was nearly full. Small portions of the sample were placed in the sieve and worked about until all the fine sand and silt were washed out. In the case of very muddy samples the process was repeated in a second quantity of water. The portion remaining on the sieve was washed through the other five sieves successively in a similar way, commencing with that of largest mesh.

The mixture of fine sand and silt was separated by stirring it up well in the sea-water, allowing it to stand for one minute, and then pouring the water off. Where two washing waters had been used, the second, with its contents, was poured on to the first sample of fine sand, the whole stirred up again, left to stand one minute, and the water poured off. The water in which the silt was suspended was allowed to settle for at least twenty-four hours and the clear portion then drawn off. The remainder was passed through a weighed filter paper and the silt collected.

The samples of gravel and sand on the various sieves and of silt on the filter paper were all dried at a low temperature and weighed, the results being expressed as percentages of the total weight. The textures of the various samples examined are shown in Table II., p. 525. One of the most curious features brought out by this method of examination of the texture of the bottom-deposits is the fact that nearly every sample of the coarser deposits is composed of a mixture of coarse gravel and fine sand or mud, material of intermediate texture being present in small quantity only. Thus sample 84 is a mixture of coarse gravel (47·6 per cent.) with fine sand (17·7 per cent.), and a little silt (2·8 per cent.), the intermediate grades of gravel and sand being small. Sample 103 is a mixture of gravel with mud, the proportion of silt here rising to 17 per cent., with only 10 per cent. of fine sand, the highest percentage of silt in any sample examined from these grounds.

For comparison with the figures in the table I have given in the last column the texture of a sample of fine, sticky mud from Plymouth Sound, which contains 70 per cent. of fine sand to 24·4 per cent. of silt.

The Organic Constituents of the Bottom-deposits. Mr. Worth reports below on the relative amounts of organic carbonate of lime contained in the different samples. The organic constituents from which this carbonate of lime is derived consist, on the grounds under investigation, almost entirely of the remains of molluscs, echinoderms, serpulids, and polyzoa, and there is no example on the whole area of a "nullipore" ground. It is especially noticeable in Grades II. and III. that the shell material is composed very largely of entire small shells of lamellibranchs or of fragments of such small shells, and not of broken pieces of large shells. Many of these shells show the clean circular perforation, such as is produced by the boring gasteropods.

Sponge spicules are abundant in the finer grades.

The Silt. Although constituting only a small percentage of the whole material forming the bottom-deposit on the grounds included in the present investigation, the silt is of great importance from the biological point of view, since many animals living on the grounds obtain their food by passing it through the alimentary canal and extracting such nourishment as it contains. The silt from a freshly taken sample of deposit, when shaken up with sea-water, forms a flocculent precipitate, the greater part of which settles fairly rapidly. On the other hand, when shaken up with fresh-water, a great deal of it remains in suspension for a long time, and the water may have a muddy appearance for several days.

Microscopical examination of the fresh silt shows that a very considerable portion of it is of organic origin, and the analysis and examination of dried samples confirm this (*cf.* p. 386). Diatoms are very numerous as well as foraminifera (for species recognised see p. 442), and *Coccoliths* are invariably present in very considerable numbers.

Attention has recently been drawn to the presence of Coccoliths in our coastal waters by Joly and Dixon (No. 57), who found them in the precipitate obtained by treating a quantity of sea-water in a centrifugal apparatus revolving at a high rate of speed. They had, however, been found by Behrens (No. 6) in samples of bottom-deposit from the Baltic as long ago as 1873.

Coccoliths can be readily obtained in large numbers by shaking up a small quantity of bottom-deposit with sea-water, pouring off the muddy water, and allowing it to settle. I have found them to be much more numerous in samples taken from below 15 fathoms than in those obtained from the shallow waters of Plymouth Sound, although a few can generally be found in the latter. These organisms must now therefore be regarded as very abundant in the sea, and their importance in the economy of many marine animals must be great, since they furnish a source of food-supply containing carbonate of lime.

Determination of the Amount of Carbonate of Lime in the samples of Bottom-deposit, and Description of their Geological Features. By R. H. Worth.

"1. Average Grade of Sample.—The sands and gravels had already been sieved and graded before their examinations for geological purposes and for the determination of carbonate of lime. It appeared evident, however, that as a ready means of determining the relative texture of a whole sample it would be necessary to compress the information contained in the table which gives the percentage of each grade in each sample (Table II., p. 525).

"The method adopted is founded on the determination of the average grade of the whole sample. The figures I., II., III., etc., having reference to grades left in a sieve of 15 mm., 5 mm., 2·5 mm., etc., are purely conventional, but may be conveniently adopted for the purpose of shortly stating the average grade of any sample. The actual method followed was to multiply each percentage in the table by the conventional number attached to its grade, add together all the figures so obtained, and divide by 100; the result has been described as the 'average grade' of each sample, and affords a ready means of comparing the texture of any two deposits. Close comparison still of necessity requires a reference to the detail on which this average is based. As an instance of the method the determination of the 'average grade' of sample 83 is appended:—

I.	Stones	0·00 × 1 = 0·0
II.	Coarse gravel	27·9 × 2 = 55·8
III.	Medium gravel	28·3 × 3 = 84·9
IV.	Fine gravel	14·1 × 4 = 56·4
V.	Coarse sand	6·0 × 5 = 30·0
VI.	Medium sand	7·3 × 6 = 43·8
VII.	Fine sand	8·3 × 7 = 58·1
VIII.	Silt	8·2 × 8 = 65·6
		394·6 ÷ 100 =

3·946, the 'average grade' of sample 83.

"Averaged in this manner the samples fall naturally into two divisions; the one division lies between the grades 3·6 and 4·6, and the other between the grades 6·3 and 7·0, the lower numbers corresponding to the coarser and the higher to the finer textures.

"Grade VII.—the 'fine sand'—varies considerably in the different samples. Its coarser forms approximate in some few samples to a sand the individual grains of which are none greatly under ·5 mm. in diameter. Its finer forms in some samples have but few grains of these dimensions, as compared with a great number of grains approximating to the 'silt.'

"2. Carbonate of Lime.—Care was taken to ascertain how far any results of chemical determination might be invalidated by the presence of inorganic carbonate of lime in the rock fragments. The result of inquiry proved that practically no lime existed in the rock fragments which was soluble in cold dilute hydrochloric acid. All carbonate of lime so soluble is in these samples of organic origin.

"In the finer grades below III. carbonate of lime was determined by treating each sample with dilute hydrochloric acid, filtering, neutralising the filtrate with ammonia and again filtering, precipitating the lime with ammonium carbonate [$(NH_4)_2CO_3$], filtering, washing precipitate, drying and weighing as carbonate of lime.

"In grades I., II., and III. the shells, shell fragments, etc., were picked out by hand and weighed.

"Tables III. and IV., p. 526, give the results thus obtained.

"A feature of these results is the low percentage of $CaCo_3$ in the fine texture deposits, having an average grade of 6·4 to 7·0. In Table V., p. 528, the samples are arranged in order of their average textures and the total percentage of $CaCo_3$ set opposite each sample.

"The coarse samples are not, perhaps, uniformly high in their percentage of carbonate (94 is a notable exception), nor are the fine samples uniformly low, 89B and 109 being the exceptions, but on averages the general figure for the fine textures falls much below that for the coarse. Another noticeable fact is that the percentage of carbonate of lime found in the finer sands of each sample shows a distinct tendency to follow the total amount of carbonate of lime present in the gravel and coarse sand of the same samples (again with the exceptions of 89B and 109, which are evidently detrital matter from adjacent shelly grounds).

"This points to the fact that most of the carbonate of lime in the fine sands is detrital matter from shell fragments, etc., in the gravels and coarse sands, and microscopic examination confirms this.

"The percentage of carbonate of lime in the silts is comparatively low, with the exception of silt 109. It apparently follows no definite rule, beyond a mere tendency to be somewhat higher in silts where the whole sample is rich. There is less variation between different samples in the matter of percentage of carbonate of lime in the silts than in any other feature.

"An attempt might be made to explain the poverty of the silts in carbonate by the fact that once shell fragments are ground sufficiently fine to pass into this grade they present so much surface area in proportion to their solid capacity as to fall an easy prey to the solvent action of sea-water.

"3. Rock Fragments and Sand Grains.—Grades I., II., and III. were examined and the rock fragments identified. Advantage was taken of the search for foraminifera to examine the sand grains in grades VI. and VII., and the residues from the acid solutions after dissolving out the carbonate of lime have also been examined.

"There are three clearly defined geological areas represented by these samples.

"The first, represented by a single dredging only, occurs at 90 (Ground V.), to the north-east of the Eddystone and south of Rame Head. Here the rock fragments are almost entirely Devonian in character, the gravel consisting of fragments of slate and quartz from veins in slate, closely resembling the rocks of Penlee Point. A little Trias occurs.

"The second area covers the whole of the rest of the samples examined from the Eddystone neighbourhood. This may be called the Triassic area. The prevailing rock fragments are the detritus of Triassic rocks; mottled sandstones, red jaspideous sandstones, micaceous sandstones, and drab sandstones. This must be taken as an indication and not an exhaustive definition of the nature of the rocks. In consequence of the presence of these rocks the bottom-deposits contain a great amount of free crystalline silica and a considerable amount of iron. Associated with the Trias are some Devonian rocks, but the amount of these present is comparatively small, rarely rising above 15 per cent. and never reaching 16 per cent. Fragments of the Eddystone gneiss also occur, but in small quantity except in the immediate neighbourhood of the reef.

"The third area is represented by samples 105 and 106 (Ground XVII.) from the neighbourhood of the Bolt. This may be described as the 'Archean Schist' area. The rock fragments are largely derived from mica and chlorite schists, similar to or the same as those forming the promontory of the Bolts. In 105, II., the Archean schists form 78·75 per cent. of the whole rock fragments, Flint pebbles form 12·74 per cent., and Triassic rocks 8·51 per cent. The Prawle Stony Ground (XVIII.) corresponds geologically to 105.

"Further south, at the point at which 106 was dredged, the Archean falls to 48·90 per cent. and the Flint rises to 40·44 per cent., apparently indicating the proximity of a cretaceous area. Trias is still present as 10·66 per cent.

"These Archean rocks are referred to in 'The Rocks of South-west Devon,' R. N. Worth, *Devonshire Association Transactions*, 1887, as well as elsewhere in the same *Transactions* by other writers.

"Briefly stated the geological results are as follows:—

"It is almost certain that the gneiss and granitoid rocks which constitute the summit of the Eddystone reef are restricted in area of exposure to little more than the summit and a portion of the sloping sides of the reef. It is only at 87 that the gneiss preponderates over all other rock constituents in the gravel, and here in 87, III., it reaches 74·07 per cent. of the total rock constituents. This is on the immediate western fringe of the reef.

"At 85, a little west of 87, the gneiss forms 25 per cent. of the rock constituents, and at 103, south-east of the reef, it forms 26 per cent.

"The presence of the Trias is not surprising. The probable existence of submarine Trias between the Lizard and Plymouth had already been suggested by R. N. Worth, who, in 1886, reported the existence of a submarine Triassic outlier, having its centre about ten miles south-east of the Lizard. (*Quart. Jour. Geol. Soc.*, Aug., 1886.)

"But although not altogether unexpected, this Trias of the Eddystone neighbourhood is now reported for the first time, and deserves more detailed and lengthy description than would be appropriate to the objects of the present investigation. For present purposes it will be sufficient to state that the nearest shore exposures of rocks of similar formation occur at Oddicombe Beach, St. Mary Church, again at a point immediately to the west of the Bolt, and lastly, on either shore of Plymouth Sound, in Cawsand Bay and to the south of Bovisand respectively.

"The presence of the iron of the Trias has apparently had its effect on the foraminifera, for some of the Miliolina especially present an unusually ferruginous appearance.

"Among the Eddystone gravels were found scattered fragments of amorphous silica, insufficient in number or weight to affect numerical results. These were mostly regarded as Triassic before the Bolt examples had been examined. Such an identification was justified by the known existence of veins of calcedony in the submarine Trias off the Lizard. Their absolute identification is still problematic. Not so, however, with the flint gravel from the Bolt district. This, although much affected by the solvent action of the sea-water, is still recognisable as flint, and possibly more exact information may on further examination be derived from some of the apparent fossils which have survived the solvent action of the water. It is interesting to note the extent to which this solution has been carried. The outside of practically every flint pebble has been converted by it into a microscopic honeycomb, and only the larger fragments have any core of unaffected silica remaining. The crystalline quartz grains of the Trias, on the other hand, have resisted the chemical action of the water.

"The sands are interesting as giving evidence of the relative degree to which wave action has affected the sea-bottom. It may seem a truism to suggest that a fine-grade sample may owe its fineness of textures either to the presence of a large quantity of fine sand or to the absence of all but a small proportion of coarser gravel. The two causes are, however, quite distinct, and either may act alone or both in conjunction.

"The dredgings in the Eddystone neighbourhood are not perhaps so many or so scattered as might be desired for this discussion, the objective having been rather zoological than geological. None the less, it is interesting to note the relative positions of the fine textures and the coarse textures. With one exception the fine textures occur at some considerable distance from the reef, while the coarse textures are clustered around the reef or around the Hand Deeps. The exception as to a fine texture occurring near the reef is in the case of dredging 89B, taken from the centre of the channel between the Hand Deeps and the Eddystone reef.

"Dredging 85 is remarkable for the manner in which the quartz grains have been rounded and polished, and also for the extremely coarse texture of the 'fine sand,' VII. As has been pointed out, this grade may either have a maximum coarseness, in which all the grains are of such size as to barely pass through the 0·5 mm. mesh, or may approximate to silt. In the present instance the maximum coarseness is closely approximated. (The actual silt only forms 0·6 per cent. of the whole sample.) The greater portion of the sample is almost uniformly distributed between III., IV., V., and VI., a feature which does not recur. The average grade is 4·597, or almost a mean between IV. and V. The conditions at this point, therefore, are unfavourable to the existence of either coarse gravel or fine sand; of the first, it is suggested, because the strong wave actions breaks up all large particles, of the second, because the same action will not allow small particles to settle. Add to this the rounded and polished quartz grains, grains rounded as they are practically never found on any beach, and almost every individual grain so polished, and the conclusion should apparently be that here is a centre of wave action. And yet it lies below the 30-fathom line. But at the same time it lies under and to the westward of the Eddystone reef, which, rising above low-water, meets and breaks the south-west Channel seas.

"The sudden check to the great Channel rollers can certainly not be effected without the accompanying creation of intense currents in the neighbouring depths, and these it is that must be looked to as providing the necessary abrading forces. That these forces only operate at intervals may be gathered from the occurrence in this storm-washed sand of fair-sized specimens of *Rotalia beccarii* and *Miliolina seminulum.* The more delicate foraminifera are, however, conspicuously absent.

"The sand grains at 87 also show a similar but not equally finished polish. This point, however, lies further to the north of the highest point of the reef. To the north-west of the Eddystone the Hand Deeps also take a share in arresting and converting the surface-wave motion.

"Between the reef and the Hand Deeps the back-wash, reflux currents or arrested and converted wave motion have scooped and maintain a channel, represented by the incurve of the 30-fathom line on the chart. All around the margin of this area there is evidence of wash, which must result in the formation of a considerable amount of fine detrital matter, and this not being able to settle when formed is constrained to collect in the quieter but still disturbed waters of the centre of the channel and forms the deposit at 89B, 56·8 per cent. of which is fine sand, a fine texture, but not comparable with, say, 92, which lies well clear of the reef and has 90·9 per cent. of fine sand, or with 102, 91, and 104, with 85·4 per cent., 82·7 per cent., and 95·8 per cent. of fine sand respectively. It is, however, more nearly comparable with 90, which lies at the northern extreme of the eastern Eddystone channel and has 68 8 per cent. of fine sand. Dredging 89B also differs from all the other fine texture sands in having a large percentage (29·2 per cent.) of medium sand.

"The conclusion which apparently follows these considerations is that the deposits around the Eddystone reef owe their coarse texture, in part at least, to the intense wave action which prevents the accumulation of the finer particles, in part to the same intenser action which provides additional coarse particles at the expense of the neighbouring submerged rock surfaces.

"The finer deposits elsewhere are in more quiescent localities, with no abrupt changes in the levels of the bottom to deflect the surface waves.

"105 and 106 (Ground XVII.) are subject to totally different geological and other conditions, and more dredgings from their locality would be necessary to fully appreciate the circumstances affecting them.

"It is to be noted that no rock fragments occur which must have necessarily, or have even probably, been drifted from the neighbouring shores, guarding, however, the case of 105 and 106, in which it is none the less quite possible and even probable that the Archean schists underlie the gravels in which they occur.

"Three of the samples of silt have been approximately analysed, with the result set out in the following table. The results should be accurate to the nearest 0·25 per cent.

ANALYSIS OF SILTS.

	83		94		103	
Loss on Ignition.						
Bunsen .	11·50	20·50	12·00	20·50	12·50	21·00
Blowpipe .	9·00		8·50		8·50	
SiO_2 . .	42·35		35·42		41·56	
Al_2O_3 . .	10·18		9·64		7·53	
Fe_2O_3 . .	9·29		7·70		8·00	
CaO . .	13·67		17·60		12·69	
MgO .	Heavy trace		Heavy trace		Heavy trace	
Undetermined	4·01		9.14		9·22	

"It is apparent that the CaO obtained in these analyses is more than can be accounted for by the organic $CaCO_3$, the figures being:

	CaO in present analysis, per cent.	CaO equivalent to organic $CaCO_3$, per cent.
83	13·67	9·24
94	17·60	10·45
103	12·69	11·85

"On the other hand, the loss on ignition before blowpipe after previous ignition over bunsen appears to roughly represent the CO_2 in the organic carbonate of lime. Thus:

	Additional loss on ignition over blowpipe, per cent.	CO_2 in $CaCO_3$, per cent.
83	9·00	7·26
94	8·50	8·21
103	8·50	9·31

"The loss on ignition has accordingly been given in two figures, of which the figure for loss over bunsen fairly represents the more volatile substances and organic matter.

"Under the head of 'undetermined' must be classed the alkalies, any slight traces of metallic oxides, and a small residue of CO_2 left after ignition.

"All the samples were fairly thoroughly washed before analysis to remove salts derived from sea-water, and were desiccated before ignition."

Section V.

DESCRIPTION OF THE GROUNDS INVESTIGATED.

The grounds from the Eddystone to Start Point lying in the neighbourhood of the 30-fathom line fall naturally into four groups. The grounds around the Eddystone rocks, comprised within a circle of about four miles radius, having the lighthouse for its centre, are for the most part coarse grounds, with bottom-deposits of gravel or broken shell mixed with more or less mud or fine sand. Towards the outer limit of the circle the deposits become more and more sandy in nature. These grounds will be referred to in a general way as the *Eddystone Grounds.* (See Chart I.) South of Bolt Head the bottom-deposit is broken shell-gravel, and the ground here will be named the *Bolt Head Shell-gravel Ground.* (Chart I., Ground XVII.) Between the Eddystone Grounds and the Bolt Head Shell-gravel is a stretch of fine sand, the *Eddystone Trawling Ground,* the inner or northern portion of which will be distinguished as the *Inner Eddystone Trawling Ground,* the outer or southern portion as the *Outer Eddystone Trawling Ground.* (Chart I., Grounds I. and II.). Between Prawle Point and the Start is a patch of ground with many stones, the *Prawle Stony Ground.* (Chart I., Ground XVIII.)

The lists of species living on the various grounds will be arranged according to zoological groups, but in the description of the fauna of each ground, which precedes the list, the species will be grouped according to their general habit, the following kinds being distinguished:—

1. Burrowing species.
2. Fixed and clinging species.
3. Wandering or free species.

Associated species will in all cases be ranged with their hosts, the host being, in the case of fixed and burrowing animals, the one most intimately connected with the bottom-deposit, in the case of wandering species, the one having the greater powers of locomotion. It will be found that the burrowing and fixed species, with their associates, are the most restricted in distribution by the nature of the bottom-deposit, whilst the wandering species may exist upon bottoms of many different textures, when the deposit is once sufficiently firm to support their weight. The distribution of the wandering species will therefore depend, under the same conditions of temperature, water-movement, etc., chiefly upon the presence of a suitable food-supply and the absence of enemies.

In considering the geographical distribution of marine animals Forbes introduced the idea of a specific centre, by which he meant the locality, named also the metropolis of the species, where the species flourished in large numbers, and he showed that as one passed away from this locality the species became less and less abundant, until it finally disappeared. In what follows I think I have been able to show that the facts with regard to the local distribution of species are of a very similar kind. Many instances will be given of a species being specially abundant upon one particular patch of ground, where the nature of the bottom-deposit or some other physical condition is specially suited to its requirements, and in almost every case of this kind it will be found that the species is taken in smaller numbers on all the immediately surrounding grounds, even though the general nature of the fauna and of the bottom-deposit of the latter grounds may be very different. In this way the fauna of any particular ground depends not only on the nature of the ground itself, and the physical conditions to which it is subject, but also to a greater or less extent upon the predominant fauna on neighbouring grounds, which in its turn depends upon the physical conditions there existing.

In the descriptions of the grounds, places where a species is especially abundant will be referred to as centres of distribution of the species, and such centres will be spoken of as influencing the fauna of surrounding grounds.

The numbers of the different grounds have been arranged according to the texture and general character of the bottom-deposit. Grounds I. to VIII. are all fine sand grounds, of which I., II., and III. show the fine sand fauna in its most typical forms. Grounds IX. to XIII. are coarse gravels mixed with sand or mud, of which IX. is the most typical. Grounds XIV. and XV. are fine gravel, of which XIV. is typical. Grounds XVI. and XVII. are clean broken-shell gravel, and Ground XVIII. is stony. In order to understand the nature of the fauna on many of the intermediate grounds, it is necessary that acquaintance should be first made with that of the various typical grounds.

For a list of the individual hauls see Table I., p. 521.

Ground I. The Inner Eddystone Trawling Ground.

Hauls. 50 (Dr.),* 51 (Dr.), 81 (B.-tr.), 82 (B.-tr.), 92 (O.-tr. and C.-dr.). The approximate limits of this ground are, on the north the 28-fathom line, south the 33-fathom line, west the Eddystone Grounds (comprised in a circle of four miles radius, with the lighthouse as centre), and east, a line drawn north and south about nine miles east of the Eddystone. (Chart I., Ground I.)

Bottom-deposit. Fine sand. The texture in haul 92 was found to be:—

IV.	Fine Gravel	0·2 per cent.
V.	Coarse Sand	0·8 ,,
VI.	Medium Sand	4·8 ,,
VII.	Fine Sand	90·9 ,,
VIII.	Silt	3·4 ,,

[92. Average grade of sample, 6·971. Percentage of carbonate of lime in whole sample, 17·41. Highest percentage occurs in IV., which contains 82·43 per cent, but this and V., containing 74·40 per cent., may be passed over as constituting but a small portion of the whole sample. VI. contains 58·00 per cent. A fine-textured deposit owing its low percentage of carbonate of lime to the fact that VII., which forms 90·9 per cent. of whole sample, only contains 14·63 per cent. of $CaCo_3$.

Triassic material is largely present, some Devonian and no Eddystone reef.

Foraminifera are fairly plentiful. The following are the species present in VI. and VII., arranged in order of frequency:—*Rotalia beccarii* (greatly predominant), *Miliolina seminulum*, *Truncatulina lobatula*, *Textularia gramen*, *Bulimina pupoides*, *Discorbina rosacea*, *Bolivina punctata*, *Miliolina bicornis* (reticulate variety). In all eight species.—R. H. W.]

Unbroken shells were scarce, with the exception of *Cardium echinatum* shells.

Burrowing species. *Astropecten irregularis*, *Cardium echinatum*,† and *Dentalium entale* are the common burrowing forms on this ground. *Corystes cassivelaunus* was present in haul 92 only, where, however, it was plentiful. (*Cf.* p. 397.)

Fixed species. The fact that few shells are present causes fixed species to be scarce. *Cellaria fistulosa* and *sinuosa* are moderately

* Dr. = Dredge. B.-tr. = Beam-trawl. O.-tr. = Otter-trawl. C.-dr. = Dredge fitted with canvas bag.

† The presence of *Cardium echinatum* on this ground and in the fine sand of the outer trawling-ground is inferred from the fact that fresh valves, often still joined together, are a constant feature of the hauls, and are the only shells at all plentiful. The species is known (*cf* p. 500) to be a sand-dwelling one.

abundant, fixed in the sand by their root-fibres; *Antennularia antennina* and *ramosa* are fairly common, fixed in the sand by "sponge-like masses of interlacing fibres" (Hincks); whilst *Aglaophenia myriophyllum*, fixed in a similar way, also occurs, though not frequently.

The tubes of the polychæte *Thelepus* (*cincinnatus?*) serve as an attachment for the hydroid *Sertularella Gayi*, which is the commonest and most typical hydroid on the ground, whilst to the base of the hydroid *Ascidiella scabra* and *Sabella pavonina* are attached. *Sertularella polyzonias*, *Eudendrium ramosum*, *Bougainvillia ramosa*, *Obelia dichotoma*, and *Clytia Johnstoni* also occur attached to other hydroids, or to polychaete tubes. *Halecium halecinum* and *H. Beanii* are represented by one or two colonies only in a haul, or are entirely absent, and *H. halecinum*, at any rate, must be regarded as an immigrant from coarser ground.

Stray tubes of *Chaetopterus variopedatus* were taken in hauls 82 and 92 only, and are also clearly immigrants from neighbouring grounds.

Of the other fixed species *Alcyonium digitatum* only occurs in moderate quantity, and the colonies, generally attached to *Cardium echinatum* shells, are small. *Epizoanthus incrustatus*, which forms a feature of the outer trawling-ground (Ground II.), has never been taken on the inner. The polyzoa *Bicellaria ciliata*, *Scrupocellaria scruposa*, and *Cellepora avicularis* are found attached to hydroids, but, owing to the absence of shells, there are few incrusting polyzoa.

Wandering species. Owing in all probability to the scarcity of fixed and burrowing forms to serve as a food-supply, the number of wandering species is also small.

Pecten opercularis is scarce, and *Asterias rubens* and *A. glacialis*, which generally are found feeding on the *Pecten* on neighbouring grounds, are never present in numbers. There are usually a few *Ophiura ciliaris*, but *Ophiothrix fragilis* is only represented by small specimens at the roots of *Cellaria* or hydroids. *Palmipes placenta* was taken in one haul only (82).

Eupagurus Bernhardus (with *Sagartia parasitica* or *Hydractinia echinata* on the *Buccinum undatum* shells which they inhabit), *Galathea dispersa* and *Porcellana longicornis* are the only Decapod Crustacea which can be considered common on this ground. There are a few examples only of *Stenorhynchus longirostris* and *Inachus dorsettensis*, which live amongst the hydroids, whilst *Maia squinado* and *Eurynome aspera* were taken twice.

The fish fauna is characterised by the abundance of *Arnoglossus laterna*, *Zeus faber*, *Trigla pini*, *Trigla gurnardus*, *Callionymus lyra*, and *Gobius Jeffreysi*.

From the list of species it will be seen that haul 82 contains several stray specimens of species which are typical of coarser grounds than the present. This suggests the presence of such grounds near it, and it is not unlikely that they will be found on the unexplored area between the present ground and the Bolt Head Shell-gravel, Ground XVII. (See Chart I.)

List of Species. Ground I.

Foraminifera.

Truncatulina lobatula. On *Sertularella Gayi* and *Cellaria.* Plentiful.

Porifera.

Cliona celata. Boring *Buccinum undatum* shell in 92.

Hydrozoa.

Hydractinia echinata. On shells inhabited by *Eupagurus Bernhardus.*

Eudendrium ramosum.

Heterocordyle Conybeari. On *Buccinum undatum* shells.

Bougainvillia ramosa. Occasional large colonies.

Clytia Johnstoni. On other hydroids.

Obelia dichotoma. Fairly common, growing on polychaete tubes and other hydroids.

Campanularia Hincksii.

,, verticillata. Not frequent.

Lafoea dumosa, *var.* robusta. Not frequent.

Lafoea fruticosa. In 81 only.

Cuspidella costata. On hydroids.

Coppinia arcta. On *Lafoea dumosa*, var. *robusta.*

Halecium halecinum. Scarce. Small colonies only.

Halecium Beanii. Somewhat more frequent than *H. halecinum.*

Sertularella Gayi. Not in large quantities, but one of the most abundant hydroids on the ground.

Sertularella polyzonias. Not in large quantity.

Diphasia rosacea. In 82 only.

Sertularia argentea. In 81 only.

Hydrallmania falcata. Not frequent.

Antennularia antennina. Plentiful.

,, ramosa. Less frequent than *A. antennina.*

plie myriophyllum. One or two pieces in 82 and 92 only.

Plumularia Catharina. Ordinary form and green variety in 82 only.

Actinozoa.

Alcyonium digitatum. Not plentiful. Generally on *Cardium echinatum* shells.

Sagartia parasitica. On shell of *Buccinum undatum* inhabited by *Eupagurus Bernhardus.* Not common.

Echinodermata.

Astropecten irregularis. In every haul.

Solaster papposus. One in 92 only.

Palmipes placenta. In 82 only.

Asterias glacialis. } Few only.
,, rubens. }

Ophiura ciliaris. Few only.

Ophiothrix fragilis. One or two small ones only, at base of hydroids and *Cellaria.*

Nemertina.

Carinella annulata.

Tetrastemma flavidum.

,, dorsale.

Lineus bilineatus.

Polychaeta.

Lagisca propinqua.

,, rarispina.

Evarne impar.

Hermadion assimile. One in 92 only recorded.

Acholoe astericola. Commensal with *Astropecten irregularis.*

Nereis pelagica. Recorded in 50 only.

Chaetopterus variopedatus. One tube in 82 and one in 92 only.

Nicolea venustula. One small one in 92.

Thelepus. Moderately plentiful.

Sabella (pavonina?). Generally at base of *Sertularella Gayi.*

Dasychone bombyx. Several in 92.

Hydroides pectinata. Generally on *Buccinum undatum* shells, inhabited by *Eupagurus Bernhardus.*

Crustacea.

Homarus vulgaris. Two specimens in 81 only.

Eupagurus Bernhardus. In *Buccinum undatum* shells, generally with *Hydractinia echinata* or *Heterocordyle Conybeari*, less frequently with *Sagartia parasitica*. Shells sometimes covered with Serpulids.

Porcellana longicornis.

Galathea dispersa.

Stenorhynchus longirostris. A few only.

Inachus dorsettensis. A few in 92 only.

Maia squinado. One or two specimens in 82.

Hyas coarctatus. In 50 only.

Eurynome aspera. A few only taken.

Corystes cassivelaunus. Many specimens in 92; none in the other hauls.

Atelecyclus heterodon. One or two specimens in 82 only.

Scalpellum vulgare. At base of stalk of hydroids.

MOLLUSCA. *Living.*

Saxicava rugosa, *var.* arctica. Small free form attached to shells and hydroids. Scarce. In 92 only.

Pecten opercularis. Small number only of adult. Many small ones on hydroids.

Chiton asellus. In 92 only on *Lepralia foliacea.*

Dentalium entalis. Buried in sand.

Tritonia plebeia.

Dendronotus arborescens. } On hydroids.
Doto fragilis. }
,, pinnatifida. }
Cratena viridis. }

Coryphella Landsburgii.

Lamellidoris oblonga. On *Cellaria.*

Loligo, *sp.* One or two small ones.

SHELLS.

Cardium echinatum. Recent shells numerous, sometimes covered with Serpulids, or bearing colonies of *Alcyonium* or hydroids (*Sertularella* and *Halecium*). Generally free from incrusting Polyzoa. On one shell *Membranipora Dumerilii* was growing on the outer side and *Hippothoa divaricata* on the inner.

Buccinum undatum. Inhabited by *Eupagurus Bernhardus.*

POLYZOA.

Cellaria sinuosa. } In considerable quantity.
,, fistulosa. }

Scrupocellaria scruposa. Small quantity only.

Bicellaria ciliata. Small quantity only.

Cellepora avicularis. On hydroids.

Membranipora Dumerilii. On outer side of a *Cardium echinatum* shell in 51.

Hippothoa divaricata. On inner side of *Cardium echinatum* shell in 51.

Lepralia foliacea. One piece (dead ?) in 92 only, on which were fixed Serpulids, *Ascidiella scabra*, *Chiton asellus*, and encrusting polyzoa.

Schizoporella linearis. } In 92 only growing on *Lepralia foliacea.*
,, auriculata. }
Porella concinna. }
Mucronella ventricosa. }
Diastopora patina. }
Lichenopora hispida. }

Pedicellina cernua.

TUNICATA.

Polycarpa varians. Small specimens on a *Buccinum* shell in 92 only.

Ascidiella scabra. Attached to base of hydroids.

FISHES.

Arnoglossus laterna (*Scaldback*). Plentiful.

Gadus minutus. Three specimens in haul 92 only.

Merluccius vulgaris (*Hake*). One in 92 only.

Capros aper (*Cuckoo*).

Zeus faber (*John Dory*). Six specimens in haul 81.

Trigla pini (*Red gurnard*). A few in each haul.

Trigla gurnardus (*Grey gurnard*). Plentiful.

,, hirundo (*Tub gurnard*). One in 81 only.

Callionymus lyra (*Dragonet*). A few specimens.

Gobius Jeffreysi (*Jeffreys' Goby*). Numerous amongst *Cellaria*, &c.

Scyllium canicula (*Rough dog*). One small one in 81.

Raia clavata (*Thornback*). One in 81.

Ground II. The Outer Eddystone Trawling Ground.

Hauls. 22 (O.-tr.), 23 (O.-tr.), 24 (O.-tr.), 25 (Dr.), and 104 (B.-tr. and C.-dr.). The outer trawling ground extends southward from the 33-fathom line (10 miles south of the Plymouth Mewstone), and hauls have been made to about the 35-fathom line. The fine sand, however, which forms its bottom-deposit extends for a long distance into the Channel. The area examined during the present investigation lies between the Eddystone Grounds on the west and a line similar to that bounding the inner trawling ground on the east.

Bottom-deposit. As will be seen from Table II., this is the finest sand ground examined. The composition in haul 104 was found to be:—

IV.	Fine Gravel	0·1	per cent.
V.	Coarse Sand	0·2	„
VI.	Medium Sand	2·1	„
VII.	Fine Sand	95·8	„
VIII.	Silt	1·9	„

[104. Average grade of sample, 6·998. Percentage of carbonate of lime in whole sample, 15·80. The following are the species of Foraminifera present in Grades VI. and VII., arranged in order of frequency:— *Rotalia beccarii*, *Miliolina seminulum*, *Truncatulina lobatula*, *Planorbulina mediterranensis*, *Discorbina rosacea*, *Textularia gramen*, *Miliolina trigonula*. R. H. W.].

Unbroken shells were scarce, with the exception of *Cardium echinatum* shells. The ground is very barren, and all the five hauls made on it yielded comparatively few specimens. The fauna is, however, well characterised, and has many invariable and distinguishing features, which mark it out from all the other grounds.

Burrowing species. *Astropecten irregularis*, *Cardium echinatum*,* and *Nucula nitida* are the commonest species. *Corystes cassivelaunus*, a characteristic fine sand species, was only represented by one specimen in haul 22. *Echinocardium cordatum* and *Echinocyamus pusillus* were present in 104. The absence of *Dentalium* from the sand in the sample taken at haul 104 is noteworthy.

Fixed species. As on Ground I., these are scarce owing to the scarcity of shells. The absence of species which fix themselves in the sand by a mass of root-fibres is noteworthy, this kind being represented by one colony of *Antennularia antennina* in haul 25, and by an occasional piece of *Cellaria*, both species of the latter genus being, however, very

* The evidence for the presence of this species is similar to that for its presence on Ground I., viz., the constant capture of recent shells of the species and of shells of no other kind.

scarce. I imagine that the scarcity of species of this habit is due to the fineness of the sand, and there are two ways in which this might be detrimental. Either the general nature of the sand might be too loose to afford a satisfactory hold, or the absence of larger particles mixed with the fine sand might prevent the embryos from fixing in their earliest stage. A comparison of the composition of the sand on this ground with that on Ground I. shows that they differ in two ways. There is a smaller percentage of medium and coarse sand on Ground II., but at the same time there is a somewhat smaller proportion of silt. The first of these differences might make it more difficult for the embryos to fix, whilst the second might tend to make the sand particles bind together somewhat less firmly.

Of the other fixed species *Sertularella Gayi* is not uncommon, fixed generally, as on the inner trawling ground, to the tube of the polychæte *Thelepus* (*cincinnatus?*), and the abundance of *Sertularia abietina*, which is not present on the inner ground nor on the Eddystone Grounds, is a characteristic feature. I have not satisfied myself as to the mode of attachment of this species on the present ground, the specimens examined for this purpose not having afforded evidence on the point. On the *Sertularia* the creeping variety of *Lafoea dumosa* and the hydroid *Coppinia arcta* are plentiful, as well as a species of Foraminifera (*Truncatulina lobatula*) tubes of *Spirorbis* and the Polyzoa *Cellepora avicularis, Cellepora ramulosa*, and *Idmonea serpens*. *Plumularia Catharina* is fairly plentiful on the ground, and as will be seen from the list several other hydroids are occasionally taken.

Three other fixed species are characteristic of Ground II., viz., *Alcyonium digitatum*, large colonies of which are abundant, fixed often to *Cardium echinatum* shells; *Chondractinia digitata*, fixed to the same kind of shells; and *Epizoanthus incrustatus* in its free form (see Haddon, No. 35, p. 638), which is constantly taken.

Ascidiella scabra attached to *Sertularella Gayi* was not plentiful, whilst a few *Ciona intestinalis* fixed to shells are recorded. The few shells which are present are generally free from encrusting Polyzoa.

Wandering species. Ophiura ciliaris is present in moderate numbers, but only a few small specimens of *Ophiothrix fragilis*, clinging to the roots of hydroids, were seen. *Asterias rubens* and *A. glacialis* were often represented by large specimens. Of Crustaceans *Galathea dispersa, Eupagurus Bernhardus*, and *Anapagurus lævis* were constantly taken, together with occasional specimens of *Stenorhynchus longirostris, Inachus dorsettensis*, and *Eurynome aspera*. A few fair-sized *Pecten opercularis* were obtained in two of the hauls. Fishes were very scarce, the three species represented being *Trigla pini, Trigla gurnardus*, and *Raia clavata*, of which only a few specimens were taken.

List of Species. Ground II.

FORAMINIFERA.

Truncatulina lobatula. Abundant on *Sertularia abietina*.

PORIFERA.

Suberites domuncula. Large pieces on *Dentalium* shell.

HYDROZOA.

Hydractinia echinata. On shells inhabited by *Eupagurus Bernhardus*. Not plentiful.

Eudendrium ramosum. One colony 4 to 5 inches high in haul 22. A fragment of the small variety in 104.

Perigonimus repens. Fine colony in 104.

Bougainvillia ramosa. A large colony in 104 only.

Clytia Johnstoni. Common on other hydroids.

Lafoea dumosa. Creeping variety only, on *Sertularia abietina*.

Coppinia arcta. Common on *Sertularia abietina*.

Sertularella Gayi. Not uncommon.

Sertularella polyzonias.

Sertularia abietina. In considerable quantity. Very characteristic of this ground. Covered with *Spirorbis* and *Truncatulina*.

Diphasia attenuata. Small quantity only.

Hydrallmania falcata One or two pieces in a haul.

Antennularia antennina. A colony in 25 only.

Plumularia pinnata. Two large, luxuriant colonies with gonophores in 24 only.

Plumularia Catharina. Large colonies moderately plentiful.

ACTINOZOA.

Sagartia parasitica, on shell of *Buccinum undatum*, inhabited by *Eupagurus Bernhardus*. Not common.

Chrondractinia digitata. Generally on shells of *Cardium echinatum*. A few specimens only.

Epizoanthus incrustatus. Moderately common. Not frequent on any of the other grounds described in this report.

Alcyonium digitatum. Large pieces plentiful, often on *Cardium echinatum* shells, sometimes on shells of *Buccinum undatum* inhabited by *Eupagurus Bernhardus*.

ECHINODERMATA.

Asterias rubens. } Both species present.
,, glacialis. } Large specimens.

Luidia Sarsi. One large specimen in 24.

Astropecten irregularis. Common.

Ophiura ciliaris Fairly common in 22 and 23, few or none in other hauls.

Ophiothrix fragilis. One or two small specimens only in each haul.

Echinus acutus. Small specimens only in 23.

Echinus miliaris. A few small.

Echinocardium cordatum. Two specimens in 104.

Echinocyamus pusillus. In stomach of *Astropecten irregularis*.

NEMERTINA.

Tetrastemma dorsale.

POLYCHAETA.

Lepidonotus squamatus. One in 104 only.

Lagisca propinqua.

Laenilla setosissima. One in 104 only.

Acholoe astericola. In ambulacral groove of *Astropecten irregularis*.

Nereis procera. Several in 104 and 24.

Chaetopterus variopedatus. One tube in 24.

Thelepus.

Sabella (pavonina ?). Few only.

Dasychone bombyx.

Hydroides pectinata. On *Cardium echinatum* and *Buccinum undatum* shells.

Potamoceros triqueter. Few only.

Spirorbis sp. Abundant on *Sertularia abietina*.

CRUSTACEA.

Eupagurus Bernhardus. Common in shell of *Buccinum undatum*.

Anapagurus laevis. Common in *Natica* shells.

Galathea dispersa. Numerous amongst the hydroids.

Porcellana longicornis.

Stenorhynchus longirostris. Not frequent.

Inachus dorsettensis. Not frequent.

Eurynome aspera. One or two in 22 only.

Corystes cassivelaunus. One female specimen in 22.

Ebalia tumefacta. Few in 23 only.

Scalpellum vulgare. Common at base of hydroids.

MOLLUSCA. *Living.*

Nucula nitida. Many specimens buried in the sand.

Pecten opercularis. A few adult specimens only, but very many small ones attached to hydroids.

Anomia patelliformis. Attached to *Pecten.*

Ovula patula. On *Alcyonium digitatum.*

Tritonia Hombergii. Small in 23 only.

Galvina tricolor. In 104.

Doto coronata. In 104. Spawning on hydroids.

Hero formosa. In 22.

Loligo sp.

Shells.

Cyprina islandica. Recent shells.

Cardium echinatum. Recent shells numerous. Typical of this ground.

Nucula nitida.

Pecten opercularis. Few only.

Dentalium entalis.

Aporrhais pes-pelecani. One in 23 only.

Natica nitida. Inhabited by *Anapagurus laevis.*

Buccinum undatum. Inhabited by *Eupagurus Bernhardus.*

POLYZOA.

Cellaria sinuosa. } A small quantity only.
,, fistulosa. }

Cellepora avicularis. } On *Sertularia abietina.*
,, ramulosa. }
Idmonea serpens. }

Membranipora Flemingii on living *Pecten opercularis.*

TUNICATA.

Ascidiella scabra. A few small specimens attached to hydroids.

Ciona intestinalis. A few only.

A compound Ascidian.

PISCES.

Trigla pini (*Red Gurnard*). Few only.

,, gurnardus (*Grey Gurnard*). Few only.

Raia clavata (*Thornback*). Two specimens in haul 104.

GROUND III. THE OUTER EAST EDDYSTONE SAND.

The position of this ground will be seen on the charts.

Hauls. 57 (B.-tr.), 72 (B.-tr.), 91 (O.-tr. and C.-dr.), 49 (O.-tr.), 53 (Dr.), and 56 (B.-tr.).

Bottom-deposit. Fine sand, which is somewhat coarser than that of Ground I., and less muddy than Ground V., the two adjoining fine sand grounds.

The texture of the sample at haul 91 was :—

IV.	Fine Gravel	0·5 per cent.
V.	Coarse Sand	2·5 ,,
VI.	Medium Sand	13·2 ,,
VII.	Fine Sand	82·7 ,,
VIII.	Silt	1·1 ,,

[91. Average grade of sample, 6·814. Percentage of carbonate of lime in whole sample, 14·13. Highest percentage occurs in IV., which contains 64·70 per cent., but this forms so small a portion of the whole sample that V. at 28·8 per cent. should be taken. As in 90 this is a fine-textured deposit with low percentage of carbonate of lime. The rock materials are Triassic and Eddystone reef. In 91 VI. Foraminifera are comparatively scarce, only twenty individuals were found in 0·45 grams (seven grains), or 44 per gram. In 91 VII. sixty-seven foraminifera were counted in 0·13 gram (two grains), or 515 per gram. In VI. *Rotalia beccarii* was present to the almost total exclusion of every other form, while in VII. the individuals of this species practically equalled in number those of all other species added together. Arranged in order of frequency the following is the list of species:—*Rotalia beccarii, Miliolina seminulum, Textularia gramen, Truncatulina lobatula, Discorbina rosacea, Bolivina dilatata, Planorbulina mediterranensis.* In all, seven species.—R. H. W.]

There are very few shells on this ground.

Burrowing species. As on the inner trawling ground (I.), *Astropecten irregularis* and *Dentalium entalis* are abundant. *Corystes cassivelaunus,* which on the inner trawling ground was taken in haul 92 only, is here abundant in all hauls excepting 53 and 56. From the position of the various hauls it will therefore be seen that a centre of distribution of this species occurs on the S.E. portion of Ground III. and the N.W. of Ground I. (Chart XIII., *cf.* also p. 492.) There is no evidence of *Cardium echinatum* on the present ground. *Aphrodite aculeata* is occasionally taken.

Fixed species. The most obvious distinction between the ground now under consideration and the inner trawling ground (I.), which adjoins it, is the much greater abundance of *Cellaria* and the much richer hydroid fauna. Of the hydroids which fix themselves in the sand by a felt-work of root-fibres *Aglaophenia myriophyllum* is invariably taken, and is much commoner than on Ground I., and *Antennularia antennina* is common also.

Sertularella Gayi is very common, being by far the most plentiful hydroid on the ground, and is generally attached to the tube of *Thelepus.* It is associated, as on the inner trawling ground, with *Sabella* (*pavonina*?) and *Ascidiella scabra.* The other characteristic hydroids are *Sertularella polyzonias, Eudendrium ramosum, Bougainvillia ramosa, Plumularia pinnata, Plumularia Catharina,* and occasional specimens of *Hydrallmania falcata. Lafoea dumosa,* var. *robusta,* is not uncommon, associated with *Coppinia arcta* and *Dondersia banyulensis.* Occasional specimens of *Halecium halecinum* and *Halecium Beanii* are the result of the influence of the neighbouring Eddystone gravel grounds, which is also shown by one or two specimens of *Chaetopterus. Alcyonium digitatum* occurs only as small colonies, and one specimen of *Paraphellia expansa* was taken in haul 72. *Cellaria fistulosa* and *Cellaria sinuosa* are both abundant, and *Bicellaria ciliata, Cellepora avicularis, Cellepora ramulosa, Scrupocellaria scruposa* are common on hydroids, but incrusting Polyzoa are very scarce.

Wandering species. *Asterias rubens* and *A. glacialis* are not numerous, and *Pecten opercularis*, which is their usual food on these grounds, is also scarce. *Ophiura ciliaris* occurs in small numbers, and *Ophiothrix fragilis* is again only represented by small specimens at the roots of hydroids and *Cellaria*. *Palmipes placenta* was taken twice (hauls 53 and 57), and one or two specimens of *Solaster papposus* and *Henricia sanguinolenta* were seen. *Echinus miliaris* was the only species of *Echinus*.

Buccinum undatum was common. *Stenorhynchus longirostris* and *Inachus dorsettensis* were abundant amongst the hydroids, and *Pandalus brevirostris* amongst the *Cellaria*. *Galathea dispersa*, *Porcellana longicornis*, *Eurynome aspera*, *Portunus depurator* were also common, together with *Eupagurus Bernhardus*, associated with *Sagartia parasitica* or *Hydractinia echinata*, and *Eupagurus Prideauxii*, associated as usual with *Adamsia palliata*.

Fishes were more numerous here than on any other ground upon which the trawl was used. The species most plentiful were *Pleuronectes limanda* and *microcephalus*, *Trigla pini* and *gurnardus*, *Callionymus lyra* and *Gobius Jeffreysi*.

List of Species. Ground III.

Foraminifera.

Truncatulina lobatula. Abundant, attached to hydroids, especially to *Sertularella Gayi*.

Porifera.

Suberites domuncula. One with *Anapagurus lævis* in 56 only.

Hydrozoa.

Hydractinia echinata. In 72 only, on shell inhabited by *Eupagurus Bernhardus*.

Eudendrium ramosum. Plentiful.

,, sp. A small species of *Eudendrium* (not *E. capillare*).

Bougainvillia ramosa. Large colonies.

Clytia Johnstoni. Abundant on hydroids and *Cellaria*.

Obelia dichotoma. Scarce. On *Cellaria*.

Campanularia Hincksii On hydroids.

,, verticillata. In 72 only.

Lafoea dumosa, *var.* robusta. In quantity, attached to shells.

,, fruticosa Not frequent.

Coppinia arcta. Common, on *Lafoea dumosa*.

Halecium halecinum. Small quantity only.

Halecium Beanii. Less common than *H. halecinum*.

Sertularella Gayi. In large quantities, generally attached to *Thelepus* tubes.

,, polyzonias. Less common than *S. Gayi*.

Sertularia argentea. Not frequent.

Hydrallmania falcata. A small quantity only.

Antennularia antennina. Plentiful.

,, ramosa. Not so common as *A. antennina*.

Aglaophenia myriophyllum. Plentiful. Several pieces in each haul of the trawl. Rooted in the sand.

Plumularia pinnata.

,, Catharina. Plentiful.

Actinozoa.

Sagartia parasitica. On *Buccinum undatum* shell inhabited by *Eupagurus Bernhardus*. Not frequent.

Adamsia palliata. On shells inhabited by *Eupagurus Prideauxii*. Not frequent.

Alcyonium digitatum. Generally only small colonies on *Pecten opercularis*.

ECHINODERMATA.

Cucumaria lactea. Not abundant.

Astropecten irregularis. Numerous.

Palmipes placenta. One or two specimens in 53 and 57 only.

Solaster papposus. One or two in 72 only.

Henricia sanguinolenta. One or two in 72 only.

Asterias glacialis. } Always present, but
,, rubens. } not in large numbers.

Ophiura ciliaris. Several in 91. Few or none in the other hauls.

Ophiothrix fragilis. A few small ones, generally at the roots of *Cellaria*.

Echinus miliaris. A few.

NEMERTINA.

None recorded.

POLYCHAETA.

Aphrodite aculeata. Three in 91 and one in 72 only.

Lepidonotus squamatus. One in 91 only.

Lagisca propinqua. Not numerous.

Harmothoe imbricata. One in 91 only.

Hyalinoecia tubicola. One in 72 only.

Nereis fucata. In 57 and 91.

,, procera. Several in 91.

Nephthys Hombergii. One in 91.

Chaetopterus variopedatus. One or two in a haul only.

Nicolea venustula.

Thelepus. Many specimens.

Sabella (pavonina ?). At base of *Sertularella Gayi*.

Dasychone bombyx. Numerous.

Serpula vermicularis.

Hydroides pectinata.

CRUSTACEA.

Pandalus brevirostris. Many, living amongst the *Cellaria* and hydroids.

Eupagurus Bernhardus. Numerous in *Buccinum undatum* shells.

,, Prideauxii. Not so frequent as *E. Bernhardus*. Shells covered with *Adamsia palliata*.

Anapagurus laevis. In 56 only, living in *Suberites domuncula*.

Porcellana longicornis. Abundant.

Galathea dispersa. Abundant.

Stenorhynchus longirostris. Abundant amongst hydroids and *Cellaria*.

Inachus dorsettensis. Abundant amongst hydroids and *Cellaria*.

Maia squinado. One in 56 only.

Eurynome aspera. A few only.

Cancer pagurus. In 56 only.

Portunus depurator. Absent in 72 and 91. Numbers taken in the remaining hauls.

Corystes cassivelaunus. Numerous in 49, 91, 72, and 57. Absent in 53 and 56.

Scalpellum vulgare. Abundant at base of stalk of hydroids, especially of *Antennularia antennina*.

MOLLUSCA. *Living.*

Pecten opercularis. Many in 49; comparatively few large ones in remaining hauls. Young specimens attached to hydroids numerous.

Anomia ephippium. On *Pecten opercularis* and on *Buccinum undatum* shells inhabited by *Eupagurus Bernhardus*.

Dentalium entalis. Numerous in the sand.

Buccinum undatum. Common.

Cypraea europaea. One or two in a haul.

Proneomenia aglaopheniae. Occasional specimens coiled on the stem of *Aglaophenia myriophyllum*.

Dondersia banyulensis. Occasional specimens on *Lafoea dumosa*, var. *robusta*.

Doto coronata. }
Coryphella rufibranchialis. } On hydroids.
Archidoris tuberculata. }

Lamellidoris oblonga. On *Cellaria*.

Shells.

Buccinum undatum. Inhabited by *Eupagurus Bernhardus*.

Dentalium entalis.

[No *Pecten* or other common shells.]

POLYZOA.

Cellaria sinuosa. } In large quantity.
,, fistulosa. }

Scrupocellaria scruposa. Plentiful.

Bugula flabellata. Not generally plentiful.

Bugula avicularia. In 56 only.

Cellepora avicularis. } Plentiful on
,, ramulosa. } hydroids.

Idmonea serpens. Plentiful on hydroids.

Alcyonidium gelatinosum. A little only.

Cylindroecium dilatatum. } On hydroids.
Pedicellina cernua. }
Membranipora Dumerilii. On *Buccinum* shell in 53 only.
Microporella ciliata. } On *Buccinum* shell in 53 only.
Mucronella ventricosa. }
Schizoporella auriculata. }

TUNICATA.

Ascidiella scabra. Numerous at base of *Cellaria* and hydroids, especially of *Sertularella Gayi*.
Botryllus, *sp*. Common on hydroids and *Cellaria*.
A compound Ascidian common on *Cellaria*.

FISHES.

Pleuronectes platessa (*Plaice*). Not numerous.
Pleuronectes limanda (*Dab*). Plentiful.
,, microcephalus (*Lemon Dab*). Plentiful.
Solea lutea. One in 56 only.
Arnoglossus laterna (*Scaldback*). Several specimens.
Capros aper (*Cuckoo*). Generally one or two specimens.
Zeus faber (*John Dory*). One or two in each haul.
Trigla pini (*Red Gurnard*). Plentiful.
,, gurnardus (*Grey Gurnard*). Plentiful.
,, lineata (*Parrot Gurnard*). Two in 72 only.
Lophius piscatorius (*Angler*). One or two only.
Callionymus lyra (*Dragonet*). Plentiful.
Gobius Jeffreysi (*Jeffreys' Goby*). Plentiful amongst *Cellaria*, &c.
Crystallogobius Nilssoni. Recorded in 91 only.
Scyllium canicula (*Rough Dog*). One small one in 91 only.
Raia, *sp*. A few small specimens.

GROUND IV. THE INNER EAST EDDYSTONE SAND.

Two to three miles east of the Eddystone.

Hauls. 34 (O.-tr.), 39 (O.-tr.), 40 (Fine mosquito net), 77 (B.-tr).

The four hauls taken between two and three miles east of the Eddystone show a fauna in most respects similar to that of the fine sand of Ground III. (the Outer East Sand), but there are several important additional features, which indicate a coarser ground. No sample of the bottom-deposit was taken here. It is not unlikely that the hauls were made on two kinds of ground, first on fine sand similar to that of Ground III., and as the Eddystone was approached on a coarser deposit.

Shells are numerous, the common ones being *Pecten opercularis*, *P. maximus*, *Tapes virginea*, and *Cardium echinatum*.

Burrowing species. There are important differences in the burrowing species on this ground and on Ground III. *Astropecten irregularis* is much less abundant here, and *Corystes cassivelaunus* is entirely absent. *Atelecyclus heterodon* was taken in haul 34, and *Cardium norvegicum* in both 34 and 39. These differences all indicate an approach to the coarser Eddystone grounds.

Fixed species. The hydroid fauna is practically identical with that of the preceding ground, excepting that *Halecium halecinum* and *H. Beanii* are much more abundant, and *Chaetopterus*, to the tubes of which these species are often fixed, is also somewhat more plentiful. *Cellaria* is still plentiful.

The Ascidians and branched Polyzoa are identical with those of

Ground III.; but incrusting Polyzoa, which were scarce on the latter ground, now become abundant with the increase in the number of shells.

Wandering species. All the important species on Ground III. are present, but in addition Ground IV. has the following:—*Porania pulvillus* (one in haul 39), *Ophiura albida* (one in 77), *Ophiactis Balli* (seen in 40 only), *Echinus acutus* and *esculentus*, *Hyas coarctatus* (in 39 only), *Portunus pusillus** (in 39 only), *Turritella communis* (in 39 only), *Pecten maximus*, many *Pecten opercularis*, and with them an increase in the number of *Asterias glacialis* and *A. rubens.* The greater abundance of shells has already been noticed. All these features indicate an approach to the coarser Eddystone grounds.

The fish fauna is much less numerous than on Ground III., but the species present are all taken on that ground also.

List of Species. Ground IV.

FORAMINIFERA.

Truncatulina lobatula. On hydroids, etc.

PORIFERA.

Cliona celata. Boring shells, especially *Pecten* and *Lutraria.*

HYDROZOA.

Hydractinia echinata. On shell inhabited by *Eupagurus Bernhardus.* In 34 only.

Eudendrium ramosum.

,, capillare. In 77.

,, sp. Small species, not *capillare.*

Clytia Johnstoni. Plentiful.

Campanularia Hincksii. On *Halecium* and other hydroids.

Lafoea dumosa, *var.* robusta. Abundant.

,, fruticosa. In 77 only.

Halecium halecinum. Fairly abundant, growing on shells and on *Chaetopterus* tubes.

Halecium Beanii. Less abundant than *H. halecinum.*

Sertularella Gayi. Abundant, generally on polychaete tubes.

Sertularella polyzonias. Less frequent than *S. Gayi.* Generally on shells.

Sertularia argentea. Scarce. In 40 only.

Hydrallmania falcata. A few colonies in each haul.

Antennularia antennina. Not very abundant.

Aglaophenia myriophyllum. Abundant, fixed in the sand.

Plumularia pinnata. In 34 only.

,, setacea. In 34 and 77.

,, Catharina. In 34 only.

ACTINOZOA.

Sagartia parasitica. On shells of *Buccinum undatum*, inhabited by *Eupagurus Bernhardus.* Not frequent.

Adamsia palliata. On shells inhabited by *Eupagurus Prideauxii.* Not frequent.

Alcyonium digitatum. Small colonies only, often on living *Pecten opercularis.*

Sarcodictyon catenata. Red variety. In 39 only.

ECHINODERMATA.

Astropecten irregularis. Very few specimens.

Porania pulvillus. One specimen in 39 only.

Solaster papposus. Common in 77, not frequent in other hauls.

Henricia sanguinolenta. One or two specimens in each haul.

Asterias glacialis. } Common generally,
,, rubens. } only small ones in 77.

* *Portunus depurator* and *P. pusillus* have been included under the head of wandering species on account of their marked adaptation for swimming. At the same time both species do sometimes burrow, although to what extent has never been determined.

Ophiura ciliaris. Very few (none in 77).
,, albida. One small specimen in 77.
Ophiothrix fragilis. A few small specimens at roots of *Cellaria* only.
Ophiactis Balli. Seen in 40 only.
Echinus acutus. Two specimens in 34 only.
,, miliaris. Few only.
,, esculentus. Several in 34, not numerous in other hauls.

NEMERTINA.

Carinella annulata.
Amphiporus pulcher.
Lineus bilineatus.
Micrura fasciolata.

POLYCHAETA.

Aphrodite aculeata. One in 77 only.
Lagisca propinqua. In 39 only.
Hyalinoecia tubicola. Several in each haul.
Nereis pelagica. One in 34 only.
Chaetopterus variopedatus. One or two specimens in 40 and in 77.
Thelepus. Abundant.
Sabella. At base of *Sertularella Gayi.*
Dasychone bombyx. Not numerous.
Serpula vermicularis. Few only recorded in 77.

CRUSTACEA.

Pandalus brevirostris. Numerous amongst the *Cellaria* and hydroids.
Eupagurus Bernhardus. In *Buccinum undatum* shells. Not numerous.
Eupagurus Prideauxii. With *Adamsia palliata.* Not numerous.
Anapagurus laevis. In 39 only.
Porcellana longicornis. Abundant.
Galathea dispersa. Abundant.
Stenorhynchus longirostris. } Abundant amongst hydroids and *Cellaria.*
Inachus dorsettensis. }
Hyas coarctatus. A few in 39 only.
Eurynome aspera. In 39 only.
Portunus depurator. Abundant except in 77.
Portunus pusillus. In 39 only.
Atelecyclus heterodon. One or two in 34 only.

Scalpellum vulgare. Frequent at base of hydroids, especially *Antennularia* and *Halecium.*

MOLLUSCA. *Living.*

Saxicava rugosa, *var.* arctica. Attached to shells.
Cardium norvegicum. Two or three specimens in 34 and 39. None in 77.
Modiola modiolus. At roots of hydroids, &c. Small only.
Pecten maximus. Few or none.
,, opercularis. Numerous full-grown specimens and many young on hydroids.
Turritella communis. In 39 only.
Buccinum undatum. Common.
Cypraea europaea. Not very frequent.

Dondersia banyulensis. On *Lafoea dumosa*, var. *robusta.*

Lamellidoris oblonga. On *Cellaria.*

Shells.

Solen ensis. Not numerous.
Solecurtus candidus. Two in 36 only.
Tapes virginea. Common.
Artemis exoleta.
Cyprina islandica.
Cardium norvegicum.
Pinna pectinata. One or two only.
Pecten maximus. Numerous.
,, opercularis. Numerous.
Dentalium entalis.
Trochus granulatus. Inhabited by *Eupagurus Prideauxii.*
Buccinum undatum. Inhabited by *Eupagurus Bernhardus.*

POLYZOA.

Cellaria sinuosa. } In masses.
,, fistulosa. }
,, Johnstoni. Small quantity.
Scrupocellaria scruposa.
Bugula flabellata. In 34 only.
Cellepora avicularis. } On hydroids, numerous.
,, ramulosa. }
Idmonea serpens. }
Incrusting forms very numerous on shells. For list see Table VI., p. 534.

TUNICATA.

Ascidiella venosa. Few in 39 only.
,, scabra. Numerous at base of *Sertularella Gayi* and of *Cellaria.*
Compound Ascidian on *Cellaria.*

PISCES.

Pleuronectes microcephalus (*Lemon Dab*). One in 77 only.
Solea variegata (*Thickback*). In 39.

Arnoglossus laterna (*Scaldback*). In 34 only.
Zeus faber (*John Dory*). One in 77 only.
Trigla gurnardus (*Grey Gurnard*). One in 77 only.
,, lineata (*Parrot Gurnard*). Five specimens in 77.
Trigla hirundo (*Tub Gurnard*). One in 77 only.
Callionymus lyra (*Dragonet*). A few only.
Gobius Jeffreysi (*Jeffreys' Goby*). Many amongst *Cellaria*, etc.
Rhina squatina (*Monk*). One small one in 77 only.

Ground V.

Four miles N.E. ¼ N. of Eddystone.

Haul 90 (otter-trawl).

It has been necessary to consider this haul separately from Ground III., as both the bottom-deposit and the fauna show several important differences.

Bottom-deposit. The sand has the following texture:—

II.	Coarse Gravel	2·7	per cent.
III.	Medium Gravel	2·3	,,
IV.	Fine Gravel	2·4	,,
V.	Coarse Sand	3·2	,,
VI.	Medium Sand	13·7	,,
VII.	Fine Sand	68·8	,,
VIII.	Silt	6·8	,,

The sand is therefore at the same time coarser and more muddy than that of Ground III.

[90. Average grade of sample, 6·561. Percentage of carbonate of lime in whole sample, 22·91. Highest percentage occurs in IV., which contains 57·50 per cent. This is one of the fine-textured deposits, in which VII. constitutes more than 50 per cent. of the whole, and shows the low percentage of carbonate of lime which characterises these fine-texture sands among the present series of samples.

Geologically 90 is parted from all the other samples by a very wide distinction indeed. Roundly speaking, 80 per cent. of the identifiable rock materials are Devonian and only 20 per cent. Triassic. No Eddystone reef material is present. No other sample presents more than 15 per cent. of Devonian rock.

In 90 VI. Foraminifera are comparatively scarce, in 90 VII. they are numerous, 104 individuals were counted in 0·13 grams (2 grains), or 800 per gram. The following species are present, arrangement as before:—*Rotalia beccarii, Miliolina seminulum, Lagena orbignyana, Bolivina dilatata, Textularia gramen, Discorbina rosacea, Truncatulina lobatula.* In all, seven species.—R. H. W.]

There are few unbroken shells.

Burrowing species. The abundance of *Aphrodite aculeata* forms a characteristic feature of the fauna. The only other burrowing species captured were *Astropecten irregularis* (one only), *Corystes cassivelaunus* (one only), *Gonoplax angulata* (one only, see p. 495).

Fixed species. The hydroid fauna is practically identical with that of Ground III., excepting that *Halecium halecinum* is entirely absent, and only a small quantity of *H. Beanii* was taken. There was only a little *Cellaria*, and branched Polyzoa were scarce.

Wandering species. The most characteristic feature is the abundance of *Palmipes placenta.* In other respects the wandering species are similar to those found on Ground III., excepting that *Solaster papposus* and *Anapagurus laevis* were plentiful, whilst *Pandalus brevirostris* and *Buccinum undatum* were not taken.

List of Species. Ground V.

Hydrozoa.

Hydractinia echinata. On shell inhabited by *Eupagurus Bernhardus.*

Eudendrium ramosum. Very small colony, probably young *ramosum*, on a piece of leather.

Bougainvillia ramosa. Two good pieces.

Clytia Johnstoni. On *Bougainvillia.* Common.

Obelia dichotoma. A little.

Lafoea dumosa, *var.* robusta. Plentiful.

Coppinia arcta. Common on *Lafoea dumosa.*

Halecium Beanii. Small quantity only.

Sertularella Gayi. A moderate quantity.

,, polyzonias. Not so plentiful as *S. Gayi.*

Hydrallmania falcata. A little only.

Antennularia antennina.

Aglaophenia myriophyllum.

Plumularia Catharina. Small quantity on a bit of old leather.

Actinozoa.

Sagartia parasitica. On *Buccinum undatum* shell inhabited by *Eupagurus Bernhardus.*

Adamsia palliata. With *Eupagurus Prideauxii.*

Alcyonium digitatum. One piece on *Chaetopterus* tube and one on *Pecten opercularis* shell.

Echinodermata.

Astropecten irregularis. One only.

Palmipes placenta. Plentiful. Five specimens.

Solaster papposus. Plentiful.

Asterias glacialis. 4 or 5 specimens.

,, rubens. Many.

Ophiura ciliaris. One.

Polychaeta.

Aphrodite aculeata. A number of specimens, probably 6 or 8.

Chaetopterus variopedatus. Piece of tube only.

Sabella (pavonina ?).

Hydroides pectinata. Few.

Crustacea.

Eupagurus Bernhardus. In *Buccinum undatum* shell, with *Sagartia parasitica.*

,, Prideauxii, with *Adamsia palliata.*

Anapagurus laevis. Plentiful.

Porcellana longicornis. Plentiful.

Galathea dispersa. Plentiful.

Stenorhynchus longirostris. Plentiful.

Inachus dorsettensis. Plentiful.

Corystes cassivelaunus. One only (male).

Gonoplax angulata. One only (male).

Mollusca. *Living.*

Pecten opercularis. Very few.

Shells.

Pecten opercularis. Few.

Polyzoa.

Cellaria sinuosa. } A little only of each.
,, fistulosa. }

Cellepora avicularia. } On *Hydrallmania*
,, ramulosa. } *falcata.*

Pedicellina cernua. On *Bougainvillia ramosa.*

Schizoporella auriculata. On piece of old leather.

TUNICATA.

Ascidiella scabra. Two or three young specimens on *Inachus dorsettensis.*

FISHES.

Trigla pini (*Red Gurnard*). Two specimens.

Trigla lineata (*Parrot Gurnard*). Two specimens.

Lophius piscatorius (*Angler*). One specimen.

Raia clavata (*Thornback*). One specimen.

,, blanda (*Blonde*). One specimen.

GROUND VI. THE SOUTH EDDYSTONE FINE SAND.

Hauls. 101 (Dr.) and 102 (Dr. and C.-dr.).

The fauna at hauls 101 and 102 was practically the same, and resembles most nearly that found on Ground III. (the Outer East Sand). In one or two points, however, it resembles also that of the fine sand of Ground II. (the Outer Trawling Ground).

Bottom-deposit. Fine sand. The texture is as follows:—

II.	Coarse Gravel	0·2 per cent.
III.	Medium Gravel	0·2 ,,
IV.	Fine Gravel	0·3 ,,
V.	Coarse Sand	1·3 ,,
VI.	Medium Sand	10·8 ,,
VII.	Fine Sand	85·4 ,,
VIII.	Silt	1·7 ,,

This resembles somewhat closely the sand of haul 91 (Ground III.). (*Cf.* Table II., p. 525.)

[102. Average grade of sample, 6·849. Percentage of carbonate of lime in whole sample, 14·86. Highest percentage occurs in II., which contains 41·38 per cent., but this grade only represents 0·2 per cent. of whole sample. In 102 VII., which is 85·4 per cent. of whole sample, the percentage of $CaCo_3$ is 13·00. This is another fine-texture sand. No Eddystone reef material occurs in either 102 II. or 102 III. The latter grade consists, as regarding rock material, of 85 per cent. Trias and 15 per cent. Devonian. 0·13 grams (two grains) of 102 VII. contained 48 Foraminifera, or 369 per gram. The species of Foraminifera present in 102 VI. and VII. are given below in order of frequency:—*Rotalia beccarii, Truncatulina lobatula, Miliolina seminulum, Discorbina rosacea, Spiroloculina planulata, Lagena orbignyana, Bulimina pupoides.* In all, seven species.—R. H. W.]

Unbroken shells are fairly common.

Burrowing species. Astropecten irregularis is represented by one specimen in 102 only. *Dentalium entalis* is common, and fresh shells of *Cardium echinatum* are abundant. Several specimens of *Atelecyclus heterodon* were also taken.

Fixed species. Cellaria is abundant, and the hydroid fauna is practically the same as that on the sand of Grounds III. and IV., excepting that *Halecium halecinum* is more abundant, corresponding to a considerable abundance of *Chaetopterus variopedatus*, upon the tubes of which it is generally growing. The tubes of the latter species were generally attached to shells on this ground. *Halecium halecinum* and *Chaetopterus* show the influence of the neighbouring coarser Eddystone grounds.

Two other noteworthy fixed species are *Chondractinia digitata*, fixed to *Cardium echinatum* shells, and large colonies of *Alcyonium digitatum*,* which are numerous. In both these features the ground resembles the fine sand of the Outer Trawling Ground (II.), which adjoins it.

Wandering species. Here again the species are practically the same as on Grounds III. and IV., the exceptional features being the presence of several specimens of *Ebalia tuberosa*, a species abundant on the Eddystone gravels, and the presence of a number of *Hyas coarctatus*.†

List of Species. Ground VI.

Hydrozoa.

Hydractinia echinata. One colony in 101.

Tubiclava cornucopiae. On *Dentalium* shell.

Perigonimus sp. On *Dentalium* shell.

Bougainvillia ramosa. On *Chaetopterus* tube.

Lafoea dumosa, *var.* robusta.

Campanularia verticillata. One or two colonies.

Halecium halecinum. Plentiful.

Sertularella Gayi. Plentiful.

Hydrallmania falcata. One piece only in 101.

Antennularia antennina. } Plentiful.
,, ramosa. }

Aglaophenia myriophyllum. One piece only, with *Scalpellum vulgare* on it.

Plumularia pinnata.

,, Catharina. On *Chaetopterus* tube.

Actinozoa.

Adamsia palliata. With *Eupagurus Prideauxii.*

Chondractinia digitata. On *Cardium echinatum* shells. Two or three specimens only.

Alcyonium digitatum. In quantity; large colonies.

Echinodermata.

Astropecten irregularis. One only, in 102.

Asterias glacialis. } Several of each.
,, rubens. }

Ophiura ciliaris. A few only.

Ophiura albida.

Amphiura elegans. Several.

Ophiothrix fragilis. A few small ones only at roots of *Cellaria.*

Echinus miliaris.

Nemertina.

Carinella annulata.

Tetrastemma dorsale.

Lineus bilineatus.

Polychaeta.

Lagisca propinqua. Two specimens only.

Nereis procera. Five or six specimens.

Typosyllis alternosetosa. Several specimens.

Polydora caeca. Several specimens.

Chaetopterus variopedatus. Fairly abundant.

Nicolea venustula. One in 101 only.

Thelepus. Many.

Sabella.

Sabellaria spinulosa. Several.

Dasychone bombyx. Four specimens.

Serpula vermicularis. Tubes only.

Hydroides pectinata. Several.

Potamoceros triqueter. Tubes only.

Crustacea.

Eupagurus Bernhardus. A few in *Buccinum undatum* shells.

,, Prideauxii. Not plentiful. With *Adamsia palliata.*

Anapagurus laevis. In shell of *Tornatella fasciata*, and in *Turritella communis* shell.

* *Cf.* p. 457.

† *Cf.* p. 490.

Porcellana longicornis. Plentiful.

Galathea dispersa. Plentiful.

Stenorhynchus longirostris. Dressed with hydroids, etc. (*Plumularia pinnata*).

Inachus dorsettensis. Dressed with barnacles, compound ascidians, sponges, and *Scrupocellaria*.

Hyas coarctatus. A few females, breeding, dressed with barnacles, compound ascidians, *Ascidiella scabra*, *Scrupocellaria*, and *Bicellaria*.

Eurynome aspera. In 101 only, one or two specimens.

Portunus depurator. Several. Females with eggs.

,, pusillus. Few.

Atelecyclus heterodon. Several.

Ebalia tuberosa. Few only.

Balanus. On *Hyas coarctatus*.

Scalpellum vulgare. On *Aglaophenia myriophyllum*.

MOLLUSCA. *Living*.

Pecten tigrinus. One specimen in 101.

,, opercularis. A few only.

Chiton asellus.

Dentalium entalis. A few.

Buccinum undatum.

Doto fragilis.

,, coronata.

,, pinnatifida.

Archidoris tuberculata.

Triopa claviger.

Polycera quadrilineata.

Shells.

Psammobia ferroensis. One or two only.

Tapes virginea. Plentiful.

Cyprina islandica. A few.

Cardium echinatum. Shells numerous.

Nucula nucleus.

Pinna pectinata. One or two only.

Pecten maximus.

,, opercularis. Many.

Dentalium entalis.

POLYZOA.

Cellaria sinuosa. } In quantity.
,, fistulosa. }

Scrupocellaria scruposa.

Bicellaria ciliata. On *Hyas coarctatus* and on *Sertularella Gayi*.

Bugula avicularia. On *Sertularella Gayi*.

Cellepora ramulosa. In quantity on hydroids.

TUNICATA.

Ascidiella scabra. Fairly common.

Compound Ascidian on *Sertularella Gayi*.

GROUND VII. THE SOUTH EDDYSTONE INTERMEDIATE SAND.

Hauls. 75 (Dr.), 76 (Dr.), 70 (Dr.), 71 (Dr.), 54 (Dr.), 69 (Dr.), 38 (Dr.), 80 (Dr.), 79 (Dr.), 100 (Dr.), 32 (Dr.), 109 (Dr. and C.-dr.).

The hauls combined under the present heading vary somewhat individually, but the prevailing features are the same, and indicate a predominant sand fauna mixed with a considerable number of species characteristic of the gravel grounds which lie immediately to the north, especially Ground XIV.

Bottom-deposit. This is probably fine sand over the whole ground, though the more northerly hauls may have been taken partly on gravel and partly on fine sand. Gravel was noted at the time in haul 76.

A sample with the canvas bag taken at haul 109 had the following texture:—

III.	Medium Gravel	0·01 per cent.
IV.	Fine Gravel	0·2 ,,
V.	Coarse Sand	1·2 ,,
VI.	Medium Sand	24·0 ,,
VII.	Fine Sand	72·7 ,,
VIII.	Silt	1·9 ,,

[109. Average grade of sample, 6·749. Percentage of carbonate of lime in whole sample, 30·15.

The following are the species of Foraminifera in grades VI. and VII. in order of frequency :—*Rotalia beccarii*, *Miliolina seminulum*, *Textularia gramen*, *Truncatulina lobatula*, *Discorbina rosacea*, *Textularia agglutinans*, *Miliolina bicornis*, *Lagena sulcata*, *Bolivina dilatata*.—R. H. W.]

Shells were plentiful in all the hauls, and in hauls 32, 75, 79, and 100 a number of stones were obtained.

Fauna. The ground as a whole is barren, and in no haul were many specimens taken, with the exception of haul 100.

Burrowing species. A few *Astropecten irregularis* were present, but the species was not at all common. *Dentalium entalis* was present in the sample of sand, and several bivalve molluscs were taken in individual hauls, as will be seen from the list of the fauna.

Fixed species. Of species which usually fix themselves in fine sand the following occur on this ground: *Antennularia antennina* and *ramosa*, *Aglaophenia myriophyllum*, and *Cellaria fistulosa* and *sinuosa*, the two latter in considerable abundance. The other representatives of the fixed fauna include species which are typical of the gravels to the north and also those typical of the fine sand to the south. Of the former are *Polycarpa varians* and *Chaetopterus variopedatus*, with *Halecium halecinum*, *H. Beanii* and *Plumularia Catharina*; of the latter *Sertularella Gayi*, *Bougainvillia ramosa*, and *Ascidiella scabra*.

Wandering species. These are not abundant, and are of kinds found both on the gravel and on the fine sand grounds. A noteworthy feature, characteristic of the ground, is the presence in almost every haul of *Palmipes placenta*.

List of Species. Ground VII.

Foraminifera.

Truncatulina lobatula. On *Cellaria* and hydroids.

Porifera.

Suberites domuncula. Fairly common, inhabited by *Eupagurus cuanensis*.

Cliona celata. Common, boring shells.

Hydrozoa.

Hydractinia echinata. In 76 only, on shell inhabited by *Eupagurus Bernhardus*.

Eudendrium ramosum. Fairly plentiful.

,, capillare. Scarce.

,, sp. Scarce.

Bougainvillia ramosa. Not uncommon.

Clytia Johnstoni. Common, on hydroids, etc.

Obelia dichotoma. In 32 only.

Campanularia Hincksii. Common, on hydroids and shells.

Lafoea dumosa, *var.* robusta. Frequent. Creeping variety also abundant on hydroids and *Cellaria*.

Calycella fastigiata. Recorded in 75 only.

Halecium halecinum. Plentiful on *Chaetopterus* tubes and on shells.

,, Beanii. Not so plentiful as *H. halecinum*.

,, labrosum. Recorded in 75 only.

Sertularella Gayi. Generally moderately plentiful. In hauls 69, 71, and 109 small pieces only.

,, polyzonias. Scarce.

Sertularia argentea. In 79 and 32 only. Not abundant.

Hydrallmania falcata. Frequent, but not abundant in any haul.

Antennularia antennina. Frequent.

,, ramosa. In 109 only.

Aglaophenia myriophyllum. In five hauls, not abundant.

Plumularia pinnata. Common.

,, setacea. In 32 only.

,, Catharina. In 100 and 109 only, abundant on *Chaetopterus* tubes.

ACTINOZOA.

Sagartia parasitica. On *Buccinum undatum* shell inhabited by *Eupagurus Bernhardus.* One specimen in 75 only.

Adamsia palliata. On shells inhabited by *Eupagurus Prideauxii.* Not numerous.

Paraphellia expansa. One in 109 only.

Caryophyllia Smithii. Not frequent.

Alcyonium digitatum. Generally small colonies only. In 100 larger colonies on stones.

Sarcodictyon catenata. In 100 only, where it was present in large quantities on stones.

ECHINODERMATA.

Cucumaria pentactes. In 100 only, attached to stones.

,, lactea. In 79 only.

Astropecten irregularis. One or two in 69, 79, and 109 only.

Palmipes placenta. Frequent, but only one or two in each haul.

Solaster papposus. Not numerous.

Henricia sanguinolenta. One or two in 71 and 75 only.

Asterias glacialis. Frequent but not numerous.

,, rubens. Not numerous.

Ophiura ciliaris. Few only.

,, albida. Few only.

Ophiactis Balli. Generally present.

Ophiothrix fragilis. Not generally plentiful. Most numerous in 76 and 109.

Amphiura filiformis. One in 109.

Echinus acutus. One in 54 only.

,, miliaris. Common.

,, esculentus. Not abundant.

Echinocyamus pusillus. Recorded in 75 and 109 only.

Spatangus purpureus. In 38 only, caught on the tangles attached to the dredge.

NEMERTINA.

Carinella superba.

Lineus bilineatus.

Micrura purpurea.

Cerebratulus fuscus.

POLYCHAETA.

Lepidonotus squamatus. In two hauls only.

Lagisca propinqua. Not uncommon.

,, rarispina. Two specimens recorded in 70 only.

Polynoe scolopendrina. In 54 only.

Harmothoë imbricata. Recorded in 54 only.

Evarne impar. One or two in 54 and 70 only.

Hyalinoecia tubicola. Not frequent.

Arabella geniculata. One in 100 only recorded.

Nereis procera. Occasional specimens. Several in 100.

Eulalia viridis. Recorded in 54 only.

Chaetopterus variopedatus. Constantly present, but not in large numbers.

Pectinaria auricoma. Occasional specimens.

Polymnia nebulosa. One in 100 only.

Nicolea venustula. Recorded in 54 only.

Thelepus. Abundant.

Amphitrite gracilis. Recorded in 32 only.

Terebellid tubes.

Sabella (pavonina ?).

Filograna implexa. Attached to shells. Frequent.

Dasychone bombyx. Abundant.

Protula tubularia. A few only.

Serpula vermicularis. Attached to shells, etc.

Hydroides pectinata.

Potamoceros triqueter.

CRUSTACEA.

Pandalus brevirostris. Few only amongst *Cellaria.*

Eupagurus Bernhardus. Not frequent. As usual in *Buccinum undatum* shells.

,, Prideauxii. Shells covered by *Adamsia palliata.* Not frequent.

,, cuanensis. Not frequent. Covered with *Suberites domuncula.*

Anapagurus laevis. Not frequent.

Porcellana longicornis.

Galathea dispersa. Frequent.

Stenorhynchus longirostris. Frequent, but not abundant in any one haul.

Inachus dorsettensis. Frequent, but not abundant in any one haul.

Eurynome aspera. Frequent, but only two or three in a haul.

Cancer pagurus. One in 75.

Portunus pusillus. In 38 only.

Atelecyclus heterodon. In 38 and 100 only. Not numerous.

Ebalia tuberosa. In 38 only.

Balanus crenatus. On *Pecten opercularis.*

Scalpellum vulgare. Attached to *Halecium* and *Antennularia.*

MOLLUSCA. *Living.*

Saxicava rugosa, *var.* arctica. Not frequent. Attached to shells and base of hydroids.

Pandora obtusa. One specimen in 75 only.

Venus verrucosa. One in 76 only.

,, casina. One in 79 only.

,, ovata. In 76 only.

Circe minima. In 76 only.

Cardium echinatum. One in 75 only.

,, norvegicum. One or two in 79 and 100 only.

Kellia suborbicularis. In 80 only.

Modiola modiolus.

Nucula nucleus. One or two in 76 only.

,, nitida. One in sample of sand of 109.

Lima Loscombii. In 75 only.

Pecten tigrinus. One or two in 38 and 80 only.

,, maximus. Generally several specimens.

,, opercularis. Generally not a large number; most abundant in 54.

Anomia ephippium. } Generally on *Pec-*

,, patelliformis. } *ten opercularis.*

Chiton asellus. On shells and stones.

Dentalium entalis. In sample of sand from 109.

Emarginula reticulata.

Lamellaria perspicua. In 75, 80, and 109.

Buccinum undatum. Generally present.

Cypraea europaea. In 75 only.

Proneomenia aglaopheniae. In 100 and 109 on stem of *Aglaophenia myriophyllum.*

Doto fragilis.

,, pinnatifida.

,, coronata.

Doris maculata. One specimen in 100.

Lamellidoris oblonga. On *Cellaria.*

Shells.

Lyonsia norvegica. In 76 only.

Solecurtus candidus. In 100 only.

Psammobia ferroensis. In 75 and 80 only.

Lutraria elliptica.

Tapes virginea. Frequent.

Artemis exoleta.

Cyprina islandica.

Cardium echinatum. Frequent.

,, norvegicum. Frequent.

Pectunculus glycimeris. A few small only.

Pinna pectinata. Few only.

Pecten tigrinus.

,, maximus. Numerous.

,, opercularis. Numerous.

Dentalium entalis.

Turritella communis. Few.

Aporrhais pes-pelecani. Few.

Fusus islandicus. One in 80 only.

POLYZOA.

Cellaria sinuosa. Plentiful.

,, fistulosa. Plentiful.

Bicellaria ciliata. Frequent, attached to *Cellaria* and hydroids.

Scrupocellaria scruposa. Abundant on shells and at base of hydroids, etc.

Bugula avicularia. Few only.

Cellepora avicularis. On hydroids. Common.

,, ramulosa. On hydroids. Common.

Crisea eburnea. Not frequent.

Pedicellina cernua. In 100 only.

Alcyonidium gelatinosum. In 100 only, on stones.

Incrusting Polyzoa numerous. For list see Table VI., p. 534.

TUNICATA.

Molgula simplex. On *Chaetopterus* tube in 100.

Polycarpa varians. Numerous.

Ascidiella scabra. Few only.

Ciona intestinalis. Few only.

Corella larvaeformis. On *Cellaria* in 75 and 109.

FISHES.

Lepadogaster bimaculatus. Single specimens in several hauls.

GROUND VIII.

Eddystone S.E. ½ S., about one mile distant.

Haul 48, (Dr.) with 89 B (?) C-dr.

Haul 48 resembles in all the characteristic features of its fauna the hauls made on the fine sand of Ground VII., and it is therefore necessary to separate it from Ground XIV., which adjoins it on the southern side. As in the case of Ground VII. the fauna is clearly very much influenced by that of XIV., but the abundance of *Cellaria*, the nature of the hydroid fauna, the presence of *Palmipes placenta*, all point to a fine sand deposit. It is not unlikely that the dredge passed over more than one kind of bottom-deposit.

That a fine sand deposit does exist in this neighbourhood was shown by a sample taken with the canvas dredge at the conclusion of haul 89. The latter haul (Ground X., see p. 417) was composed almost entirely of *Ophiothrix fragilis*, but when at the end of it the canvas dredge was used, it came up full of fine sand, and with no specimens of the ophiurid. This sample has been numbered 89 B. That the ophiurid ground had been passed when it was obtained I have no doubt, as in all cases where the canvas dredge has been used on grounds where *Ophiothrix* was very abundant, both on the Eddystone grounds and in other localities, a very large number of specimens of the species came up with the sample of deposit, and the latter was always muddy gravel.

The composition of the sample 89B is therefore given here:—

II.	Coarse Gravel	1·3 per cent.
III.	Medium Gravel	1·5 ,,
IV.	Fine Gravel	2·8 ,,
V.	Coarse Sand	6·3 ,,
VI.	Medium Sand	29·2 ,,
VII.	Fine Sand	56·8 ,,
VIII.	Silt	2·0 ,,

[89B. Average grade of sample, 6·386. Percentage of carbonate of lime in whole sample, 48·61. Highest percentage occurs in VI., which contains 62·73. This is one of the fine-texture deposits, in which the percentage of grade VII. to whole sample rises above 50 per cent.

In 89 B VI. Foraminifera were numerous, thirty-eight individuals being counted in 0·16 grams (2½ grains), or 237 per gram. In 89B VII. Foraminifera were very numerous. The following are the species found, in order of frequency:—*Rotalia beccarii, Miliolina seminulum, Truncatulina lobatula, Textularia gramen, Textularia agglutinans, Discorbina rosacea, Planorbulina mediterranensis, Lagena sulcata, Miliolina trigonula, Miliolina bicornis.* In all, ten species.—R. H. W.]

No shells were present in the sample.

List of Species. Ground VIII.

Hydrozoa.

Campanularia Hincksii.
Lafoea dumosa.
Halecium halecinum.
Sertularella Gayi.
Sertularia argentea. A few young colonies.
Antennularia antennina.
Aglaophenia myriophyllum. Fairly common.

Actinozoa.

Alcyonium digitatum. One or two pieces only.

Echinodermata.

Palmipes placenta.
Henricia sanguinolenta. One or two only.
Asterias glacialis. One or two.
,, rubens. One only.
Ophiura ciliaris. Many.
,, albida. One.
Ophiocoma nigra. A moderate number.
Ophiothrix fragilis. A moderate number.
Echinus esculentus.
Spatangus purpureus.

Polychaeta.

Hyalinoecia tubicola.
Chaetopterus variopedatus. Few only.
Pectinaria auricoma. One or two only.
Thelepus.
Protula tubularia. Few only.

Crustacea.

Eupagurus Prideauxii.
Anapagurus laevis.
Porcellana longicornis.
Galathea dispersa.
Stenorhynchus longirostris
Inachus dorsettensis.
Eurynome aspera.
Portunus depurator.
,, pusillus.
Ebalia tumefacta.
,, tuberosa.

Mollusca. *Living.*

Pecten maximus.
,, opercularis. A few adults. Young on hydroids common.
Aporrhais pes-pelecani. One living specimen.
Ovula patula. One or two only.
Proneomenia aglaopheniae. On *Aglaophenia myriophyllum.*

Shells.

Eulima. With *Anapagurus laevis.*
Lutraria elliptica.
Cardium echinatum.
,, norvegicum.
Pecten opercularis.
Dentalium entalis.

Polyzoa.

Cellaria sinuosa. } In quantity.
,, fistulosa. }
Bugula avicularia.
,, flabellata.
Scrupocellaria scruposa. In quantity on Terebellid tubes.
Bicellaria ciliata. On *Sertularella Gayi.*
Cellepora avicularis. } Common on hydroids.
,, ramulosa. }
Idmonea serpens. }
Alcyonidium gelatinosum. A large piece.
Pedicellina cernua.
Lichenopora hispida. } On *Pecten opercularis* shell.
Mucronella ventricosa. }

Tunicata.

Ascidiella scabra.

Ground IX. The West Eddystone Coarse Gravel.

Hauls. 93 (Dr.) and 94 (C.-dr.).

These two hauls show the fauna of the West Eddystone coarse gravels in its most typical form, without admixture of the fine sand fauna, and the description of the ground will therefore be given in some detail.

Bottom-deposit. A mixture of coarse gravel with fine sand. The texture is shown by the percentage composition as follows:—

I.	Stones	0·9 per cent.	
II.	Coarse Gravel	44·4 „	
III.	Medium Gravel... ...	14·0 „	} 69·5 per cent. (I.–IV.)
IV.	Fine Gravel	10·2 „	
V.	Coarse Sand	7·5 „	
VI.	Medium Sand	5·5 „	
VII.	Fine Sand	16·2 „	} 30·4 „ (V.–VIII.)
VIII.	Silt	1·2 „	

[94. Average grade of sample, 3·66. Percentage of carbonate of lime in whole sample, 17·71. Percentage in each grade except I., which may be neglected, uniformly low; highest in VI. at 29·14 per cent. In 94 II. 75 per cent. by weight of the gravel is Triassic, 9 per cent. derived from the Eddystone reef, 16 per cent. is Devonian. In 94 III. 69 per cent. Triassic, 18 per cent. Eddystone reef, 13 per cent. Devonian. Some amorphous silica, probably flint and cretaceous, is present in this and many other samples, and is referred to elsewhere. (p. 384.) Foraminifera are fairly numerous in VII. and numerous in VI. The following species are present, following order of frequency:—*Rotalia beccarii, Truncatulina lobatula, Discorbina rosacea, Miliolina seminulum, Planorbulina mediterranensis, Textularia gramen, Bulimina pupoides, Lagena striata, Spiroloculina planulata, Miliolina bicornis, Lagena apiculata.* In all, eleven species.—R. H. W.]

Shells were very numerous on this ground. (See list, p. 416.) The fauna is varied and abundant, the nature of the ground offering great advantages, especially to fixed species.

Burrowing species. Ebalia tumefacta and *Ebalia tuberosa** were very numerous, as well as small specimens of *Atelecyclus heterodon.* The other burrowing animals were one small specimen of *Astropecten irregularis* and one specimen of *Cardium norvegicum.*

Fixed species. Hydroids which root themselves directly in the bottom-deposit are represented by one or two specimens of *Antennularia antennina* only, and *Cellaria* is also practically absent, one small piece of *C. fistulosa* only having been obtained.

One of the chief characteristics of the ground, and one which has a marked influence on its general fauna, is the presence of large numbers of *Chaetopterus variopedatus.* The large, leathery tubes of these worms are found either attached to shells, joined together into masses of considerable size, or, less frequently, apparently living freely

* Mr. Garstang tells me that he has observed the burrowing of *Ebalia* in gravel in the Laboratory. They do not burrow deeply, but remain with the front part of the carapace just above the surface.

buried in the gravel. The tubes form excellent fixing places for other species of animals, more especially for the hydroid *Halecium halecinum*, which is exceedingly abundant and characteristic of this ground. *Plumularia Catharina*, *P. pinnata*, and *Halecium Beanii* are also commonly found attached to the tubes of the same worm.

Only one or two small pieces of *Sertularella Gayi*, which was the abundant hydroid on the fine sand, were taken here. Another characteristic species is the ascidian *Polycarpa varians*, which is very numerous, and seems to be attached directly to the gravel, since pieces of gravel and shell are generally fixed all over its base when it comes up in the dredge.

Caryophyllia Smithii is abundant on shells, especially on *Pecten* shells, associated with the barnacle *Pyrgoma anglicum*. *Alcyonium digitatum* is found only in the form of small colonies on living *Pecten opercularis*. One specimen of *Paraphellia expansa* was obtained.

Amongst other fixed species *Anomia ephippium*, *A. patelliformis*, *Scrupocellaria scruposa* are common attached to the *Chaetopterus* tubes or to shells, *Bicellaria ciliata* on *Halecium*, and incrusting polyzoa on shells.

Wandering species. *Pecten opercularis* is numerous, and with it *Asterias rubens* and *Asterias glacialis*. *Pecten maximus* is also common, and is a characteristic species of these coarse gravel grounds, though by no means so numerous as *P. opercularis*. *Ophiothrix fragilis*, of which only a few small specimens at the roots of hydroids and *Cellaria* were seen on the fine sand, is here very numerous. *Ophiura ciliaris* is present in considerable numbers, but is by no means so plentiful as *O. fragilis*. *Ophiura albida*, which was never taken on the fine sand, is common, as well as *Ophiactis Balli*, a small species which hides away in crevices amongst shells and *Chaetopterus* tubes. *Echinus acutus* and *esculentus* are both taken.

The hermit crabs *Eupagurus Bernardus* and *E. Prideauxii* are plentiful, the former associated with *Hydractinia echinata*, the latter with *Adamsia palliata*. *Anapagurus laevis* is very abundant, so much so that it becomes one of the peculiar features of the ground. *Inachus dorsettensis* is plentiful, covered with sponges, &c. *Stenorhynchus longirostris* is less abundant. *Eurynome aspera* was represented by several specimens. *Porcellana longicornis* and *Galathea dispersa* are exceptionally numerous. The polychaete fauna is abundant and varied, the abundance of *Hyalinoecia tubicola* and the presence of *Hermione hystrix* being characteristic of the coarse deposit.

Living specimens of *Turritella communis*, a species only represented by single specimens on other grounds, were here numerous. *Buccinum undatum* was present, and single specimens of *Lima Loscombii* and

Trochus granulatus were seen. The small sucker, *Lepadogaster bimaculatus*, was the only fish taken.

List of Species. Ground IX.

Foraminifera.

Truncatulina lobatula. On hydroids.

Porifera.

Cliona celata. Boring shells of *Pecten maximus* and *Pecten opercularis*.

Hydrozoa.

Hydractinia echinata. On shell inhabited by hermit crab.

Eudendrium ramosum. Small colony, growing on *Ascidiella scabra*.

Campanularia Hincksii. Large variety, growing on *Pecten opercularis* shell.

Halecium halecinum. Very plentiful on tubes of *Chaetopterus* and on shells, especially *Pecten maximus*.

Halecium Beanii. Several pieces.

Sertularella Gayi. One or two pieces only.

Hydrallmania falcata. A little only, growing on *Cyprina Islandica* shell.

Antennularia ramosa. One or two pieces only.

Plumularia pinnata. On *Chaetopterus* tubes, fairly plentiful.

,, setacea. Small variety, with gonophores.

,, Catharina. On *Chaetopterus* tubes, common, both ordinary and green variety.

Actinozoa.

Caryophyllia Smithii. Common on old shells of *Pecten maximus*.

Adamsia palliata. With *Eupagurus Prideauxii*.

Paraphellia expansa. One specimen.

Alcyonium digitatum. Small colonies on *Pecten opercularis* only.

Echinodermata.

Astropecten irregularis. One small specimen.

Solaster papposus. One only.

Asterias glacialis. } Plentiful.
,, rubens. }

Ophiura ciliaris. Many.

,, albida. Many.

Ophiactis Balli. Plentiful.

Ophiocoma nigra. One large one and one small one only seen.

Ophiothrix fragilis. Plentiful.

Echinus acutus. Two specimens.

,, miliaris. A few.

,, esculentus. Two specimens.

Nemertina.

Carinella superba.

Micrura fasciolata.

,, purpurea.

Tetrastemma (? flavidum).

Polychaeta.

Hermione hystrix. One specimen.

Lepidonotus squamatus. Very many specimens.

Lagisca propinqua. Very many.

Halosydna gelatinosa. One only.

Hyalinoecia tubicola. Many.

Chaetopterus variopedatus. Very abundant, attached to shells and to gravel.

Polymnia nebulosa. Three specimens.

Thelepus. Very abundant.

Terebellid tubes.

Sabella (pavonina ?).

Filograna implexa. Small pieces on *Pecten opercularis* shells.

Dasychone bombyx. Abundant.

Serpula vermicularis. Fairly plentiful, attached to shells.

Hydroides pectinata.

Potamoceros triqueter.

Crustacea.

Pandalus brevirostris. Few only.

Eupagurus Bernhardus. Several in *Buccinum undatum* shell.

,, Prideauxii. With *Adamsia palliata*. In *Trochus granulatus* shell.

Anapagurus laevis. Common in the following shells, *Turritella communis*, *Natica nitida*, *Mangelia gracilis*, and *Nassa incrassata*.

Porcellana longicornis. Plentiful.

Galathea dispersa. Plentiful.

Stenorhynchus longirostris. Common. Less plentiful than *Inachus*.

Inachus dorsettensis. Common.

Eurynome aspera. A number of specimens.

Portunus pusillus. One or two.

Atelecyclus heterodon. Many small specimens.

Ebalia tumefacta. } Very numerous.
,, tuberosa.

Balanus, *sp.* Common on shells.

Scalpellum vulgare. Attached to base of *Halecium halecinum.*

Pyrgoma anglicum. Associated with *Caryophyllia Smithii.*

MOLLUSCA. *Living.*

Saxicava rugosa, *var.* arctica. On *Pecten maximus* shell.

Cardium norvegicum. One living only.

Modiola modiolus. Small, on *Pecten opercularis* shells.

Lima Loscombii. One living.

Pecten maximus. Many.

,, opercularis. Many.

Anomia ephippium. } Many small ones on shells.
,, patelliformis.

Chiton asellus. On *Pecten* shells.

Pileopsis hungaricus. One specimen.

Trochus granulatus. One living.

Turritella communis. Many.

Buccinum undatum. Several specimens and spawn.

Doto fragilis. Abundant on *Halecium halecinum.*

Shells.

Lutraria elliptica.

Tapes virginea. Many.

Venus verrucosa. Few.

,, ovata. Many.

Cyprina islandica. A few only.

Cardium norvegicum. Numerous.

Pinna pectinata. One or two only.

Pecten tigrinus. Few.

,, maximus. Plentiful.

,, opercularis. Plentiful.

Trochus granulatus. Inhabited by *Eupagurus Prideauxii* and covered with *Adamsia palliata.*

Turritella communis. Numerous, many inhabited by *Anapagurus laevis.*

Aporrhais pes-pelecani. One shell.

Natica nitida. Shells inhabited by *Anapagurus laevis.*

Nassa incrassata. Shells inhabited by *Anapagurus laevis.*

Mangelia gracilis. Shells inhabited by *Anapagurus laevis.*

Trophon muricatus. One shell.

POLYZOA.

Cellaria fistulosa. One piece only.

Scrupocellaria scruposa. In quantity on shells, on *Chaetopterus* tubes, and on *Polycarpa varians.*

Bicellaria ciliata. On *Halecium Beanii.*

Incrusting forms fairly common on shells. For list see Table VI., p. 534.

TUNICATA.

Polycarpa varians. Many, attached to shells or to gravel.

Ascidiella scabra. At base of stem of *Antennularia antennina* and *Sertularella Gayi.*

Botryllus, *sp.*

Fishes.

Lepadogaster bimaculatus. One or two only.

GROUND X. THE *OPHIOTHRIX FRAGILIS* GROUND.

Hauls. 42 (Dr.), 55 (Dr.), 89 (Dr.), 95 (Dr.), and 96 (C.-dr.).

This ground lies to the west and north-west of the Eddystone, between the medium gravel of Ground XIV. and the coarse gravel of Grounds IX. and XI.

Bottom-deposit. Coarse gravel and muddy sand. The texture of the sample at haul 96 was:—

II.	Coarse Gravel	35·3 per cent.
III.	Medium Gravel	14·3 ,,
IV.	Fine Gravel	9·1 ,,
V.	Coarse Sand	8·9 ,,
VI.	Medium Sand	16·3 ,,
VII.	Fine Sand	12·1 ,,
VIII.	Silt	3·9 ,,

[96. Average grade of sample, 4·081. Percentage of carbonate of lime in whole sample, 33·18. Highest percentage occurs in IV., which contains 60·08 per cent. In 94 II. the gravel consists of Trias, 77 per cent.; Eddystone reef, 13 per cent.; Devonian, 10 per cent. In 94 III. the proportions are, Trias, 69 per cent.; Eddystone reef, 18 per cent.; Devonian, 13 per cent. In 96 VII. Foraminifera are numerous. The following species occur in VI. and VII., following order of frequency:—*Rotalia beccarii, Textularia gramen, Miliolina seminulum, Truncatulina lobatula, Spiroloculina planulata, Lagena sulcata, Textularia agglutinans, Biloculina ringens, Miliolina bicornis, Polymorphina lactea, Discorbina rosacea.* In all, eleven species.—R. H. W.]

Shells were numerous. For list see p. 418.

The fauna of this ground is characterised by the very great abundance of *Ophiothrix fragilis*, which occurs almost to the exclusion of every other species. The dredge comes up nearly full of these ophiurids. In haul 89 the only other living species taken was *Ophiocoma nigra*, of which there were a few large specimens. In the remaining hauls a few specimens of other species were obtained, but generally not more than one or two in each. These species, as will be seen from the following list, consist of immigrants from the grounds on either side, that is, from the medium gravel of Ground XIV. and from the coarse gravel of Ground IX. Ground X. may be regarded as a great centre of distribution of *Ophiothrix fragilis*, from which it extends on all sides on to the surrounding grounds (Chart VIII.). The ophiurids were found to be feeding on the fine silt, of which there is a somewhat high percentage in the bottom-deposit.

List of Species. Ground X.

A. *Haul* 89.

Echinodermata.

Ophiothrix fragilis. Dredge half full.

Ophiocoma nigra. A few, large.

Mollusca. *Shells.*

Pecten opercularis. A few only.

B. *Hauls* 42, 55, 95.

(B). Hydrozoa.

Eudendrium, *sp.* Small *sp.* not *E. capillare*, in 55 only, growing on *Hydrallmania*, which was fixed to a stone.

Campanularia Hincksii.

Lafoea dumosa, *var.* robusta. In 55 only.

Halecium halecinum. Not plentiful. Most abundant in 55.

Halecium Beanii. Not plentiful.

Sertularella Gayi. Not plentiful. Largest quantity in 55.

Hydrallmania falcata. In 55 only, growing on a stone.

Antennularia antennina. Not plentiful.

,, ramosa. One piece in 42 only.

Aglaophenia tubulifera. In 55 only, growing on *Polycarpa varians*.

Plumularia Catharina. Green variety in 55 only.

(B). Actinozoa.

Alcyonium digitatum. Young colonies on *Pecten opercularis*. One or two only.

Sarcodictyon catenata. A small quantity in 95 only.

Caryophyllia Smithii. Fairly plentiful on shells.

Adamsia palliata. With *Eupagurus Prideauxii* in 42 only.

(B). ECHINODERMATA.

Porania pulvillus. One specimen in 42 only.

Solaster papposus. A few small.

Asterias glacialis. } One or two only.
,, rubens. }

Ophiura ciliaris. One or two specimens in each haul.

Ophiactis Balli. Few.

Ophiocoma nigra. One in 42, one small one in 95.

Ophiothrix fragilis. In very large numbers.

Echinus acutus. One in 42 only.

,, miliaris.

,, esculentus. In 55. One small one in 42.

Spatangus purpureus. One or two in each haul.

(B). NEMERTINA.

Drepanophorus rubrostriatus. In 55 only.

(B). POLYCHAETA.

Hermione hystrix. One in 42 only.

Lepidonotus squamatus. One in 95 only.

Lagisca propinqua. One in 95 only.

Hyalinoecia tubicola. One in 95 only.

Chaetopterus variopedatus. A few specimens in each haul.

Pectinaria auricoma. One in 42 only.

Nicolea venustula. In 55 only.

Terebellid tubes.

Sabella (pavonina ?). One or two in 95.

Dasychone bombyx. In 55 only.

Protula tubularia. Few only.

Serpula vermicularis. Few only.

Hydroides pectinata. Few only.

(B). CRUSTACEA.

Eupagurus Bernhardus. One or two in 95 only.

,, Prideauxii. One or two in 42 only.

Porcellana longicornis.

Galathea dispersa. In 55 only.

Stenorhynchus longirostris. In 55 only (the haul in which hydroids were plentiful).

Portunus pusillus. Not numerous.

Atelecyclus heterodon. Two or three in a haul.

Ebalia tumefacta. } Few only. None
,, tuberosa. } in 55.

Balanus crenatus. On *Pecten opercularis*.

Scalpellum vulgare. On *Halecium halecinum* in 55 only.

(B). MOLLUSCA. *Living.*

Astarte sulcata. Plentiful in 95 only.

Cardium norvegicum. In 42 only.

Kellia suborbicularis. In 42 only, in fine mud in bivalve mollusc shells.

Pecten maximus. A few in each haul.

,, opercularis. Few only.

Anomia ephippium. } Chiefly on *Pecten*
,, patelliformis. } *opercularis.*

Chiton asellus.

Pileopsis hungaricus. On *Pecten opercularis* in 95.

Emarginula reticulata. One or two only.

Aporrhais pes-pelecani. One in 55 only.

Buccinum undatum. Few only.

Dondersia banyulensis. On *Lafoea dumosa*, var. *robusta* in 55 only.

Shells.

Lutraria elliptica.

Tapes virginea.

Venus ovata.

Astarte sulcata.

Cardium echinatum. One in 42 only.

,, norvegicum.

Pinna pectinata. One in 42 only.

Lima Loscombii.

Pecten tigrinus.

,, maximus.

,, opercularis. Numerous.

Dentalium entalis.

Aporrhais pes-pelecani. One in 42 only.

(B). POLYZOA.

Cellaria sinuosa. } Scarce. Most plentiful
,, fistulosa. } in 55.

Scrupocellaria scruposa. }
Bugula avicularia. } In 55 only.
,, flabellata. }

Cellepora ramulosa. } On hydroids in 55
Pedicellina cernua. } only.

Incrusting polyzoa only moderately plentiful. For list see Table VI.

(B). TUNICATA.

Polycarpa varians. Several specimens in a haul.

(B). FISHES.

Lepadogaster bimaculatus. Single specimens in a haul.

Ground XI. The North-West Eddystone Coarse Gravel.

Hauls. 8 (Dr.), 9 (Dr.), 46 (Dr.), 47 (Dr.), 84 (Dr. and C.-dr.).

This ground lies just to the eastward of the Hand Deeps, and at a distance of two to three miles from the Eddystone. The dredgings were generally commenced on the line passing through the old and new Eddystone Lighthouses.

Bottom-deposit. Coarse gravel mixed with fine sand.

The texture, as indicated by percentage composition, is as follows, in the sample taken at haul 84:—

II.	Coarse Gravel	... ... 47·6	per cent.
III.	Medium Gravel	... ... 14·5	„
IV.	Fine Gravel	... ... 7·5	„
V.	Coarse Sand	... ... 4·0	„
VI.	Medium Sand	... ... 5·9	„
VII.	Fine Sand	... ... 17·7	„
VIII.	Silt	... ... 2·8	„

[84. Average grade of sample, 3·704. Percentage of carbonate of lime in whole sample, 34·66. Highest percentage occurs in IV., which contains 64·90. In 84 VI. Foraminifera are not numerous. Twenty-one were counted in 0·45 grams (seven grains) of this grade, or 46 per gram. In 84 VII. Foraminifera are not numerous. In these grades the following foraminifera were found, arranged in order of frequency:—*Truncatulina lobatula, Textularia gramen, Rotalia beccarii, Planorbulina mediterranensis, Discorbina rosacea, Miliolina bicornis, Bolivina dilatata, Miliolina seminulum, Bulimina pupoides, Lagena orbignyana, Nodosaria sp., Polymorphina lactea.* In all, twelve species.—R. H. W.]

Shells are plentiful. For list see p. 422.

The principal difference of texture between this sample and that of Ground IX., which seems to be of importance, is the larger percentage of sand and silt in the present case, 18 per cent. and 3 per cent. respectively, as against 16 per cent. and 1 per cent. on Ground IX.

As will be seen by comparing the two faunas, the great difference between them is the presence or greater abundance on the present ground (XI.) of species typical of the fine sand grounds, which species are scarce or absent on Ground IX. Since the general nature of the fauna of the two grounds (IX. and XI.) is very similar, I shall assume in the following account of Ground XI. that the reader is acquainted with the nature of the fauna of Ground IX., which is the typical coarse gravel fauna, and shall confine myself to pointing out the differences between the two grounds. This method of treatment should bring out clearly the fact that fine sand species are more abundant on Ground XI. than on the typical Gravel Ground IX.

Burrowing species. *Ebalia tumefacta* and *Ebalia tuberosa* are decidedly less numerous in XI. than in IX. *Atelecyclus heterodon*, of which small specimens are numerous in IX., is not abundant in XI. *Cardium norvegicum*, which was represented by one specimen in IX., was not taken in XI. *Dentalium entalis*, which was absent in IX., was present in one haul (47) in XI.

Fixed species. The only species common on the typical Coarse Gravel IX., which is scarce in XI., is *Polycarpa varians*, of which one or two specimens were taken in haul 47 only. On the other hand:—

Sertularella Gayi is much more common on XI. than it is on IX.

Antennularia antennina. Common on XI., is scarce on IX.

,, *ramosa.* ,, XI. ,, IX.

Aglaophenia myriophyllum. Occasionally taken on XI., is absent on IX.

Ascidiella scabra is more common on XI. than it is on IX.

Cellaria sinuosa }
Cellaria fistulosa } are much more common on XI. than on IX.

Proneomenia aglaopheniae was found on XI., clinging to the stalk of *Aglaophenia myriophyllum.*

Wandering species. *Pecten opercularis* and *Pecten maximus*, which are common on the typical Gravel Ground IX., are scarce or absent on XI., and with them *Asterias rubens* and *A. glacialis* become scarce. The following species also, which are common on IX., are scarce or absent on XI.:—*Ophiura albida, Eupagurus Bernhardus, Eupagurus Prideauxii, Anapagurus laevis,* and *Turritella communis.*

List of Species. Ground XI.

Hydrozoa.

Eudendrium *sp.* Small species, not *capillare.*

Bougainvillia ramosa. One piece in 84 only.

Clytia Johnstoni. Plentiful on hydroids and shells.

Lafoea dumosa. Creeping form only.

,, fruticosa. Plentiful in 84 only.

Halecium halecinum. Plentiful, growing on *Chaetopterus* tubes and on shells, especially *Pecten maximus* shells.

,, Beanii. Plentiful, growing on *Chaetopterus* tubes and on shells, especially *Pecten maximus* shells.

Sertularella Gayi. Plentiful, attached to polychaete tubes (especially *Chaetopterus*), or less frequently to shells. Not so common as *Halecium.*

Sertularella polyzonias. Less common than *S. Gayi.*

Antennularia antennina. Common, fixed in the sand by felt-work of fibres, or attached to *Chaetopterus* tubes.

,, ramosa. Less common than *A. antennina.* Often fixed to *Chaetopterus* tubes.

Aglaophenia myriophyllum. Generally abundant, fixed in the sand by felt-work of fibres.

Plumularia pinnata. On stems of *Halecium* or other hydroids.

,, setacea. In 84 only, growing on stem of *Antennularia antennina.*

,, Catharina. Plentiful, generally growing on *Chaetopterus* tubes.

ACTINOZOA.

Adamsia palliata. One specimen in 8 only, surrounding a *Trochus granulatus* shell.

Paraphellia expansa. Three or four specimens covered with sand.

Caryophyllia Smithii. Attached to shells, often *Pecten maximus* shells.

Alcyonium digitatum. One or two small colonies only in each haul.

ECHINODERMATA.

Astropecten irregularis. In 47 only.

Palmipes placenta. Two or three specimens in 8 and 9.

Solaster papposus. Small specimens (1 to 2 in. diam.) only.

Asterias glacialis. Not numerous.

,, rubens. Generally not numerous, but several large ones in 84.

Ophiura ciliaris. Abundant.

Ophiactis Balli. Generally present, hiding in crevices of shells, *Chaetopterus* tubes, &c.

Ophiocoma nigra. Large specimens fairly plentiful in 47. Absent in other hauls.

Ophiothrix fragilis. Abundant.

Echinus acutus. One or two generally present.

,, miliaris. Numerous.

,, esculentus. Not numerous.

NEMERTINA.

Eupolia curta. One specimen in 47 only.

POLYCHAETA.

Lepidonotus squamatus. Not numerous.

Lagisca propinqua. One in 9 only.

Hyalinoecia tubicola. Several in each haul.

Nereis pelagica. Few in 8 only.

Chaetopterus variopedatus. Plentiful in all hauls.

Thelepus. Plentiful.

Terebellid tubes.

Sabella (pavonina ?).

Sabellaria spinulosa. One in 8 only.

Hydroides pectinata.

Potamoceros triqueter.

Eurylepta cornuta.

Phascolion strombi.

CRUSTACEA.

Eupagurus Bernhardus. One full-sized one in 84 and one small one in 9.

,, cuanensis. Not plentiful.

Anapagurus laevis. In 9 only.

Porcellana longicornis. Common.

Galathea dispersa. Common.

Stenorhynchus longirostris. Not plentiful.

Inachus dorsettensis. Not plentiful.

Eurynome aspera. One or two generally taken.

Portunus pusillus. Often numerous.

Atelecyclus heterodon. One in 47, one small one in 84.

Ebalia tumefacta. }
,, tuberosa. } Two or three generally present in each haul.
,, Cranchii. }

Balanus crenatus. On *Pecten opercularis.*

Scalpellum vulgare. On stem of *Halecium* and *Antennularia.*

Pyrgoma anglicum.

Phthisica marina.

Erichthonius abditus. Forming tubes on stem of *Sertularella Gayi.*

A Caprellid. On *Antennularia.*

MOLLUSCA. *Living.*

Saxicava rugosa, *var.* arctica. Numerous, attached to shells, roots of hydroids, &c.

Venus fasciata. One specimen in 9 only.

Kellia suborbicularis. Living in the mud inside empty bivalve mollusc shells.

Modiola modiolus.

Lima Loscombii. In 46 only.

Pecten tigrinus. One in 47 only.

,, maximus. One or two generally taken.

,, opercularis. Few adults. Small ones attached to hydroids numerous.

Anomia ephippium.

Dentalium entalis. In 47 only.

Pileopsis hungaricus. Attached to shells.

Emarginula reticulata. Common on shells.

,, rosea. In 8 only.

Trochus granulatus. One in 9 only.

Eulima polita. One large specimen in 84.

Natica nitida. In 46 only.

Lamellaria perspicua.

Buccinum undatum. Generally two or three specimens.

Proneomenia aglaopheniae. Occasionally found, on stem of *Aglaophenia myriophyllum.*

Scaphander lignarius.

Doto fragilis. On *Halecium halecinum.*

Shells.

Lyonsia norvegica. One or two only.

Solen ensis. One or two only.

Tellina donacina. Few only.

Tapes virginea. Numerous.

Artemis exoleta. Numerous.

Cardium echinatum. Few only.

,, norvegicum.

Lima Loscombii. Many in 46 only.

Pecten maximus. Fairly numerous.

,, opercularis. Abundant. (Few in 84.)

Dentalium entalis.

Trochus granulatus. One in 8, with *Adamsia palliata.*

Turritella communis. Few.

POLYZOA.

Cellaria sinuosa. ,, fistulosa. } Not in large quantity.

Bicellaria ciliata. Fixed to hydroids, &c.

Scrupocellaria scruposa. Fixed to the base of hydroids and to shells. Plentiful.

Cellepora avicularis. ,, ramulosa. Idmonea serpens. } Attached to hydroids.

Incrusting species not very numerous. For list see Table VI., p. 534.

TUNICATA.

Molgula oculata. In 47 only.

,, *sp.* In 46.

Polycarpa varians. One or two large in 47 only.

Ascidiella venosa. Few.

,, scabra. Few only.

GROUND XII.

Edge of Hand Deeps.

Hand 83 (Dr. and C-dr.).

Bottom-deposit. Medium gravel mixed with some mud. Texture:—

II.	Coarse Gravel	27·9 per cent.
III.	Medium Gravel	28·3 ,,
IV.	Fine Gravel	14·1 ,,
V.	Coarse Sand	6·0 ,,
VI.	Medium Sand	7·3 ,,
VII.	Fine Sand	8·3 ,,
VIII.	Silt	8·2 ,,

[83. Average grade of sample, 3·946. Percentage of carbonate of lime in whole sample, 40·74. Highest percentage occurs in V., which contains 62·29. In II. over 90 per cent. by weight of the rock constituents are Triassic, and only about 8 per cent. derived from the Eddystone reef. In III. over 70 per cent. by weight of the rock constituents are Triassic, over 18 per cent. derived from the Eddystone reef, and about 10 per cent. are Devonian. In 83 VI. Foraminifera are particularly abundant, as also in 83 VII. In these grades the following species occur, arranged in order of frequency:—*Truncatulina lobatula, Miliolina seminulum, Spiroloculina planulata, Rotalia beccarii, Discorbina rosacea, Textularia gramen, Textularia agglutinans, Miliolina bicornis, Lagena orbignyana, Planorbulina mediterranensis, Bolivina dilatata, Spirillina vivipara, Biloculina ringens, Bulimina pupoides.* In all, fourteen species.—R. H. W.]

Shells are plentiful.

The fauna of this haul was comparatively poor both in number of species and in number of specimens. It will be seen that the species taken consist in about equal numbers of those typical of the fine sand, as found on Grounds I. and III., and of those typical of the coarse gravel, as found on Ground IX.

Burrowing species. There was no burrowing species recorded in the haul.

Fixed species. Of species fixing by masses of root-fibres to the bottom-deposit, *Antennularia antennina* was abundant, and *Antennularia ramosa* and *Aglaophenia myriophyllum*, the latter bearing *Proncomenia aglaopheniae*, were present in smaller quantity. *Cellaria* was represented only by one fragment of *C. fistulosa.* There was a moderate number only of *Chaetopterus variopedatus* and a small quantity of *Halecium halecinum. Sertularella Gayi* was plentiful fixed as on the fine sand grounds to the tubes of *Thelepus* (*cincinatus?*). A few other hydroids were present, as will be seen from the list. One specimen of *Ascidiella scabra* was found, attached to the base of *Antennularia antennina.* There were few incrusting Polyzoa. One specimen of *Lepadogaster bimaculatus* was taken.

Wandering species. Ophiura ciliaris and *Ophiothrix fragilis* were both numerous, but only one specimen of *Asterias glacialis* and of *Echinus esculentus* was taken. Single specimens of *Eupagurus Bernhardus, Eurynome aspera, Pecten maximus,* and *Buccinum undatum* were found, and a few half-grown *Pecten opercularis.*

List of Species. Ground XII.

Hydrozoa.

Eudendrium ramosum. Fairly plentiful.

,, *sp.* Small species, not *E. capillare.*

Bougainvillia ramosa. Small variety in quantity.

Campanularia Hincksii. On *Cellaria fistulosa.*

Halecium halecinum. Small quantity only.

Sertularella Gayi. Plentiful.

,, polyzonias. Moderate quantity.

Antennularia antennina. Plentiful.

,, ramosa. One or two pieces only.

Aglaophenia myriophyllum. One or two pieces only.

Plumularia pinnata. Small quantity.

[*Antennularia antennina* and *ramosa* were much more plentiful in this haul than in 84 on Ground XI. In 81 *Halecium halecinum* was much more common.]

Echinodermata.

Asterias glacialis. One large specimen.

Ophiura ciliaris. Eight or ten specimens.

Ophiactis Balli. One in an empty *Chaetopterus* tube.

Ophiocoma nigra. One small one only.

Ophiothrix fragilis. Very many.

Echinus esculentus. One.

Polychaeta.

Chaetopterus variopedatus. Few only.

Pectinaria auricoma. One only.

Thelepus.

Dasychone bombyx. Several.

Crustacea.

Eupagurus Bernhardus. One in *Buccinum undatum* shell.

Eurynome aspera. One.

Scalpellum vulgare. On *Halecium halecinum.*

Erichthonius abditus. Forming tubes on *Sertularella Gayi.*

MOLLUSCA. *Living.*

Modiola modiolus. Small specimens only.

Pecten maximus. One only.

,, opercularis. A few half-grown ones.

Anomia ephippium. Small, abundant on *Chaetopterus* tubes.

Buccinum undatum. One.

Proneomenia aglaopheniae. On *Aglaophenia myriophyllum.*

Doto fragilis. On *Halecium halecinum.*

Shells.

Lutraria elliptica.

Cyprina islandica.

Cardium echinatum.

,, norvegicum. Small shells only.

Pecten maximus. One.

Pecten opercularis. Many.

Buccinum undatum. With *Eupagurus Bernhardus.*

POLYZOA.

Cellaria fistulosa. One small piece only.

Idmonea serpens.

Cellepora avicularis.

Few incrusting Polyzoa. Shells mostly clean.

On *P. opercularis* shells :—

Schizoporella linearis.

Porella concinna.

Schizoporella auriculata.

Rhynchopora bispinosa.

TUNICATA.

Ascidiella scabra. One at root of *Antennularia antennina.*

PISCES.

Lepadogaster bimaculatus. One.

GROUND XIII.

One mile south-east of the Eddystone.

Haul 103 (Dr.).

Bottom-deposit. The bottom-deposit consists of a mixture of shell-gravel of medium texture, with a considerable quantity of mud. This is shown by the following figures expressing the composition of the sample :—

II.	Coarse Gravel	13·4 per cent.
III.	Medium Gravel	29·0 ,,
IV.	Fine Gravel	17·0 ,,
V.	Coarse Sand	6·2 ,,
VI.	Medium Sand	6·9 ,,
VII.	Fine Sand	10·4 ,,
VIII.	Silt...	17·1 ,,

[103. Average grade of sample, 4·638. Percentage of carbonate of lime in whole sample, 61·18. Highest percentage occurs in III., which contains 90·50 per cent. This grade, which constitutes 29 per cent. of the whole sample, is the predominant grade in the sample. The rock constituents in 103 II. are proportioned as follows :—Trias, 79 per cent.; Eddystone reef, 17 per cent.; Devonian, 4 per cent.; while 103 III. contains little or no Devonian, but Trias and Eddystone reef materials in the proportion of 74 per cent. and 26 per cent. 0·13 grams (two grains) of 103 VII. contained 203 foraminifera, or 1562 per gram, a large number as compared with nearly every other sample, except perhaps 89B. The following species of foraminifera occur in 103 VI. and VII., arranged in order of frequency:—*Truncatulina lobatula*, *Rotalia beccarii*, *Textularia gramen*, *Miliolina seminulum*, *Bulimina pupoides*, *Discorbina rosacea*, *Lagena orbignyana*, *Bolivina dilatata*, *Polymorphina lactea*, *Miliolina trigonula*, *Textularia agglutinans*, *Spirillina vivipara*, *Globigerina bulloides*. In all, fourteen species—the largest number of distinct species found in any of the samples.—R. H. W.]

Shells are numerous. For list see p. 426.

It is possible that the accumulation of silt at this place may be due to its being somewhat sheltered from the south-westerly swells by the Eddystone reef, which runs out in a southerly direction. Rocky ground was found due south of the lighthouse, at a distance of one mile (hauls 31 and 78. See Chart I.).

Fauna. The fauna has many points in common with that of the gravel and fine sand grounds to the west of the Eddystone (*e.g.*, Ground IX.). *Chaetopterus*, for instance, is very plentiful and with it *Halecium halecinum* and *Plumularia Catharina*. *Ophiothrix fragilis* is also very abundant, and the Echinoderm and Crustacean faunas are similar to those of Ground IX. There are, however, some marked points of difference between the two grounds. *Pecten opercularis*, which was plentiful on Ground IX., is scarce on XIII., and with it *Asterias rubens* and *A. glacialis* are scarce. Many full-sized specimens of *Atelecyclus heterodon* were taken on Ground XIII., which may be regarded as a centre of distribution for this species, whilst on Ground IX. the specimens, though numerous, were all small.* On the other hand, *Turritella communis*, of which living specimens were numerous on IX., was not taken on XIII., and *Polycarpa varians*, the abundance of which was one of the features of IX., was represented by a few small specimens only in XIII. *Hyalinoecia tubicola*, as on Ground IX., was plentiful.

Species typical of the fine sand grounds were absent or represented only by stray specimens.

The presence of several fair-sized pieces of *Alcyonium digitatum*, of which only very small colonies were taken growing on *P. opercularis* on Ground IX., is noteworthy, and, like the large quantity of silt in the bottom-deposit, may be due to the more sheltered position of the ground. (*Cf.* p. 376.) The masses of *Filograna implexa* also were much larger here than on any other ground examined.

* Haul 93 (Ground IX.) was made on March 3rd, 1898, and haul 103 (Ground XIII.) on May 26th, 1898. The difference in size between the specimens on the two grounds was probably greater than would be accounted for by growth between the two dates, though in the absence of direct evidence the point is somewhat uncertain.

List of Species. Ground XIII.

Hydrozoa.

Lafoea dumosa, *var.* robusta. Plentiful.
Halecium halecinum. Plentiful.
Sertularella Gayi. Scarce.
Hydrallmania falcata. A little.
Antennularia antennina.
Aglaophenia myriophyllum.
Plumularia pinnata.
,, Catharina.

Actinozoa.

Caryophyllia Smithii. On shells.
Alcyonium digitatum. Several pieces.
Sarcodictyon catenata. A little on shells.
Adamsia palliata. Few only, with *Eupagurus Prideauxii.*

Echinodermata.

Thyone fusus. One large specimen.
Solaster papposus. One.
Asterias rubens. One.
Ophiura ciliaris. One.
,, albida. Several.
Ophiactis Balli. Plentiful in crevices amongst *Chaetopterus* tubes.
Ophiothrix fragilis. Many.
Echinus miliaris.
,, esculentus. One only.
Echinocyamus pusillus.

Nemertina.

Amphiporus pulcher.
Micrura purpurea.
,, fasciolata.

Polychaeta.

Lepidonotus squamatus. Two specimens.
Lagisca propinqua. Five specimens.
Hyalinoecia tubicola. Several.
Lumbriconereis, small. One only.
Chaetopterus variopedatus. Very numerous.
Polymnia nebulosa. One large specimen.
Polycirrus aurantiacus. Two specimens.
Filograna implexa. Considerable quantity.
Dasychone bombyx. Three large specimens.
Serpula vermicularis.
Hydroides pectinata.

Crustacea.

Eupagurus Prideauxii. Few only.
,, cuanensis. In Aporrhais pes-pelecani shell.
Porcellana longicornis.
Galathea dispersa. Plentiful.
Stenorhynchus longirostris.
Inachus dorsettensis. Dressed with sponges, Compound Ascidians, *Anomia,* and small Serpulids.
Eurynome aspera. Few only.
Portunus depurator.
Atelecyclus heterodon. Numerous.
Ebalia tuberosa.

Mollusca. *Living.*

Saxicava rugosa, *var.* arctica.
Astarte sulcata. One living.
Nucula nucleus. One living.
Pecten tigrinus. One living.
Pecten maximus.
,, opercularis. A few only.
Anomia ephippium. Large specimens.
,, patelliformis.
Trochus granulatus. One living.
Eulima polita. One large living specimen.
Buccinum undatum. One small one.
Cypraea europaea.

Doto fragilis. On *Halecium halecinum.*

Shells.

Lyonsia norvegica. One.
Tapes virginea.
Venus ovata.
Cardium echinatum.
,, norvegicum.
Nucula nucleus.
Pectunculus glycimeris. One small shell.
Pecten maximus. Numerous.
,, opercularis. ,,
Aporrhais pes-pelecani. Shell inhabited by *Eupagurus cuanensis.*

Polyzoa.

Cellaria sinuosa. } A little only.
,, fistulosa. }
Scrupocellaria scruposa.
Many incrusting forms on shells.

Tunicata.

Ascidiella scabra. Few only.
Polycarpa varians. A few small.
Styelopsis grossularia. Squat variety plentiful on *Pecten* shells.
Compound ascidian on *Sertularella Gayi.*

Pisces.

Lepadogaster bimaculatus. One.

GROUND XIV. THE WEST EDDYSTONE FINE GRAVEL.

Hauls. 73 (O.-tr.), 74 (Dr.), 35 (Dr.), 36 (O.-tr.), 88 (Dr.), 41 (Dr.), 85 (C.-dr. and Dr.), 58 (Dr.), 59 (Dr.).

Bottom-deposit. Fine gravel. A sample with the canvas dredge was taken only at haul 85, and had the following texture:—

II.	Coarse Gravel	4·1	per cent.
III.	Medium Gravel	17·5	„
IV.	Fine Gravel	28·1	„
V.	Coarse Sand	21·0	„
VI.	Medium Sand	23·4	„
VII.	Fine Sand	5·2	„
VIII.	Silt	0·6	„

[85. Average grade of sample, 4·597. Percentage of carbonate of lime in whole sample, 27·87. Highest percentage occurs in II., which contains 56·00 per cent., but this grade is only present in small proportion, and III. at 39·50 per cent. is more reliable. Practically speaking in grades II. and III. 66 per cent. by weight of the rock fragments are Triassic, 28 per cent. derived from the Eddystone reef, and 6 per cent. apparently Devonian. A great feature in this sample is the evidence of long-continued and somewhat violent wave action, presented by the beautifully rounded and polished form of the quartz grains and other constituents of the gravels and sands, especially in the finer grades. This will be found referred to at greater length elsewhere (pp. 376 and 385). Foraminifera are not numerous, the smaller varieties are absent, and Milioline forms largely predominate. The following species were found in VI. and VII., and have been arranged in order of frequency:—*Miliolina seminulum, Rotalia beccarii, Textularia gramen, Textularia agglutinans, Miliolina bicornis, Discorbina rosacea, Biloculina ringens.* In all, seven species.—R. H. W.]

Shells were numerous (for list see p. 430). The material of the gravel in the above sample was largely inorganic, but in some of the other hauls, where no samples were taken with the canvas dredge, there were indications of the deposit containing a much larger quantity of broken shell, more nearly approaching that of Ground XVI. (Haul 87.)

Burrowing species. The most characteristic burrowing animals on this ground are *Spatangus purpureus, Cardium norvegicum,* and *Drepanophorus rubrostriatus.*

Fixed species. Very few hydroids are present, the most common forms being *Halecium halecinum* and *Halecium Beanii* fixed to the tubes of *Chaetopterus,* which is moderately plentiful, but not nearly so numerous as on the typical coarse gravel and sand of Ground IX. The scarcity of hydroids may be due to the disturbance of the deposit by periodic wave action, the existence of which, as pointed out above, is also shown by the rounded and polished quartz grains. One of the characteristic features of the fauna is the presence of large specimens of *Polycarpa varians* attached to the gravel. *Caryophyllia Smithii* is plentiful on shells and *Sarcodictyon catenata* is also not uncommon. There are few branched polyzoa, but incrusting forms on shells are numerous.

Wandering species. The presence of *Porania pulvillus* in considerable numbers, and of *Luidia Sarsi* in small numbers, must be regarded as characteristic. *Ophiothrix fragilis* is plentiful, but *Ophiura ciliaris*, though generally present, is never numerous. *Echinus esculentus* and *E. acutus* are not uncommon. *Pecten opercularis* was very numerous in some hauls, but scarce in others, the abundance of *A. glacialis* and *A. rubens* varying with that of the mollusc. Two or three specimens of *Pecten maximus* were present in each haul, and must be considered as one of the characteristic features of the ground. Crustaceans were not numerous; the species represented were those typical both of the fine sand and of the coarse gravel.

Considering the fauna of this ground as a whole, one may regard it as composed of four elements, viz. (1), a fauna of its own, represented by an abundance of *Polycarpa varians, Porania pulvillus, Pecten opercularis, Cardium norvegicum, Echinus esculentus,* and *E. acutus;* (2) many species found on the coarse gravel grounds, *e.g., Ophiothrix fragilis* (abundant), *Chaetopterus variopedatus* and its associates, *Ebalia tumefacta* and *tuberosa;* (3) species characteristic of the clean shell gravel of the neighbouring Ground XVI., *e.g., Spatangus purpureus, Sarcodictyon catenata;* (4) a few immigrants from the fine sand grounds, *e.g., Sertularella Gayi* (scarce), *Astropecten irregularis* (an occasional small specimen only), *Ophiura ciliaris*, and *Ascidiella scabra*.

List of Species. Ground XIV.

Porifera.

Suberites domuncula.

Cliona celata. Common, boring shells.

Hydrozoa.

Hydractinia echinata. In 73 only.

Clytia Johnstoni. On hydroids in 73.

Campanularia Hincksii. On hydroids and on shells.

Lafoea dumosa, *var.* robusta. Recorded in 58 only.

Halecium halecinum. Fairly abundant on *Chaetopterus* tubes and on shells.

Halecium Beanii. Small quantity in 59 only.

,, labrosum. One colony in 73.

Sertularella Gayi. Small quantity only.

,, polyzonias. Small quantity only.

Sertularia argentea. A little in 35 only.

Hydrallmania falcata. A few colonies only.

Antennularia antennina. A few colonies only.

,, ramosa. A few colonies only.

Plumularia pinnata. In 35 only.
,, Catharina. Green variety in 58 only.

ACTINOZOA.

Adamsia palliata. On shell inhabited by *Eupagurus Prideauxii* in 73 only.

Caryophyllia Smithii. Plentiful on shells.

Alcyonium digitatum. A few small colonies only, chiefly on *Pecten opercularis*.

Sarcodictyon catenata. Good colonies on shells in 41 and 58, in latter case on *Lutraria elliptica* shell.

ECHINODERMATA.

Astropecten irregularis. One or two specimens, generally small, in a haul. One or two large specimens in 58.

Luidia Sarsi. One specimen in each of the hauls 73 and 36 (Otter-trawl).

Porania pulvillus. Plentiful in 73 and 36.

Solaster papposus. Few specimens, generally small.

Henricia sanguinolenta. One specimen in 36 and in 88.

Asterias glacialis. Generally plentiful. Some very large specimens.
,, rubens. Comparatively few. Much less numerous than *A. glacialis*.

Ophiura ciliaris. One or two specimens in each haul.
,, albida. Not numerous.

Ophiactis Balli. Fairly numerous amongst *Chaetopterus* tubes, &c.

Ophiocoma nigra. Few or none.

Ophiothrix fragilis. Numerous.

Echinus acutus. Present in 36, 73, and 74.
,, miliaris. Generally present.
,, esculentus. Present in 73, 36, and 41; abundant in 36 only.

Echinocyamus pusillus. In 74.

Spatangus purpureus. A few generally taken, except in 73 and 36, which were hauls of the Otter-trawl.

NEMERTINA.

Carinella superba.

Drepanophorus rubrostriatus. In 73, 58, and 85.

Tetrastemma flavidum.
,, candidum.

Lineus bilineatus.

Micrura purpurea.
,, fasciolata.

POLYCHAETA.

Lepidonotus squamatus. Few only.

Evarne impar. One in 41 only.

Eunice Harassi. One in 88 only.

Lumbriconereis. Large species.
,, Small ,,

Chaetopterus variopedatus. Numerous, attached to shells.

Polymnia nebulosa. One in 88.

Thelepus. One only recorded.

Terebellid tubes. Very plentiful.

Filograna implexa. Common on *Pecten opercularis* shells.

Protula tubularia. Few only.

Serpula vermicularis. Fairly plentiful.

Hydroides pectinata. Fairly plentiful.

Phascolion strombi.

CRUSTACEA.

Eupagurus Bernhardus. A few only in *Buccinum undatum* shells.
,, Prideauxii. In 73 only, with *Adamsia palliata*.
,, cuanensis. One in 85 only.

Porcellana longicornis.

Galathea dispersa.

Stenorhynchus longirostris. Not numerous.

Inachus dorsettensis. Not numerous.

Eurynome aspera. In 73 only.

Portunus depurator. In 36 and 88 only.

Ebalia tumefacta. In 88 only. One or two specimens.
,, tuberosa. One or two specimens in 35 and 85 only.

Balanus crenatus.

Scalpellum vulgare. On stem of hydroids.

MOLLUSCA. *Living.*

Tapes virginea. One each in 88 and 41 only.

Astarte sulcata. One or two specimens in 73 only.

Cardium norvegicum. In 58, 85, and 88.

Montacuta substriata. On spines of *Spatangus purpureus*.

Kellia suborbicularis. In 88 only.

Modiola modiolus.
,, barbata.

Lima Loscombii. In 35 and 41 only.

Pecten maximus. A few specimens generally present.
,, opercularis. Many in 73 and 36. Few in other hauls.

Anomia ephippium. } Generally on *Pecten opercularis*.
,, patelliformis. }
Chiton asellus. Frequent on shells.
Pileopsis hungaricus.
Emarginula reticulata.
Trochus zizyphinus. In 35 only. Small variety.
Buccinum undatum. Few or none.
Cypraea europaea. In 73 only.

Tritonia plebeia.
Doto fragilis. } On hydroids.
Coryphella Landsburgii. }

Shells.

Solen ensis. Few.
Psammobia ferroensis. One small one in 74.
Lutraria elliptica. Common.
Tapes virginea. Very common.
Venus striatula.
,, fasciata.
Artemis exoleta.
Cyprina islandica.
Astarte sulcata.
Cardium echinatum. Few only.
,, norvegicum. Abundant.
Nucula nucleus.
Pectunculus glycimeris.
Pinna pectinata. One in 73 only.
Lima Loscombii. Frequent.
Pecten tigrinus. Not numerous.
,, maximus. Abundant.
,, opercularis. Abundant.
Dentalium entalis Not abundant.
Turritella communis. Not abundant.
Scalaria Turtonis. One in 73 only.
Buccinum undatum. In 73 only.

POLYZOA.

Cellaria fistulosa. Very little.
Scrupocellaria scruposa. In 85 only at roots of *Antennularia*.
Bugula avicularia. One piece in 85.
Cellepora avicularis. } On hydroid stems.
Crisea eburnea. }
Incrusting Polyzoa numerous. For list see Table VI., p. 534.

TUNICATA.

Styelopsis grossularia. Small flat variety common on shells, especially *Pecten maximus* shells.
Polycarpa varians. Abundant.
Ascidiella scabra. Not numerous.
Ciona intestinalis. In 73 only.

GROUND XV. EAST EDDYSTONE FINE GRAVEL.

Hauls. 33 (Dr.) and 97 (Dr. and C.-dr.).

Two hauls lying from one to two miles east and south-east of the Eddystone have a similar fauna, and have been united as Ground XV.

Bottom-deposit. Fine gravel.

The texture of a sample taken at 97 is as follows:—

II.	Coarse Gravel	13·4 per cent.
III.	Medium Gravel	20·5 ,,
IV.	Fine Gravel	18·2 ,,
V.	Coarse Sand	16·0 ,,
VI.	Medium Sand	19·7 ,,
VII.	Fine Sand	9·0 ,,
VIII.	Silt	3·1 ,,

[97. Average grade of sample, 4·471. Percentage of carbonate of lime in whole sample, 46·68. Highest percentage in V., which contains 77·70 per cent. In 97 II. the gravel consists of Trias, 91 per cent.; Eddystone reef, 7 per cent.; Devonian, 2 per cent. In 97 III. the proportions are Trias, 75 per cent.; Eddystone reef, 17 per cent.; Devonian, 8 per cent. Sixty foraminifera were counted in 0·13 grams

(2 grains) by weight, of 97 VII. 461 per gram. The following list of species of foraminifera in 97 VI. and VII. is arranged as before:—*Miliolina seminulum, Rotalia beccarii, Textularia gramen, Truncatulina lobatula, Discorbina rosacea, Miliolina trigonula, Lagena sulcata, Biloculina depressa, Miliolina bicornis, Lagena orbignyana, Spirillina vivipara, Bulimina pupoides.* In all, twelve species.—R. H. W.]

Unbroken shells were not numerous.

Fauna. As will be seen from the list, the ground is very barren. The fauna shows no distinct characteristic species of its own, and seems to be made up of stray individuals from the various grounds in the neighbourhood, the sand, the gravel, and the broken shell faunas being represented.

List of Species. Ground XV.

Porifera.

Cliona celata. Boring shells.

Hydrozoa.

Eudendrium, *sp.* Small species with male and female gonophores on *Halecium Beanii* in 33.

Clytia Johnstoni. In 97.

Lafoea dumosa, *var.* robusta. In 97.

Trichydra pudica. In 97 on *Halecium* and on *Pecten* shell.

Halecium halecinum. A little in both.

,, Beanii. A little in both.

Sertularella Gayi. A small quantity in each.

Hydrallmania falcata. In 97 only.

Antennularia antennina. } A little only.
,, ramosa. }

Aglaophenia myriophyllum. In 33 only.

Plumularia Catharina. Growing in *Halecium.*

Actinozoa.

Caryophyllia Smithii. Several specimens on shells in 97.

Alcyonium digitatum. Very small colony on stem of *Halecium Beanii* in 33.

Sarcodictyon catenata. In 97 only, on shells.

Echinodermata.

Astropecten irregularis. One in 97 only.

Echinocardium cordatum. One in 97 only.

Polychaeta.

Chaetopterus variopedatus. One small piece of tube in 97.

Terebellid tubes.

Hydroides pectinata.

Crustacea.

Galathea dispersa.

Stenorhynchus longirostris. In 33 only.

Inachus dorsettensis. In 33 only.

Atelecyclus heterodon. One in 97 only.

Scalpellum vulgare. At base of hydroids.

A caprellid on *Antennularia antennina.*

Mollusca. *Living.*

Pectunculus glycimeris. A few small.

Pecten opercularis. Small ones only.

Anomia patelliformis. On *Pecten maximus* shells.

Chiton asellus.

Shells.

Tapes virginea.

Pectunculus glycimeris. Small only.

Lima Loscombii.

Pecten maximus.

,, opercularis.

Polyzoa.

Shells mostly clean.

On *P. maximus* shell:—
Lichenopora hispida.
Mucronella ventricosa.

On Terebellid tube:—
Cellepora avicularis.

Tunicata.

Forbesella tesselata. In 97.

Cephalochorda.

Amphioxus lanceolatus. In 97.

GROUND XVI. THE WEST EDDYSTONE CLEAN SHELL GRAVEL.

Hauls. 86 (Dr.), 87 (Dr. and C.-dr.), 10 (Dr.), 13 (Dr.), 14 (Dr.), 98 (Dr.), and 99 (Dr.).

Immediately bordering the rocky ground of the reef, north, west, and south of the Eddystone, at a distance of from half to one mile from the lighthouse, is a strip of clean shell gravel upon which the fauna is very scanty, though at the same time very characteristic.

Bottom-deposit. Clean shell gravel.

A sample taken at haul 87 had the following texture :—

II.	Coarse Gravel	17·3	per cent.
III.	Medium Gravel	31·7	„
IV.	Fine Gravel	19·3	„
V.	Coarse Sand	10·5	„
VI.	Medium Sand	14·9	„
VII.	Fine Sand	5·2	„
VIII.	Silt	1·1	„

[87. Average grade of sample, 4·151. Percentage of carbonate of lime in whole sample, 72·25. Highest percentage occurs in IV., which contains 79·60 per cent. This deposit lying on the northern boundary of the Eddystone reef, just below the 30-fathom line, is the one and only sample in which Eddystone reef materials predominate over the other rock constituents. In grade II. no rock fragments but those derived from the reef are present, while in grade III. Eddystone material stands at 74 per cent. and Trias at 26 per cent. Foraminifera are numerous; in VII. 81 individuals were counted in 0·13 grams (2 grains), or 623 per gram. The Miliolina greatly predominate. The following species were found in VI. and VII., arranged as before in order of frequency :—*Miliolina seminulum, Rotalia beccarii, Textularia gramen, Truncatulina lobatula, Miliolina bicornis, Miliolina trigonula, Spiroloculina planulata, Lagena orbignyana, Spirillina vivipara, Discorbina rosacea.* In all, ten species.—R. H. W.]

Large unbroken shells were not numerous.

Haul 99 was partly on rocky ground.

Burrowing species. The most characteristic species are *Spatangus purpureus, Echinocyamus pusillus, Eupolia curta, Amphioxus lanceolatus,* and *Glycera convoluta.* Several bivalve molluscs not taken on other grounds were found here (see p. 433). Occasional specimens of *Polygordius* were obtained, and *Terebellid* tubes were numerous.

Fixed species. These were very scarce. *Lafoea dumosa,* var. *robusta,* was the hydroid most frequently taken, other species being represented by occasional small pieces only. *Sarcodictyon catenata* attached to shells was common, and one of the characteristic species of the ground. *Molgula oculata* occurs fixed in the gravel. Polyzoa were not numerous.

Wandering species. The only species taken in numbers were *Echinus miliaris, Amphiura elegans* (peculiar to this ground), and *Porcellana longicornis.* Occasional specimens of the following species not commonly distributed on the other grounds around the Eddystone are noteworthy:—*Plumularia frutescens, Cucumaria lactea, Holothuria nigra, Lima Loscombii, Aporrhais pes-pelecani* (living), *and Aegirus punctilucens.*

List of Species. Ground XVI.

Hydrozoa.

Lafoea dumosa, *var.* robusta. Frequent, but in small pieces.

Halecium halecinum. Little or none.

Sertularella Gayi. Little or none.

Diphasia rosacea. } In 99 only.
,, tamarisca. }

Sertularia argentea. Growing on *Diphasia tamarisca.*

Hydrallmania falcata. A little in 99 only.

Antennularia ramosa. Little or none.

Aglaophenia tubulifera. In 99 only.

Plumularia Catharina. In 99 only.

,, frutescens. A large colony on *Pecten opercularis* shell in 10 only.

Actinozoa.

Caryophyllia Smithii. Many in 10. Few or none in other hauls.

Alcyonium digitatum. Several pieces in 99 broken from rock. None in other hauls.

Sarcodictyon catenata. Frequent.

Echinodermata.

Cucumaria lactea. Two specimens in 99 only.

Holothuria nigra. In 10 and 99. Two or three specimens.

Astropecten irregularis. One in 87 only.

Solaster papposus. Small. In 10 only.

Amphiura elegans. Numerous in 10 and 14.

Ophiactis Balli. Occasional specimens only.

Ophiocoma nigra. Small. In 10 only.

Ophiothrix fragilis. Small. In 10 only.

Echinus miliaris. Plentiful.

,, esculentus. Three specimens in 99 only.

Echinocyamus pusillus. Generally present.

Spatangus purpureus. One or two in each haul.

Nemertina.

Carinella annulata.

Tetrastemma candidum.

Eupolia curta.

Micrura purpurea.

,, fasciolata.

Cerebratulus fuscus.

Polychaeta.

Polygordius, *sp.* Occasional specimens.

Harmothoë imbricata. One in 87.

Lumbriconereis. Large. One in 98.

Ehlersia cornuta. One in 87.

Glycera convoluta.

Terebellid tubes. Numerous.

Dasychone bombyx. One in 87.

Protula tubularia. Occasional specimens.

Hydroides pectinata. Occasional specimens.

Crustacea.

Eupagurus cuanensis. Infested with *Sacculina.* In *Dentalium* shell. One in 10 only.

Porcellana longicornis.

Galathea dispersa. In 13 only.

Portunus pusillus. In 10 only.

Ebalia tumefacta. In 10 and 13.

Balanus crenatus. On *Pecten opercularis.*

Pyrgoma anglicum. With *Caryophyllia Smithii.*

Mollusca. *Living.*

Psammobia costulata, Turton. One living specimen in 10.

Tellina crassa. In 87 and 99 only.

Tapes virginea. One in 87 only.

Venus fasciata. In 13 only.

Artemis exoleta. Two living specimens in 99 only.

Cardium norvegicum. In 87 only.

Montacuta substriata. On *Spatangus purpureus*.
Lima Loscombii. Fairly plentiful in 10.
Pecten tigrinus. In 13 only.
,, maximus. One or two in 13 and 14.
,, opercularis. Few, mostly small specimens.
Chiton asellus. In 13 only.
Emarginula reticulata. Few.
Aporrhais pes-pelecani. In 87 only.

Aegirus punctilucens. One specimen in 10 only. This was very pale in colour, and no green specks were to be seen. Small specimen.

Shells.

Tellina crassa.
Lutraria elliptica.
Tapes virginea. Numerous.
Artemis exoleta. Numerous, especially in 99.
Astarte sulcata.
Cardium norvegicum. Numerous.
Pectunculus glycimeris. Small only.
Lima Loscombii.
Pecten maximus.
,, opercularis.
Dentalium entalis.
Aporrhais pes-pelecani.

POLYZOA.

Cellepora ramulosa. In 99 only.
Crisea ramosa. In 13 only.
Idmonea serpens. In 13 only.

Incrusting polyzoa not very numerous, though a good many species are represented. For list see Table VI., p. 534.

TUNICATA.

Ascidiella scabra. A few in 87 only.
Molgula oculata. A few only.
Botryllus, *sp.*

CEPHALOCHORDA.

Amphioxus lanceolatus. A small specimen in 87.

GROUND XVII. THE BOLT HEAD SHELL GRAVEL.

Hauls 1, 6, 7, 21, 43, 44, 61, 62, 68, 105, 106, 107. 27, 28. 20, 60 (all hauls of Dredge. Canvas-dredge at 105 and 106).

The position of this ground, which lies south of Bolt Head, will be seen from the charts. The hauls enumerated above have been combined as one ground, though further investigation would probably lead to a division into at least three. This is indicated in the enumeration of the hauls by the separation of 27 and 28 and of 20 and 60 from the other numbers. The two deepest hauls (27 and 28), and the two to the westward of Bolt Head (20 and 60), show several differences from the typical shell-gravel hauls.

Bottom-deposit. Clean shell gravel.

Samples taken at 105 and 106 have the following texture :—

		105.	106.
I.	Stone and Broken Shells (above 15 mm.)	1·4 per cent.	0·7 per cent.
II.	Coarse Gravel	23·1 ,,	33·8 ,,
III.	Medium Gravel	15·4 ,,	18·8 ,,
IV.	Fine Gravel	8·3 ,,	12·6 ,,
V.	Coarse Sand	7·3 ,,	7·3 ,,
VI.	Medium Sand	25·7 ,,	19·9 ,,
VII.	Fine Sand	18·3 ,,	6·7 ,,
VIII.	Silt	0·5 ,,	0·3 ,,

[105. Average grade of sample, 4·498. Percentage of carbonate of lime in whole sample, 47·26. Highest percentage occurs in V., which contains 75 per cent. Geologically there is a wide separation between samples 105 and 106 and the other samples taken from the westward. A large percentage of the rock fragments in 105 and 106 is derived from Archean rocks similar to those which constitute the Bolt promontory. Trias is present, but flint, which has suffered considerable surface decay, is also a prominent constituent. The rock fragments in 105 II. are divisible as follows:—Archean (chiefly mica schists), 78·75 per cent.; Flint, 12·74 per cent.; Trias, 8·51 per cent. In 105 VII. 43 foraminifera were found in 0·19 grams (3 grains), or 226 per gram. *Rotalia beccarii* and *Miliolina seminulum* greatly predominated; the complete list of species from 105 VI. and VII. being: *Rotalia beccarii, Miliolina seminulum, Textularia gramen, Truncatulina lobatula.* In all, four species.

[106. Average grade of sample, 3·803. Percentage of carbonate of lime in whole sample, 52·77. Highest percentage occurs in IV., which contains 78·75 per cent. The rock constituents of this gravel are similar to those of 105, but the proportions are different, the Archean rocks are not so well represented, while flint is much more frequent. The proportions in 106 II. are: Archean, 48·90 per cent.; Flint, 40·44 per cent.; Trias, 10·66 per cent. Fifty-eight foraminifera were counted in 0·26 grams (4 grains) of 106 VII., or 223 per gram. Again, as in 105, *Rotalia beccarii* and *Miliolina seminulum* greatly predominate. The species found in 106 VI. and VII. are as follows, arranged in order of frequency:—*Rotalia beccarii, Miliolina seminulum, Truncatulina lobatula, Bulimina pupoides, Miliolina bicornis, Textularia gramen, Textularia agglutinans, Discorbina rosacea.* In all, eight species.—R. H. W.]

Shells were numerous in all hauls, for list see p. 438. In haul 20 stones were taken.

As on the clean broken shell to the west of the Eddystone (XVI.), to which ground the present one has many points of resemblance, the fauna is comparatively poor, especially in the number of fixed species, for the shells present, although numerous, are generally almost clean.

Burrowing species. The typical burrowing species are *Spatangus purpureus, Pectunculus glycimeris* (abundant), *Echinocyamus pusillus, Polygordius*, sp., *Eupolia curta*, and a few *Amphioxus lanceolatus.*

Fixed species. In the most typical hauls *Sarcodictyon catenata*, a few encrusting polyzoa, an occasional specimen of *Caryophyllia Smithii*, with perhaps one or two stray colonies of some hydroid, are all the fixed species constantly met with. In haul 107 the hydroid *Campanularia flexuosa* was fairly abundant on empty *Pectunculus glycimeris* shells, and in the same haul and in haul 105 *Tubiclava cornucopiae* was abundant on living specimens of the same mollusc and of *Venus fasciata*. The deepest hauls (27 and 28) are characterised by large colonies of *Alcyonium digitatum*, as well as by the hydroids *Sertularia abietina* and *Thuiaria articulata*.

Wandering species. As on the Eddystone shell gravel these are not numerous, the only forms generally common being *Echinus miliaris*, *Porcellana longicornis*, and a few *Ebalia*. Occasional specimens of many other species are found, as will be seen from the list below. The presence of several specimens of *Fusus islandicus* in hauls 105 and 107 is noteworthy, as this is the only locality in the neighbourhood where the species has been found. *Asterias glacialis* was present only in haul 60 (the most westerly haul on the ground), and has never been taken at any point to the eastward of this (*cf.* p. 466).

List of Species. Ground XVII.

Foraminifera.

Truncatulina lobatula. On hydroids.

Porifera.

Cliona celata. Boring shells.

Hydrozoa.

Tubiclava cornucopiae. In 105 and 107, on living *Pectunculus glycimeris* and *Venus fasciata*.

Eudendrium rameum. One colony in each of the hauls 106 and 107 only. In 106 on piece of old *Chaetopterus* tube, in 107 on *Pecten opercularis* shell.

,, capillare. Occasional specimens on other hydroids.

,, *sp.* A small species, not *E. capillare*. Not uncommon.

Clytia Johnstoni. On other hydroids.

Campanularia Hincksii. On other hydroids.

,, verticillata. One colony in 28 and one in 60.

,, flexuosa. Common on *Pectunculus glycimeris* shells in haul 107.

Lafoea dumosa. Recorded in 21 only.

Calycella syringa.

Halecium halecinum. Occasional specimens only. Most plentiful in 60.

,, Beanii. Very rare.

Diphasia attenuata. In 21 only.

,, tamarisca. Young colonies in 28 only.

Sertularia abietina. Common in deepest hauls (7, 27, 28). Occasional pieces only in remaining ones.

,, argentea. Occasional specimens frequent.

Hydrallmania falcata. One or two colonies in each haul.

Thuiaria articulata. In the two deepest hauls, 27 and 28 only.

Antennularia antennina. Not common.

,, ramosa. In 21 only.

Plumularia pinnata. In 43 and 61 only. Scarce.

Scyphistoma. In 107, on inner side of *Pecten opercularis* shell.

Actinozoa.

Alcyonium digitatum. Occasional small colonies only, except in hauls 27 and 28, the two deepest dredgings on the ground.

Sarcodictyon catenata. Red variety not uncommon on shells.

Caryophyllia Smithii. Occasional specimens on shells. Not frequent.

Epizoanthus incrustatus. Rare. Hauls 21 and 27 only.

Adamsia palliata. Occasional specimens with *Eupagurus Prideauxii*.

Echinodermata.

Cucumaria lactea. In 20 only, where stones were present.

Solaster papposus. Occasional specimens only.

Asterias glacialis. In haul 60 only (the most westerly haul).

,, rubens. Present in hauls 43, 44, 60, 61, 62, 68. Two small ones in 107.

Ophiura ciliaris. One or two in 28 and 60 only.

,, albida. Occasional specimens.

,, affinis. One in 28 only.

Amphiura elegans. Occasional specimens.

Ophiactis Balli. Not frequent. Occasional specimens only.

Ophiocoma nigra Not frequent. Occasional specimens only.

Ophiothrix fragilis. Not frequent. Occasional specimens only.

Echinus acutus. Not frequent. Occasional specimens only. Several in haul 60.

,, miliaris. Frequent and abundant.

,, esculentus. Single specimens in many hauls.

Echinocyamus pusillus. Not uncommon.

Spatangus purpureus Generally a number of specimens.

Echinocardium pennatifidum. One in haul 7 only.

NEMERTINA.

Eupolia curta. Rare.

Micrura fasciolata.

POLYCHAETA.

Polygordius, *sp.* Plentiful.

Lepidonotus squamatus. Several specimens.

Lagisca propinqua. One recorded in 68 only.

Nereis pelagica. Few.

Amblyosyllis specabilis. Recorded in 27 only.

Glycera, *sp.* Milk-white in colour.

Chaetopterus variopedatus. Occasional specimens only. Most numerous in 7.

Pectinaria auricoma. Single specimens frequent.

Amphitrite gracilis. Recorded in 28 only.

Terebellid tubes. Numerous

Sabellaria spinulosa Recorded in 43 and 27 only.

Protula tubularia. Recorded in 28 only.

Serpula vermicularis. Occasional specimens only, attached to shells

Hydroides pectinata.

CRUSTACEA.

Eupagurus Bernhardus. Occasional specimens, generally in *Buccinum undatum* shell. In hauls 106 and 107 in *Fusus islandicus*. Never with *Sagartia parasitica*.

,, Prideauxii. In 68 and 27 only. In *Trochus* shell.

,, cuanensis. In 28 only.

Anapagurus laevis. In 27 only.

Porcellana longicornis. Plentiful.

Galathea dispersa. Generally not numerous.

Stenorhynchus longirostris. Present in hauls 27, 28, and 60 only.

Inachus dorsettensis. Present in hauls 68, 27, 28, and 60 only.

Hyas coarctatus. Not uncommon.

Eurynome aspera. In hauls 6, 27, and 44 only.

Portunus pusillus. Occasional specimens only.

Corystes cassivelaunus. In 27 only.

Atelecyclus heterodon. In 27 and 28 only.

Ebalia tumefacta.
,, tuberosa
,, Cranchii.
} One or two generally in a haul.

Balanus crenatus.

Scalpellum vulgare. Seldom.

Pyrgoma anglicum. With *Caryophyllia Smithii.*

Ampelisca spinipes.

Gammaropsis erythrophthalmium.

MOLLUSCA. *Living.*

Saxicava arctica. Single specimens frequent.

Lyonsia norvegica. One in haul 7.

Venus fasciata. In hauls 6, 68, and 107. Single specimens.

Astarte sulcata. One in 106.

Montacuta substriata. With *Spatangus purpureus.*

Modiola, *sp.* Small. Occasional.

Arca tetragona. Small. Occasional.

Pectunculus glycimeris. Common, and characteristic of the ground.

Lima Loscombii. In 27 only.

Pecten tigrinus. Single specimens in 21 and 107 only.

,, opercularis. Very few or none. Most common in 60.

Anomia ephippium.
,, patelliformis.
} Frequent.

Chiton asellus. Common.
Dentalium entalis. In 7, 28, and 20.
Pileopsis hungaricus. One specimen in 106 and 107 only.
Emarginula reticulata. In 21 and 27 only.
Trochus zizyphinus. One small in 27 only.
,, granulatus. One in 27 only.
Lamellaria perspicua. One in 28 only.
Nassa incrassata. In 20 only.
Buccinum undatum. Not uncommon.
Fusus islandicus. Four or five in 105 and one in 107.
Cypraea europaea. In 27 only.

Tritonia Hombergi. In 27 and 28 only.
Dendronotus arborescens. In 28 only.
Doto coronata. In 28 only.

Shells.

Solen ensis. Few.
Solecurtus candidus. In 20 and 28; single valves.
Tellina crassa. One in 105.
Lutraria elliptica. Frequent.
Tapes virginea. Not frequent.
Venus fasciata. Not frequent.
,, ovata. Common.
Artemis exoleta. One in 105.
Astarte sulcata. One in 106 only.
Cardium norvegicum. Not frequent.
Pectunculus glycimeris. Numerous.
Pecten maximus. Very few.
,, opercularis. Numerous.
Trochus granulatus. Occasional.
Aporrhais pes-pelecani. In 27 only.
Natica nitida In 27 only.
Fusus islandicus. In 105 and 107, not uncommon.
Ostrea edulis. Occasional shells.

POLYZOA.

Branched forms almost absent. Incrusting forms numerous. See Table VI.

TUNICATA.

Styelopsis grossularia. Small, squat variety on shells.
Ascidiella scabra. One or two in 20 and 107 only.
Ciona intestinalis. Frequent, but not numerous. Attached to shells.
Ascidia depressa. A few specimens, attached to shells.
,, mentula. One in haul 1 only.

CEPHALOCHORDA.

Amphioxus lanceolatus. One in 28 only.

PISCES.

Lepadogaster bimaculatus. One in 106 only.

GROUND XVIII. THE PRAWLE STONY GROUND.

Hauls. 2 (O.-tr.), 3 (O.-tr.), 4 (Dr.), 45 (Dr.), 66 (Dr.), 65 (Dr.), 64 (Dr.), 63 (Dr.), 29 (Dr.), 30 (Dr.).

This ground again could probably, with further investigation, be subdivided. The hauls all lie to the eastward of a line passing north and south through Prawle Point, and are characterised by the presence of stones, often of considerable size. The ground is very rough and dredging upon it difficult. No samples of the bottom-deposit were taken with the canvas bag.

Burrowing species. *Spatangus purpureus*, *Echinocyamus pusillus*, and occasional specimens of *Ebalia* were the forms most frequently taken. The boring mollusc *Pholadidea papyracea* was common in the Trias rock of haul 4. *Atelecyclus heterodon* was taken once, and an occasional burrowing bivalve mollusc was found.

Fixed species. It is, however, by its fixed species that the fauna of this stony ground is specially characterised. The following species, which were absent from the other grounds, or at most only very occasionally met with, were present here, generally attached to stones:— *Corynactis viridis*, *Gorgonia verrucosa*, *Garveia nutans*, *Tubularia indivisa*, *Diphasia rosacea*, *Hydrallmania falcata* (abundant), *Sertularia argentea*, and *Thuiaria articulata*. The presence of large colonies of *Alcyonium digitatum* may also be noted (see p. 457), as well as the abundance of *Sertularia abietina* (see p. 453), and *Caryophyllia Smithii* with the associated barnacle *Pyrgoma anglicum*.

Wandering species. Characteristic of the stony ground are *Cucumaria lactea* and *Ophiocoma nigra*. Other species plentiful are *Ophiactis Balli*, *Echinus miliaris*, *Porcellana longicornis*, and *Galathea dispersa*, whilst occasional specimens of many forms common on sand and gravel grounds are taken.

List of Species. Ground XVIII.

PORIFERA.

Cliona celata. Boring shells.

HYDROZOA.

Eudendrium, *sp.* Small species, not *E. capillare*, common.

Garveia nutans. In haul 29, on large stone.

Tubularia indivisa. In haul 29, on large stone.

Clytia Johnstoni. Common.

Obelia dichotoma. Occasional only.

Campanularia Hincksii. On shells and hydroids.

Campanularia verticillata. In 45 only.

Lovenella clausa. Recorded in 29 only.

Opercularella lacerta. In 29 only.

Lafoea dumosa. Common on other hydroids. Also var. *robusta* on shells, &c.

Calycella syringa. Recorded in 45 only.

Halecium Beanii. A little in haul 4 only.

Diphasia rosacea. In 4 and 29.

Sertularia abietina. Common, especially in the deepest hauls.

,, argentea. Frequent, but not very abundant.

Hydrallmania falcata. Present in nearly every haul, and often abundant. Attached to stones or sometimes to shells.

Thuiaria articulata. Several pieces in 45 and 63.

Antennularia antennina. Not frequent.

,, ramosa. Not frequent.

Aglaophenia myriophyllum. In 29 only.

Plumularia pinnata. Not common.

,, setacea. Not common.

ECHINODERMATA.

Cucumaria lactea. One or two in 30 only.

Solaster papposus. Occasional specimens only.

Asterias rubens. Occasional specimens only.

Ophiura albida. One in haul 4.

Ophiactis Balli. Moderately plentiful.

Ophiocoma nigra. In four hauls. Numerous in 30 and 63. Present in 45 and 66.

Ophiothrix fragilis. Occasional specimens only.

Echinus miliaris. Frequent.

,, esculentus. Occasional small specimens.

Echinocyamus pusillus. In 4 and 45 only.

Spatangus purpureus. In 29, 45, and 63, one or two specimens.

ACTINOZOA.

Alcyonium digitatum. Large colonies common, especially in hauls 3, 4, 45, and 66.

Sarcodictyon catenata. In 4 and 63 only, on shells.

Gorgonia verrucosa. In 3 only. Probably growing on rock.

Caryophyllia Smithii. Frequent and plentiful, on stones and shells. With *Pyrgoma anglicum*.

Corynactis vividis. In 29 and 30, on large stones.

NEMERTINA.

Carinella superba.

Micrura purpurea.

,, fasciolata.

Lineus marinus.

GEPHYREA.

Phascolion strombi.

POLYCHAETA.

Lepidonotus squamatus. One each in 29 and 45.

Eunoe nodosa. One in 45.
Evarne impar. One in 29.
Chaetopterus variopedatus. One or two in 45 and 63 only.
Pectinaria auricoma. Occasional specimens only.
Serpula vermicularis. Recorded in 3 only.
Hydroides pectinata. Few only.

CRUSTACEA.

Eupagurus Bernhardus. Scarce. In haul 45 and 63 only.
Anapagurus laevis. In 3, 4, and 29 only.
Porcellana longicornis. Common.
Galathea dispersa. Common.
Stenorhynchus longirostris. One or two in haul 3 only.
Inachus dorsettensis. One or two in hauls 4 and 45 only.
Hyas coarctatus. Frequent.
Eurynome aspera. Many in 4. Occasional in other hauls.
Pilumnus hirtellus. One in haul 3 only.
Portunus pusillus. In 4 and 45 only.
Atelecyclus heterodon. One or two in 45 only.
Ebalia tumefacta. ⎫
,, tuberosa. ⎬ Occasional specimens only.
,, Cranchii. ⎭

Ampelisca spinipes.
Melita obtusata. In 29.
Pyrgoma anglicum. Associated with *Caryophyllia Smithii.*

MOLLUSCA. *Living.*

Pholas parva. One specimen in Trias rock. Haul 4.
Pholadidea papyracea. Many in Trias rock. Haul 4.
Saxicava arctica. One or two in 29 only.
Tapes virginea. One small one in 29.
Venus fasciata. In haul 45 only.
Kellia suborbicularis. In haul 30 only.
Modiola, *sp.* Small, in 30.
Arca tetragona. Occasional small specimens.
Pectunculus glycimeris. One small one in haul 29.
Pecten tigrinus. One in haul 4.
,, maximus. One small one in haul 4.
,, opercularis. A few in haul 4 only.
Chiton asellus. Common.
,, discrepans. Two in haul 4 only.
Emarginula reticulata. Frequent.
Trochus zizyphinus. Occasional small specimens.
Nassa incrassata. In 45 only.
Buccinum undatum. In 45 only.
Ovula patula. In haul 4.

Doto coronata. In 29 only.
Polycera quadrilineata. In 3 only.
Coryphella Landsburgii. In 30 only.

Shells.

Lutraria elliptica. In 4 only.
Tapes virginea. In 45 only.
Venus fasciata. In 45 only.
Cardium norvegicum. In 45 only.
Pectunculus glycimeris. In 45 and 63 only.
Lima Loscombii. In 4 only.
Pecten tigrinus. In 45 only.
,, opercularis. A few generally present.
Murex erinaceus. In 45 only.
Fusus islandicus. In 45 only.

POLYZOA.

Cellaria sinuosa. ⎫
,, fistulosa. ⎪
Scrupocellaria scruposa. ⎬ In 29 only, a little.
Bicellaria ciliata. ⎭
Bugula turbinata. In 4 and 66.

Incrusting forms numerous. See Table VI., p. 534.

TUNICATA.

Ciona intestinalis. In 63 only.
Ascidia depressa. In 29 only.

SECTION VI.

THE DISTRIBUTION OF PARTICULAR SPECIES ON THE GROUNDS UNDER INVESTIGATION.

IN this section the distribution of the individual species of the more important groups on the grounds from the Eddystone to Start is discussed, and the relation of this distribution to changes in the nature of the bottom-deposit pointed out. Notes are also given on some habits of the species which appear likely to influence their distribution.

In the case of many of the species the geographical and bathymetric distribution is noted, and this is followed by an account of the kinds of deposit upon which the species has been obtained by other observers in different localities. In considering the latter records it must be constantly borne in mind that the terms made use of up to the present time (sand, gravel, mud, etc.) have not been employed in the strict and definite sense which has been given to them in the present paper, and there has been much obvious confusion in their use.

There is, in particular, one source of error which has probably operated very frequently, and by which I was myself several times misled until actual samples of the deposits were obtained with the canvas dredge. Dead shells of bivalve molluscs are frequently taken with the two valves united and closed, which, on being opened, are found to be filled with fine mud or muddy sand. No doubt this has often been supposed to indicate that the deposit is mud or fine muddy sand. Such, however, is by no means the case, as shells so filled may be taken on all grounds where a certain proportion of mud is mixed with coarser material, and I have found them particularly numerous on the coarse muddy or sandy gravels. It is very probable that this circumstance has led to many animals being recorded as living on mud, when in reality the bottom-deposit from which they were taken was a muddy gravel or coarse sand.

The explanation of the fact that the shells are filled with mud appears to be that when the bottom is disturbed, either by wave action or by the movements of animals, the mud in the deposit is stirred up, and the muddy water, entering the shells by a narrow aperture, deposits its solid particles, which gradually accumulate inside the shells.

In addition to the error which has probably been made in describing as mud the deposit on grounds where such shells have been dredged, the term sand has clearly been used in a very general sense to include much coarser deposits than those included in the present paper under that head.

FORAMINIFERA.

[*Nomenclature*:—Brady, No. 13.]

Truncatulina lobatula. This species is abundant on all hydroid grounds, whether the prevailing species is *Sertularella Gayi*, *Halecium halecinum*, or *Sertularia abietina*, and on the grounds where *Cellaria* is plentiful. It is found clinging in numbers to the stems of the zoophytes.

Foraminifera were also found in large numbers in the dried samples of the bottom-deposit. The skeletons, many of which doubtless contained living protoplasm when captured, were picked out from weighed quantities of the samples and mounted by Mr. Worth, the species being afterwards identified by Mr. Worth and myself working together.

[Although numerically well represented, the Foraminifera do not appreciably affect the percentage of carbonate of lime in the sample. Thus, although 103 VII. with 203 foraminifera in 0·13 grams has the high percentage of 40·15, this is due to the abnormal amount of shell in the coarser grades of the sample; for 83 VII. has an even higher percentage of 47·83 of carbonate of lime with only 93 foraminifera to 0·13 grams, and other similar examples might be instanced.

This is not surprising when it is remembered that it would take to cover 13 sq. cms. about 5500 grains of sand of the largest size that could pass a half-millimetre mesh, while the actual number of grains present in such an area from most of the fine sands would probably be from 16,000 to 20,000. The numerical proportion of 200 foraminifera would thus be small, and their chambered structure, as compared with the solidity of the sand grains, would render their proportionate weight even smaller.

Foraminifera are found in the medium sands (Grade VI.), the fine sands (Grade VII.), and the silts (Grade VIII.). They are more numerous in VII. than in VI., and more numerous in VI. than in VIII. Only the Foraminifera from Grades VI. and VII. have been thoroughly examined. These have been recorded in Section V., under the headings of the different grounds.

The silts contain numerous foraminifera of small species and small specimens of foraminifera of large species. As a result of floating them from the silts it was found that many species sparingly represented in either grades VI. or VII. were all present in almost every sample of silt, as well as species entirely absent from grades VI. and VII.

Among the species sparingly represented in VI. and VII., but frequent in the silts, are *Globigerina bulloides* (very frequent), *Bulimina pupoides*, *Lagena striata*, *Bolivina dilatata*, *Polymorphina lactea*, and *Spirillina vivipara*.

The species present in the silts but not found in VI. and VII. are *Cristellaria crepidula*, *Nodosaria scalaris*, *Nodosaria laevigata*, *Nodosaria communis*, *Bolivina punctata*, *Haplophagmium canariensis*, and *Lagena lagenoides*.

In some few cases a census was taken of the number of Foraminifera to be found in 13 centigrammes by weight of fine sand, spread out to cover 13 sq. cm. in such manner as to present a single layer of sand grains lying as nearly as possible side by side without overlap. The figures were as follows:—

102 VII.,	13 c. grms. by weight,	48	foraminifera.		
103 VII.	„ „ „	203	„		
90 VII.	„ „ „	104	„		
91 VII.	„ „ „	67	„		
87 VII.	„ „ „	81	„		
97 VII.	„ „ „	60	„		
105 VII.	„ „ „	29	„		
106 VII.	„ „ „	29	„		
83 VII.	„ „ „	93	„	R. H. W.]	

Porifera.

The only two species of sponges of which satisfactory records were kept are *Suberites domuncula* and *Cliona celata*. The sponge fauna was nowhere numerous on the grounds; but in addition to the above, two or three other unidentified species were occasionally taken.

Suberites domuncula was met with, forming the dwelling of the hermit crab *Eupagurus cuanensis*.

Cliona celata. The importance of this species is very great, for, boring as it does in mollusc shells of all kinds, it is the chief agent which brings about their disintegration, and prevents their continued accumulation on the sea-floor. On all the coarse grounds in the neighbourhood of the Eddystone there are few shells, with the exception of those which are obviously quite recently dead, which have not been attacked to a greater or less extent by *Cliona*, and a large number are reduced to what is little more than a framework held together by the sponge.

Hydrozoa.

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

In this group I have received much assistance from my friend Mr. E. T. Browne, the specimens in a number of hauls having been identified by him. For geographical distribution I have relied largely on Hartlaub (No. 38).

The influence of the bottom-deposit on the distribution of hydroids. The Hydrozoa being all fixed organisms, the nature of the bottom-deposit has in most cases, either directly or indirectly, a very great influence on their distribution, and in an area such as that examined during the present investigation, where the remaining physical conditions to which the grounds are subjected are practically the same for all, this influence can be very largely traced.

Considered from the point of view of their modes of attachment, and of the nature of the objects to which they fix, several kinds of hydroids may be distinguished, namely:—

1. Hydroids which usually fix directly to the bottom-deposit.
   a. Those which attach themselves, generally by means of a creeping stolon, most frequently to rocks or stones, less frequently to dead shells.
   b. Those which fix themselves in sand or gravel by means of a felt-work of root-fibres.
2. Hydroids which usually fix themselves to other living organisms or their remains.
   c. Those which fix to moving organisms.
   d. Those which fix to stationary organisms or remains of organisms.

It must not, of course, be supposed that any species of hydroid is entirely confined to one only of these manners of fixing, but it will be found that for each species there is one (or in some cases possibly two) of these ways of attachment to which its structure is specially adapted, and that in the great majority of instances, more particularly where the species is exceptionally abundant, it will be fixed in this way.

a. Hydroids attaching themselves to rocks or stones. The nature of the rock is of importance in this connection, though the amount of evidence at present available on this point is not sufficient to render profitable a detailed discussion of the matter.

Of the hydroids considered in the present paper, those most typical of this class are *Garveia nutans, Tubularia indivisa,** *Aglaophenia tubulifera*, and *Hydrallmania falcata*, the latter species being most frequently attached to stones or gravel. Such hydroids are plentiful on rocky or stony grounds.

b. Hydroids fixing themselves in sand or gravel by a felt-work of root-fibres. Examples of this class are *Aglaophenia myriophyllum, Antennularia antennina*, and *Antennularia ramosa*. The texture of the bottom-deposit is a most important factor in determining the distribution of such forms, as will be seen especially by referring to the account of the distribution of *Aglaophenia myriophyllum*. *Antennularia antennina* and *A. ramosa* are perhaps not such good representatives of the class as the species first mentioned, since they are also rather frequently found attached to shells, especially in shallow water.

c. Hydroids which fix to moving organisms. Hydractinia echinata, Heterocordyle Conybeari, Perigonimus repens represent this class. The habit has evidently been acquired by the hydroid by reason of the advantages in the matter of food-supply offered by the constant movement of the host.

* *Cf.* p. 448.

The distribution of such species depends upon that of suitable hosts, and since the hosts are all wandering animals, the nature of the bottom-deposit, when it is once sufficiently firm to support them, has little direct effect on their distribution.

d. Hydroids which generally fix themselves to stationary living organisms or remains of organisms. We may to some extent distinguish between those which most frequently fix (1) to dead shells of molluscs,* (2) to sea-weeds, (3) to other zoophytes, (4) to the membranous or leathery tubes of polychaetes, (5) to living lamellibranch molluscs. Typical examples of (1) are *Eudendrium rameum* and *ramosum*, *Campanularia verticillata* (?), and *Lafoea dumosa*, var. *robusta;* of (2) *Sertularia pumila* and *Obelia geniculata;* of (3) *Eudendrium capillare*, *Coppinia arcta*, *Halecium tenellum;* of (4) *Halecium halecinum*, *Sertularella Gayi*, *Lar sabellarum;* of (5) *Tubiclava cornucopiae*. The distribution of these forms depends almost entirely upon the distribution of their hosts, which are themselves fixed organisms generally directly attached to the bottom, whose distribution therefore is largely influenced by the nature of the bottom-deposit.

Tubiclava cornucopiae (Table VI., p. 529). This species was abundant on the Bolt Head Shell Gravel (Ground XVII). In haul 105, in which *Pectunculus glycimeris* was abundant, nearly every living specimen of that mollusc had *Tubiclava* growing in considerable quantity on the posterior margin of the shell. In haul 107 on the same ground *Tubiclava cornucopiae* was growing on the posterior end of living *Venus fasciata*.

The hydroid was also present on the fine sand south of the Eddystone (Ground VI., haul 102), growing on the posterior end of the shell of *Dentalium entalis*.

DISTRIBUTION. *Geographical.* Shetland (Norman, No. 90); Northumberland (Alder); Plymouth (Garstang, No. 27, p. 334; No. 28, p. 212).

Depth. 15 fathoms (Garstang) to 80–100 fathoms (Norman).

Habitat. Norman found his specimens growing on *Astarte sulcata* and *Dentalium entalis*. In every instance the mollusc was living and the hydroid was on the posterior extremity of the shell, where, as Norman says, "it would receive the benefit of the aqueous currents caused by the mollusc, which, while providing for its own necessities, thus unwittingly performed the kindly office of feeding its hungry neighbour." Alder's specimens were also found on the posterior end of *Dentalium entalis*.

Garstang found the species upon *Aporrhais pes-pelecani* shells inhabited by *Phascolion strombi*, and subsequently also on shells of *Turritella* inhabited by the same Gephyrean. These specimens were obtained in 15–25 fathoms, south of the Plymouth Mewstone. The species is still frequently taken in this locality on a bottom of clean shell gravel.

Speaking of *Pectunculus glycimeris*, Gwyn Jeffreys (No. 55, p. 168) says, "The anterior side of the shell, while the animal is alive, is frequently fringed with the tubes of a

* Those hydroids which fix on shells are less clearly marked as a separate class, probably since a dead shell offers conditions very similar both to those of stones and of other living organisms.

Hydroid polype (one of the *Tubulariidae*), which seems to take advantage of the strong gyratory current produced by the mollusc for its own food-seeking purpose." It is probable that the reference is to the present species, though in my specimens the hydroid was always on the *posterior* end of the shell.

Hydractinia echinata (Table VI., p. 529). Generally on *Buccinum undatum* shells occupied by *Eupagurus Bernhardus,* occasionally (haul 93) on shell occupied by *E. Prideauxii.* The presence of *Hydractinia* appears to be rather more frequent on the fine sand than on the coarser grounds.

Distribution. *Geographical.* Greenland, Iceland, North Sea, British coasts, Normandy and Brittany, and North America (Agassiz). [*Fide* Hincks, No. 46, and Hartlaub, No. 38.]

Depth. Low-water to 90 fathoms.

Habitat. On *Buccinum undatum, Fusus corneus, Turritella communis, Nassa reticulata, Littorina, Natica, Trochus zizyphinus* (Hincks). On *Mytilus edulis* and on stones (Hartlaub).

Eudendrium rameum (Chart III.). Specimens of *E. rameum* were obtained only on the Bolt Head Shell Gravel, in hauls 106 and 107 (Ground XVII.). In 106 a fine colony was growing on an old fragment of the leathery tube of *Chaetopterus,* and in 107 another fine colony was found on a shell of *Pecten opercularis.*

Distribution. *Geographical.* West Greenland, Kara Sea, Norway, Baltic, North Sea, British Seas, Mediterranean, and Kerguelen (*Challenger*). [*Fide* Hartlaub, No. 38.]

Depth. 5-105 fathoms (*Challenger*, No. 3).

Habitat. On shells, stones, etc. (Hincks, No. 46).

Eudendrium ramosum (Chart III.). Generally growing on shells or on other hydroids. The species is far more frequent and abundant on sandy grounds than on the gravels. It was most numerous on Grounds I., III., IV., VII., and XII.

Distribution. *Geographical.* Greenland, Norway, North Sea, British Seas, Mediterranean (Hartlaub, No. 38).

Depth. Low-water to 542 fathoms (*Porcupine*, Allman, No. 4).

Habitat. On shells and on Laminaria roots (Hincks, No. 46 ; Hartlaub, No. 38).

Eudendrium capillare and *E. sp.* (Table VI., p. 529). The true *Eudendrium capillare* was met with on several grounds, generally growing on other hydroids, sometimes on worm tubes or shells. A small *Eudendrium* of a rather more robust character was also frequently taken in similar situations, but there is some doubt as to whether this is a distinct species.

Distribution. *Geographical.* Norway, Baltic, North Sea, British coasts (Hartlaub, No. 38).

Depth. 4 to 30 fathoms (E. J. A.).

Habitat. On *Antennularia ramosa, Delesseria sanguinea,* on *Salicornaria farciminoides* (= *Cellaria fistulosa*) (*fide* Hincks).

Perigonimus repens (Table VI.). A good colony of this hydroid was found growing on the claw of *Eupagurus Bernhardus,* in haul 104, on the fine sand of Ground II. The species was not found on any other ground.

DISTRIBUTION. *Geographical.* Norway, Baltic, Kattegat, North Sea, British Coasts, Mediterranean (Hartlaub, No. 38).

Depth. Shallow water to 33 fathoms (E. J. A.).

Habitat. On Sertularians and on the Spider Crab (Wright). On *Dentalium entalis*, *Fusus antiquus*, *Turritella communis*, and on stones (*fide* Hincks, No. 46). On *Mya arenaria*, on mussel shells, frequent on *Nucula nucleus* (Hartlaub). On *Turritella*, *Chiton*, *Leda*, *Nucula*, and *Dentalium* (Levinsen, No. 66). Growing on legs of a crab and on *Turritella* shells at Plymouth (Bourne, No. 12). It is also frequently taken at Plymouth on *Nassa reticulata*. *Perigonimus repens* is clearly a species which fixes itself most frequently to living crustaceans and molluscs.

Garveia nutans. On the Prawle Stony Ground only, in haul 29 (depth, 30 fathoms), growing on *Tubularia indivisa*, which was itself fixed to a large stone.

DISTRIBUTION. *Geographical.* Scottish Coasts, Shetland, Morecambe Bay (Hincks, No. 46, and Allman, No. 2); Hilbre Island, Mouth of Dee; Plymouth (Garstang).

Depth. Between tide-marks (Allman) to 30 fathoms (E. J. A.).

Habitat. On rocks, zoophytes, and sea-weeds (Allman).

Heterocordyle Conybeari. On the fine sand of Ground I., in haul 51 only, fixed to shell of *Buccinum undatum* inhabited by *Eupagurus Bernhardus.*

DISTRIBUTION. *Geographical.* Glengariff Harbour, co. Cork, Oban (Allman and Hincks).

Depth. Near low-water mark (Hincks) to 30 fathoms (E. T. B.).

Habitat. On univalve shells tenanted by Hermit Crabs (Allman). On *Buccinum* (Hincks). Mr. E. T. Browne has found the species abundant in Plymouth Sound on the shells of living *Nassa reticulata*. *Heterocordyle Conybeari* is clearly a species which fixes itself to living and freely-moving animals.

Bougainvillia ramosa (Chart III). As will be seen from the Chart, in the area described in this report, this species is practically confined to the fine sand grounds, on which it is frequently met with, though not in large quantities. The only exception to this was in haul 84, on Ground XI., where the bottom-deposit is coarse gravel mixed with fine sand, and in this haul only one piece was seen. It was generally found growing on polychaete tubes or on other hydroids.

DISTRIBUTION. *Geographical.* Baltic, North Sea, British Coasts.

Depth. Low-water (Allman, No. 2) to 26 fathoms (Hartlaub, No. 38), 35 fathoms (E. J. A.).

Habitat. On shells and stones and on other zoophytes (Hincks). On *Virgularia mirabilis* (Dalyell). Allman records it on rocks near low-water. On *Hyas aranea* (Apstein). Hartlaub found it at Heligoland, in 8½ fathoms, on sandy ground, with many Ascidians. By the *Pommerania* expedition it was dredged on ground described as muddy, in 26 fathoms (Schulze, No. 105).

Tubularia indivisa (Table VI., p. 529) was taken only on the Prawle Stony Ground (XVIII.), where it was growing on a large stone.

DISTRIBUTION. *Geographical.* Alaska, Greenland, North Cape, White Sea, Norway, Baltic, North Sea (rare at Heligoland), British Coasts, Bay of Biscay (*fide* Allman, No. 2, and Hartlaub, No. 38), Mediterranean (Pruvot, No. 98).

Depth. Low-water to 55 fathoms.

Habitat. *Tubularia indivisa* is most frequently found on rocky and stony ground. It is often taken on floating objects, such as buoys, hulks, etc. It also, however, is not unfrequently met with, according to various authors, on fine sandy or muddy ground. Hincks (No. 46) quotes Thomas as saying that "on the oozy bottom which lies outside a line drawn between Flamborough Head and the Staples" it grows to a very large size. According to the same author Forbes found it in Rothesay Bay, flourishing, as it seemed, "upright, on a muddy ground, like a flower, fixed by the tapering root-like termination of its horny case." Schulze (No. 105) records it in a number of the *Pommerania* hauls, from bottoms of sand and shell at depths from 23 to 50 fathoms. The entire absence of the species from all the sand and gravel grounds examined during the present investigation is therefore noteworthy. Indeed, I know of no such locality in this neighbourhood where the species lives.

Clytia Johnstoni (Table VI.). Abundant on all grounds where other hydroids or *Cellaria* are common. It appears to grow less frequently upon *Halecium halecinum* and *Beanii* than on Sertularians and *Hydrallmania*.

DISTRIBUTION. *Geographical.* Norway to the Mediterranean, Baltic, Greenland, Alaska, east coast of North America (*fide* Hartlaub, No. 38).

Depth. To 50 fathoms (?).

Habitat. On algae and hydroids.

Obelia dichotoma (Table VI.). This species has been met with on fine sand grounds in the neighbourhood of the Eddystone, and occasionally on the Bolt Head Shell Gravel and the Prawle Stony Ground. It was found growing on *Pecten opercularis* shells, on other hydroids (*Hydrallmania, Bougainvillia, Sertularia argentea*), and on *Cellaria*.

DISTRIBUTION. *Geographical.* Norway, Baltic, British Seas to Mediterranean (*fide* Hartlaub, No. 38).

Depth. 6–29 fathoms.

Habitat. On shells, algae, and other zoophytes.

Obelia longissima was only found in haul 80 on Ground VII., south of the Eddystone.

DISTRIBUTION. *Geographical.* Circumpolar, Norway to British and Belgian Coasts (*fide* Hartlaub, No. 38).

Depth. To 20 fathoms (Hartlaub).

Campanularia Hincksii is generally distributed on the grounds examined, growing sometimes on shells, sometimes on *Cellaria*, and probably less frequently on hydroids.

DISTRIBUTION. *Geographical.* British Coasts (Hincks, No. 46).

Depth. 10 or 20 fathoms to deep water (Hincks).

Habitat. On zoophytes, etc.

Campanularia verticillata (Table VI.). Occasional specimens were taken on the fine sand grounds, I., III., and VI., in the neighbourhood of the Eddystone. A fine colony was taken growing on a stone in haul 45 on the Prawle Stony Ground (XVIII.), and it was also met with in hauls 28 and 60 on the Bolt Head Shell Gravel.

Distribution. *Geographical.* Kara Sea, White Sea, North Cape, Norway, Baltic, North Sea, British Coasts to Mediterranean; Greenland, Labrador, Nova Scotia, Massachusetts (*fide* Hartlaub, No. 38).

Depth. To 300 fathoms (Sars, *fide* Allman, No. 2).

Habitat. On shells and other hydroids (Hincks, No. 46, Schulze, No. 105).

Campanularia flexuosa. A hydroid was very abundant in haul 107 on the Bolt Head Shell Gravel (XVII.), growing on dead shells of *Pectunculus glycimeris.* The specimens were without gonophores, but were identified independently by Mr. Browne and myself as *C. flexuosa. C. flexuosa* was not taken in any other haul.

Distribution. Hincks (No. 46) says it is confined to the littoral region, and is extremely common on all parts of our coasts. Mediterranean (Carus, No. 14).

Lovenella clausa. Growing on *Tubularia indivisa,* in haul 29, on the Prawle Stony Ground (XVIII.).

Distribution. On stones in Torbay, 10 fathoms (Hincks). On *Fuci* from stony ground off the coast of Sweden (Lovén). Taken once at Heligoland (Hartlaub).

Opercularella lacerta. Growing on *Tubularia indivisa,* in haul 29, on the Prawle Stony Ground (XVIII.).

Distribution. Between tide-marks and in moderate depths not uncommon. British Coasts and Belgium (*fide* Hincks).

Lafoea dumosa. The creeping variety of *L. dumosa** was present on practically all grounds, growing on shells and on other hydroids when the latter were present. The branched variety (var. *robusta*) was frequently met with, especially upon fine sand grounds, attached to shells or polychaete tubes. The Neomenian *Dondersia banyulensis* was often found associated with this variety.

Distribution. *Geographical.* White Sea, North Cape, eastern side of Atlantic to Mediterranean (Pruvot, No. 98), Greenland, Alaska, Labrador and western side of Atlantic, West Indies, Chili (*fide* Hincks, No. 46, and Hartlaub, No. 38).

Depth. To 450 fathoms (*Challenger*, Allman, No. 3).

Lafoea fruticosa. This species was taken occasionally on different fine sand grounds (I., III., IV., VII.), and a fine colony was also found in haul 84 on the coarse gravel and fine sand north-west of the Eddystone (Ground XI.).

Distribution. *Geographical.* North Cape, Iceland, Norway, British Seas (*fide* Hincks), Strait of Magellan (*Challenger*, Allman, No. 3).

Depth. To 100 fathoms (Iceland, Hincks).

Habitat. On shells and zoophytes.

Calycella syringa. This was recognised occasionally on the Bolt Head Shell Gravel and on the Prawle Stony Ground, growing on *Pecten opercularis* shells, on *Sertularia abietina*, and on *Hydrallmania falcata.*

Distribution. *Geographical.* White Sea, Iceland, Greenland, Alaska, North Sea, British Coasts, north coast of France (*fide* Hartlaub, No. 38; and Hincks, No. 46), Mediterranean (Carus, No. 14).

* What we have regarded as the creeping form of *L. dumosa* has probably often been the form recorded by other authors as *Filellum serpens*, but we have not felt able to distinguish between the two. We have often compared the Plymouth *Lafoea* with Hincks' figures of *Filellum serpens*, but up to the present have not seen anything like *Filellum* as figured.

Depth. To 42 fathoms (Hartlaub).
Habitat. On other zoophytes and sea-weeds, very common (Hincks).

Calycella fastigiata. This was recognised in haul 75 (Ground VII.).

DISTRIBUTION. Scotland, Cornwall (Norman, No. 90; Hincks, No. 46), North Sea (Schulze, No. 105). Growing on other hydroids. To 81 fathoms (*Porcupine*, Allman, No. 4).

Cuspidella costata. Recognised in haul 81 on the fine sand ground (I.).

DISTRIBUTION. Whitby, Yorkshire. On *Syncoryne eximia* (Hincks).

Trichydra pudica. This species was found by Mr. Browne growing on *Halecium halecinum* and on a *Pecten opercularis* shell in haul 97 (Ground XV., fine gravel).

DISTRIBUTION. Found by Wright in the Firth of Forth, on a small shell. There are no other records (Hincks, No. 46).

Coppinia arcta (Table VI.). Abundant on the fine sand grounds, especially on *Lafoea dumosa* (var. *robusta*) and on *Sertularia abietina.* Whenever special attention has been paid to the point, I have always found the creeping variety of *Lafoea dumosa* growing on the branch of *Sertularia abietina* upon which the *Coppinia* was found. As the gonothecæ of *Lafoea dumosa* are quite unknown, the constant association of *Coppinia arcta* with it naturally suggests the idea that the latter might be the reproductive stage of *Lafoea.**

DISTRIBUTION. *Geographical.* Circumpolar (Norman), Norway, British Seas, Pas-de-Calais (*fide* Hartlaub, No. 38).
Depth. To 50 fathoms (Schulze).
Habitat. Growing on *Sertularia abietina* and on *Hydrallmania falcata* (Hincks). Hartlaub also found it on these two hydroids, generally associated with *Filellum serpens.* Schulze (*Pommerania*, No. 105) records it on *Hydrallmania falcata.*

Halecium halecinum (Chart II.). The distribution of this hydroid is both interesting and significant. The species is very abundant on the grounds to the westward of the Eddystone, but is scarce or entirely absent on the remaining grounds. The abundance of *Halecium* is specially characteristic on the mixed coarse gravel and fine sand of Grounds IX. and XI., on the finer gravel of Ground XIV., and on the coarse sand of Ground VII. As will be seen from the chart, the species extends from these grounds on to those which immediately surround them, in what appears to be diminishing quantity according to the distance from the centre of abundance. Thus on the fine sand of Ground VI. it is fairly abundant, on the coarse sand of Ground IV. it is still met with in some quantity, on the fine sand of Ground III. it is scarce, whilst on the fine sand of Ground I. it is represented by two colonies only, one in haul 92 and one in haul 82. On the fine gravel of Ground XII., again, the species is present, but in much

* Since the above was in type C. C. Nutting's paper on "Hydroids from Alaska and Puget Sound" (*Proceed. U.S. Nat. Museum*, vol. xxi.) has come to hand, in which it is maintained that *Coppinia arcta* is in reality the gonosome of *Lafoea*, a view which appears to have been definitely held by Levinsen in 1893. (*Meduser, Ctenophorer, og Hydroider fra Grönlands Vestkyst*, Copenhagen, 1893.)

smaller quantity than on the neighbouring coarse gravel of Ground XI. Ground X., as Chart II. shows, is surrounded by grounds on which *H. halecinum* is abundant. As has been already explained (p. 416), this ground is occupied almost exclusively by *Ophiothrix fragilis*, but occasional specimens of *H. halecinum* were taken upon it in some hauls. A single specimen of the hydroid occurred in haul 10 on the clean shell gravel of Ground IX., close to the Eddystone rocks, a ground upon which hydroids were practically absent. It was occasionally taken on the Bolt Head Shell Gravel, but never on the Prawle Stony Ground.

On the grounds where the species was most abundant the specimens of *Halecium halecinum* were in by far the greater number of instances fixed to the leathery tubes of *Chaetopterus*, the distribution of which, as will be seen by comparing Chart II. with Chart X., is practically identical with that of the hydroid we are considering. But in addition to the *Chaetopterus* tubes the hydroid was also found, though much less frequently, attached to shells or (in haul 100 only) to stones. The shells of *Tapes virginea* and *Pecten opercularis* were the most common ones used by the hydroid, but exceptionally fine colonies were sometimes found attached to the flat upper valve of living *Pecten maximus*. This latter mollusc was generally present on the *Halecium* grounds, but only a comparatively small proportion of the specimens had colonies of the hydroid growing upon them.

Undoubtedly the presence of *Chaetopterus* in numbers, by offering a suitable fixing place for the hydroid, is an important factor in determining the abundance of *Halecium halecinum* upon the grounds where it is found in quantity. At the same time it is not the only cause, since *Chaetopterus* is obtained in numbers on a ground some four miles south-west of Rame Head, where *Halecium halecinum* is by no means plentiful.

Distribution. *Geographical.* North Cape, Norway, Baltic, Kattegat, North Sea, British and French Coasts, Mediterranean, Massachusetts Bay (*fide* Hartlaub, No. 38).

Depth. 12–50 fathoms (Sars, *fide* Hartlaub).

Habitat. On shells, stones, etc., in both shallow and deep water, but more usually the latter (Hincks). Schulze (No. 105) states that in the *Pommerania* dredgings the species was found on bivalve shells, worm tubes, etc. It was taken six times on stony ground or sand with stones, four times on sand and shell, and twice on mud.

Halecium Beanii (Table VI., p. 529) was met with on all the grounds upon which *H. halecinum* was found, although it was by no means so abundant as the latter species on the grounds to the westward of the Eddystone. It was found, so far as I remember, for I have no definite records on the point, more frequently upon shells than on *Chaetopterus* tubes, differing in this respect from *H. halecinum*.

Distribution. *Geographical.* British Seas; Azores (450 fathoms, *Challenger*, Allman, No. 3), south-east coast of Australia (150 fathoms, ditto); Mediterranean (Carus, No. 14).

Depth. To 150 fathoms.

Habitat. On shells, etc., and very often parasitic on other zoophytes, from moderate depths to deep water (Hincks, No. 46). The *Pommerania* took it on a bottom of sand, and on sand, shell, and small stones (Schulze, No. 105).

Halecium labrosum was identified by Mr. E. T. Browne, in hauls 73 and 75, on Grounds XIV. and VII., west and south-west of the Eddystone.

Distribution. *Geographical.* North Sea, Scotland, Shetlands (*fide* Hartlaub, No. 38). Very common at Heligoland, especially on *Phallusia* (*Ascidiella*) *virginea*. Allman (No. 2) states that this is a northern form, confined to the north coasts of the British Isles. Mediterranean (Carus, No. 14).

Halecium tenellum was recognised only in haul 29 on the Prawle Stony Ground, growing on the stem of *Tubularia indivisa*. In haul 77 on Ground IV. a fragment of a small *Halecium*, which was probably this species, was seen growing on *Cellaria*.

Distribution, etc. Salcombe Bay, Devon, on *Salicornaria farciminoides* (= *Cellaria fistulosa*); Filey (T. H.); Northumberland, on *Tubularia indivisa* and *Sertularia abietina*, from deep water (J. A.) [Hincks, No. 46].

Sertularella Gayi (Chart II.). In contradistinction to *Halecium halecinum* this species is specially abundant on the fine sand grounds, where it forms one of the most characteristic features of the fauna. It is most abundant on the fine sand grounds III. and IV. to the eastward of the Eddystone, and on Grounds VI. and VII. to the south. It is present in quantity also on the fine sand of the inner and outer trawling ground (I. and II.). On the coarser grounds to the westward of the Eddystone, it is still moderately plentiful on the coarse gravel mixed with fine sand of Grounds XI. and XII. It is scarce on the remaining grounds in the neighbourhood of the Eddystone (one or two colonies at most in a haul and absent in many hauls), and has never been taken on the Bolt Head Shell Gravel (XVII.) or the Prawle Stony Ground (XVIII.).

On the grounds upon which it is abundant *Sertularella Gayi* is most frequently attached to the membranous tubes of *Thelepus*. It is also found less frequently attached to shells.

A group of animals of the following kind, in which *S. Gayi* plays an important part, is exceedingly frequent on the grounds where this hydroid is abundant:—The tube of the polychaete *Thelepus* serves as a base from which the hydroid *Sertularella Gayi* springs. Attached to the lower portion of the stem of the hydroid are the Ascidian *Ascidiella scabra* and the Polychaete *Sabella* (*pavonina* ?), as well as the barnacle *Scalpellum vulgare*. Attached also to the stem of the *Sertularella* will probably be some of the smaller creeping hydroids, especially *Clytia Johnstoni*, together with a number of foraminifera belonging to the species *Truncatulina lobatula*.

Distribution. *Geographical.* British Seas and coast of Normandy (Hincks), New Zealand (Allman, No. 2).

Depth. To 374 fathoms (Allman, No. 4, *Porcupine*).

Sertularella polyzonias (Table VI., p. 530). In the earlier hauls I did not distinguish between *S. Gayi* and *S. polyzonias,* until the difference between the two forms was pointed out to me by Mr. Browne. The distribution of *S. polyzonias* is practically identical on the Eddystone Grounds with that of *S. Gayi*, though it is much less frequently met with, generally not more than two or three pieces being found amongst a large mass of *S. Gayi.*

Distribution. *Geographical.* Kara Sea, Norway, Kattegat, Baltic, North Sea (not frequent at Heligoland), British Coasts, Madeira, Mediterranean, Alaska, Greenland, east coast of United States, Florida, Australia and New Zealand, Chili, South Africa (*fide* Hartlaub, No. 38 ; Allman, No. 2, p. 160 ; and Hincks, No. 46).

Depth. To 374 fathoms (Allman, No. 4, *Porcupine*).

Habitat. On shells, sea-weeds, etc. (Hincks).

Diphasia rosacea (Table VI.). Only occasionally met with, in hauls 82 and 99 on the Eddystone Grounds, 4 and 29 on the Prawle Stony Ground.

Distribution. *Geographical.* Faröe, British Coasts, North France, Massachusetts Bay (*fide* Hartlaub, No. 38).

Depth. Tide-marks to 50 fathoms (Hincks, No. 46).

Habitat. On other zoophytes (chiefly) and on shells. Hartlaub found it on *Tubularia indivisa* and on *Sertularia cupressina.* Schulze (No. 105) records it three times in the *Pommerania* dredgings on sand and shell. Packard found it very abundant on gravelly bottom, in 50 fathoms, in Straits of Belle Isle.

Diphasia attenuata. In hauls 23 and 24 on the fine sand of the outer trawling ground (II.), and in haul 21 on the Bolt Head Shell Gravel. Never plentiful.

Distribution. British Coasts, generally on other zoophytes (Hincks, No. 46) ; Australia (von Lendenfelt and Hincks), South Africa (Allman, No. 2).

The *Pommerania* took it twice on sand and shell, once on small stones.

Diphasia tamarisca. In haul 99 south of the Eddystone, and in haul 28 on the Bolt Head Shell Gravel. Small colonies only.

Distribution. British Coasts, Bay of Biscay, Grand Manan, Massachusetts Bay (Hincks), Mediterranean (Carus, No. 14). On shells and stones from deep water. The *Pommerania* took it once on sand, shell, and small stones in 30 fathoms (Schulze, No. 105).

Sertularia abietina (Chart II.). This species is characteristic of the fine sand of the outer trawling ground (Ground II.), where it is taken in quantity. It is not present on the fine sand of the inner trawling ground (Ground I.), nor on any of the grounds in the neighbourhood of the Eddystone. It is frequently taken on the Bolt Head Shell Gravel and on the Prawle Stony Ground, being abundant in some of the deeper hauls (especially hauls 7, 28, 4, and 45).

In haul 28 it was growing largely on *Pecten opercularis* shells, but I unfortunately have no notes on its attachments in other hauls.

DISTRIBUTION. *Geographical.* Kara Sea, White Sea, North Cape, Norway, Baltic, North Sea, British Coasts, Bay of Biscay, Mediterranean. Iceland, Greenland, Labrador, Newfoundland (*fide* Hincks, No. 46, and Hartlaub, No. 38). South Africa (Allman, No. 2, p. 158).

Depth. 5–75 fathoms (Allman, No. 4, *Porcupine*).

Habitat. On shells, stones, etc., from deep water (Hincks). Attached to living molluscs (M'Intosh, St. Andrews). Schulze (No. 105) records it from the *Pommerania* dredgings nine times on hard or coarse ground, twice on mud or sand in 30 and 50 fathoms.

Sertularia argentea (Table VI.). This species was not unfrequently met with on both coarse and fine grounds, though never in quantity. It was growing on *Pecten opercularis* shells, on stones, and on other hydroids (*Diphasia tamarisca*).

DISTRIBUTION. *Geographical.* North Cape, Kattegat (Levinsen, No. 66), British and French Coasts, Adriatic, Greenland, Labrador, east coast of United States, South Africa (*fide* Hincks, No. 46).

Depth. 8–50 fathoms.

Habitat. On shells, stones, etc., chiefly from deep water.

Hydrallmania falcata (Chart III.) was abundant on the Prawle Stony Ground (XVIII.) and moderately plentiful on the Bolt Head Shell Gravel (XVII.). On most of the fine sand grounds and coarse grounds in the neighbourhood of the Eddystone occasional specimens were taken, but on none of these was it at all abundant.

The hydroid was generally attached to stones, occasionally to shells. I have never seen this species attached to polychaete tubes.

DISTRIBUTION. *Geographical.* White Sea, Norway, Baltic, North Sea, British Coasts, Gulf of St. Lawrence, east coast of United States, South Africa (*fide* Hincks, No. 46, and Hartlaub, No. 38).

Depth. 12–542 fathoms (*Porcupine*, Allman, No. 4).

Habitat. On shells and stones in the coralline zone (Hincks). On dead shells (*Cyprina islandica*, *Ostrea edulis*) in Kattegat (Levinsen, No. 66). Schulze (No. 105) records *Hydrallmania* in the *Pommerania* dredgings four times on coarse bottom (with small stones), eight times on sand and shell, and once on mud.

Thuiaria articulata (Chart IV.). Several colonies in hauls 27 and 28 on the Bolt Head Shell Gravel (XVII.), and several in hauls 45 and 63 on the Prawle Stony Ground (XVIII.) The species was never met with on the Eddystone Grounds. Attached to stones or shells.

DISTRIBUTION. *Geographical.* British Seas (Hincks, No. 46), Mediterranean (Carus, No. 14).

Depth. To 632 fathoms (*Porcupine*, Allman, No. 4).

Habitat. On stones and shells from deep water (Hincks). Schulze (No. 105) records it once only in the *Pommerania* dredgings on a bottom of sand, shell, and small stones.

Antennularia antennina (Chart IV.). This is typically a sand species, possessing at the base of the stalk a felt-work of root-fibres, by means of which it fixes itself in the sand. It is, however, not unfrequently also found attached to shells. It is most abundant on the fine sand grounds, I., II., V., and VI., and on Ground XII., where the bottom is medium gravel mixed with muddy sand. It is rare on the very fine sand of the outer trawling ground (II.), not very plentiful on the fine gravel of Ground XIV., the coarse gravel mixed with sand of Ground XI., and on Ground VII. It is only occasionally met with on Grounds X., XIII., XV., and on the Bolt Head Shell Gravel (XVII.) and Prawle Stony Ground (XVIII.).

On the whole the species, in the area examined, seems to flourish best in the coarser sand grounds, being scarce on gravels and stony ground, and also on very fine sand.

DISTRIBUTION. *Geographical.* British Coasts, Belgium, Bay of Biscay (*fide* Hincks, No. 46), Mediterranean (Pruvot, No. 98), western side of North Sea (*Pommerania*). Not recorded at Heligoland (Hartlaub, No. 38), nor in Kattegat (Levinsen, No. 66).

Habitat. Commonly on a sandy bottom (Hincks). Schulze (No. 105) records it three times in the *Pommerania* dredgings on coarse ground, three times on sand and shell.

Antennularia ramosa (Chart IV.). Generally on the same grounds as *A. antennina*, but never so abundant. It was most numerous on Grounds VI. and XII. This species also fixes in the sand by a felt-work of root-fibres.

DISTRIBUTION. British Coasts, South Africa (*fide* Hincks, No. 46), North Sea, 12–50 fathoms (Schulze, No. 105). In the *Pommerania* dredgings it was recorded on sand, on sand and shell, and on small stones.

Aglaophenia myriophyllum (Chart II.). Like *Antennularia antennina* and *ramosa* this species fixes itself in the sand by a felt-work of fine root-fibres. It confines itself much more entirely to this mode of attachment than *Antennularia*, and I have never found it growing on shells, stones, or polychaete tubes. Probably in consequence of this, *A. myriophyllum* is much more restricted in its distribution. On the Eddystone Grounds it was most common on the fine sand of Ground III., north-east and east of the rocks. It was constantly present on the adjoining sand (Ground IV.), and also on the coarse gravels mixed with fine sand or mud of Grounds XI., XII., and XIII. It was rare or absent on the remaining gravel and sand grounds in the neighbourhood of the Eddystone. On the fine sand of the inner and outer trawling grounds (I. and II.) it was only present in one haul, viz., haul 82.* It was absent on the Bolt Head Shell Gravel (XVII.), and was only once met with (in haul 29) on the Prawle Stony Ground (XVIII.).

DISTRIBUTION. *Geographical.* British Coasts, Mediterranean, Gulf of St. Lawrence, Massachusetts Bay (*fide* Hincks, No. 46).

Depth. Chiefly from deep water (Hincks). 364 fathoms (Allman, *Porcupine*, No. 4).

Aglaophenia tubulifera. This species has only been taken twice; once fixed to a specimen of the Ascidian *Polycarpa varians*, in haul 55 (Ground X.), and once in haul 99 (Ground XVI., probably on a stone).

DISTRIBUTION. *Geographical.* British Seas, South Africa (*fide* Hincks, No. 46).

Depth. In moderately deep water (Hincks).

Habitat. On sea-weeds, zoophytes, shells, etc.

* It will be noticed that this haul is exceptional also in the presence of *Halecium halecinum* and of fragments of *Chaetopterus* tubes. There is probably some coarse ground near it, the influence of which is being felt (*cf.* p. 391).

Plumularia pinnata. This species is very generally distributed, but less frequently met with on the fine sand grounds than on the gravels to the westward of the Eddystone. It is usually attached on these gravels to *Chaetopterus* tubes or to other hydroids. It was met with occasionally only on the Bolt Head Shell Gravel (XVII.) and on the Prawle Stony Ground (XVIII.).

DISTRIBUTION. *Geographical.* Norway, Baltic, Kattegat (common), North Sea (rare at Heligoland), British Seas (Hartlaub, No. 38; Levinsen, No 66; Hincks, No. 46), Mediterranean (?) (Carus, No. 14).

Depth. To 50 fathoms (Schulze, No 105, *Pommerania*).

Habitat. On shells, stones, sea-weeds, etc. (Hincks). This species seems to be less restricted by the nature of the material to which it readily fixes than some other hydroids.

Plumularia setacea. Less common on the Eddystone Grounds than *P. pinnata.* Especially scarce on fine sand grounds. Generally growing on other hydroids or on polychaete tubes. Taken several times on the Prawle Stony Ground (XVIII.).

DISTRIBUTION. *Geographical.* Mediterranean, French Coast, British Seas. More plentiful at Heligoland than *P. pinnata* (*fide* Hartlaub, No. 38).

Depth. Littoral to 106 fathoms.

Habitat. On weed, zoophytes, rock, etc. (Hincks). On *Ciona intestinalis* (Sars, *fide* Hincks, No. 46), on *Laminaria* (Van. Ben. *fide* Hincks; Hartlaub), on *Halichondria panicea* (Bourne, No. 12).

Plumularia Catharina (Chart IV.). This is the most abundant species of *Plumularia* on the Eddystone Grounds, and it is present both on the fine sand grounds and on the gravels. On the fine sand grounds it is generally growing on other hydroids. On the gravels to the west of the Eddystone it is often very abundant on *Chaetopterus* tubes, generally in the form of the green variety described by Hincks, in which the erect stem is wanting. In this form it is quite a characteristic feature of the grounds where *Chaetopterus* abounds. In haul 90 (Ground V.), which is a fine sand ground, one colony only of this variety was taken, and it was growing on a piece of old leather. This is significant in view of the two facts that there were plenty of *Pecten* shells on this ground, to which one would at first sight have supposed that the species could attach itself, and that the species is abundant on other grounds in the immediate neighbourhood, fixed to the leathery tube of *Chaetopterus.*

Amongst the hydroids to which the ordinary form of the species has been found attached I have noted *Hydrallmania falcata* and *Halecium halecinum.* The species was never taken on the Bolt or Prawle Grounds.

DISTRIBUTION. *Geographical.* British Coasts (Hincks, No. 46), Heligoland (Leuckart), between Cuba and Florida (Allman, No. 2), North Sea (Schulze, No. 105).

Depth. To 50 fathoms (Schulze).

Habitat. On shells, corallines, and especially the tests of Ascidians from deep water, shells of *Pinna;* stemless variety on *Sertularella Gayi* (Hincks). The *Pommerania* generally dredged the species on sandy ground.

Plumularia frutescens. A very fine specimen in haul 10 (Ground XVI.), 5–6 inches high, growing on a *Pecten maximus* shell.

DISTRIBUTION. *Geographical.* British Coasts, Algoa Bay (Krauss) [*fide* Hincks, No. 46]; Mediterranean (*fide* Carus, No. 14).

Depth. 5–34 fathoms (Schulze, No. 105, *Pommerania*).

Habitat. On stones and shells in deep water (Hincks). The *Pommerania* took the species twice, on shells and stones (34 fathoms) and on stony ground (5–10 fathoms).

ACTINOZOA.

[*Nomenclature:*—Gosse, No. 30; or Haddon, No. 35.]

Alcyonium digitatum. The relative distribution of *Alcyonium* on the grounds examined is indicated in Chart I. Large colonies are abundant on the fine sand of the outer trawling ground (Ground II.), where they are generally fixed to *Cardium echinatum* shells, and also on the fine sand of Ground VI., south of the Eddystone, where they are attached to shells of various kinds. Large colonies are also abundant in the two deepest hauls on the Bolt Head Shell Gravel (hauls 27 and 28), and in the deeper hauls on the Prawle Stony Ground (hauls 4, 45, 66). On the other grounds near the Eddystone, and in the remaining hauls on the Bolt and Prawle Grounds, young colonies are frequently met with growing on living *Pecten opercularis* or on shells of different kinds, but they seldom, if ever, attain any considerable size.

It will be seen from the chart that all the grounds indicated above, upon which large colonies are taken, lie at depths of 34 and 35 fms., and are in fact the deepest portions of the area investigated. Other situations in which *Alcyonium* flourishes in the neighbourhood of Plymouth show that depth in itself can only indirectly influence its distribution, and that the species can also adapt itself to a variety of conditions of density, temperature, etc., without injury. For instance, very fine colonies are often found growing a few feet only below low-water mark, on the iron pillars supporting the Promenade Pier within the Sound. Colonies of moderate size are also found, exposed at low water, on the Eddystone rocks, attached to the overhanging ledge beneath the remains of the old lighthouse, on the more sheltered side of the rock.

Two of the most important factors which determine the local distribution of the species would appear to be (1) the presence of suitable objects upon which it can fix, and (2) the absence of movements of the water strong enough to break the colony from its base or to overturn the object to which it is attached. Since the species can fix to rocks, to stones, or to shells, the first of these conditions is fulfilled upon all the grounds examined in the present investigation, for suitable shells at least are everywhere found, so that the second becomes of the more practical importance. A large colony of *Alcyonium* when fully expanded offers a very considerable surface to any movement of the water, and when such a colony is attached to a shell of the size of *Pecten opercularis* or *Cardium echinatum* (which are the shells to which the small colonies are generally attached on the grounds under investigation) a very slight movement will be sufficient to overturn it. At a depth of 30 to 35 fms. we are probably approaching the limit at which wave action is seriously felt on the sea-bottom in this portion of the Channel.* This diminution of wave action certainly seems a reasonable explanation of the facts observed in the distribution of *Alcyonium*, namely, that at depths less than 34 or 35 fms., although small colonies growing on shells are common, large colonies are seldom found attached to such objects, but large colonies do exist, at any rate in sheltered situations, fixed to rocks or solid structures: at depths greater than 34 or 35 fms., on the other hand, large colonies are plentiful attached to shells.

Distribution. *Geographical.* Bergen and Hardanger Fjords (Norman *fide* Hickson, No. 45, p. 352); Kattegat (Levinsen, No. 66); North Sea (Schulze, No. 105; Hartlaub, No. 38). British Coasts; Brittany (Pruvot, No. 98); Bay of Biscay (*Caudan*, No. 61).

Depth. Low-water to 312–383 fathoms (*Caudan*).

Sarcodictyon catenata (Chart I.). The red variety is found growing, sometimes in considerable quantity, on old shells (chiefly old and worn shells of *Lutraria elliptica* and *Pecten opercularis*), and is generally most numerous on clean shell gravel, though by no means confined to such ground. It was most regularly taken on the shell gravel west of the Eddystone (Ground XVI. and some hauls of XIV.). On Ground VII., south of the Eddystone, it was present in one haul only (haul 100), where it was very abundant, growing on a flat piece of red Trias stone. It was occasionally taken on Grounds X., XIII., XV., and IV. (haul 39 only), in the neighbourhood of the Eddystone, and was not unfrequent on the Bolt Head Shell Gravel and on the Prawle Stony Ground.

The species was not taken on the fine sand grounds, I., II., III., V., VI., and VIII.

Distribution. Shetland (Norman, No. 90); west coast of Scotland and Irish Sea (Herdman, No. 40, p. 319, and No. 41, Vol. IX.); Brittany and Mediterranean (Pruvot, No. 98).

On nullipore ground, on sand and shell, on shell sand and small gravel, on shells, stones, and echinoderm spines, and on stones and mud. 10–40 fathoms (Herdman, No. 41).

Gorgonia verrucosa (red variety, *G. Cavolini*, v. Koch) was taken only in haul 3, on the Prawle Stony Ground (XVIII.). The trawl had here been over a patch of rocky ground, and came up very much torn. The species is always obtained on rocky ground in this neighbourhood.

* See page 375, *ante*.

Distribution. *Gorgonia verrucosa* occurs in the Mediterranean (v. Koch, No. 59; Pruvot, No. 98; Marion, No. 74), on the coast of Brittany (Pruvot), and on the south-west coast of England. Johnston (*British Zoophytes*, No. 56) records it, on the authority of Dr. Walker and of Sowerby, from Scotland. There is a British Museum specimen said to be collected by Forbes in the Shetlands (*Cat. Brit. Rad. Animals*, p. 56). Herdman and Leslie (No. 43) think that the species does not occur in the fresh condition in the Firth of Forth, although dead pieces have been occasionally seen there. *Gorgonia verrucosa* is therefore clearly a southern species which is seldom met with in any locality north of the English Channel.

In the Mediterranean von Koch seems to have always found this species of *Gorgonia* attached to stones.

Caryophyllia Smithii (Chart I.) is found attached to shells and to stones on the gravel grounds in the neighbourhood of the Eddystone, on the Bolt Head Shell Gravel, and on the Prawle Stony Ground. On the Eddystone Gravels it is very commonly attached to old *Pecten maximus* shells. The barnacle, *Pyrgoma anglicum*, is generally associated with it.

The species is entirely absent from the fine sand grounds.

Distribution. *Geographical.* Shetlands (abundant, Norman, No. 90); west of Scotland (Hoyle, No. 52); south-west of Ireland (Haddon, No. 34); Devon and Cornwall; Brittany (Lacaze Duthier, No. 63); Azores (?) (*Challenger*, Moseley, No 89).

Leslie and Herdman (No. 43) do not record the species from the Firth of Forth. The *Pommerania* (Schulze, No. 105) found the dead skeleton only on the south coast of Norway, so that it appears to be absent from the North Sea. According to Lacaze Duthier (No. 63) the Mediterranean form, *C. clavus*, is a distinct species, and *C. Smithii* is not found in that sea.

Depth. 0–450 fathoms (*Challenger*, No. 89).

Habitat. On rocks, stones, and shells.

Epizoanthus incrustatus (Chart I.) was generally present on the outer trawling ground (II.), of which it is a characteristic species. It was taken twice (hauls 27 and 21) on the Bolt Head Shell Gravel. It was not present on the other grounds.

Distribution. *Geographical.* There is still considerable confusion as to the synonymy of this species. According to Haddon (No. 35) *E. incrustatus* (Düb. and Kor.) occurs on the east and west coasts of the North Atlantic, as far south as the English Channel and the Massachusetts coast. *E. arenaceus* (Delle Chiaje) he regards as a distinct species confined to the Mediterranean.

According to the same authority the species ranges in depth from shallow water to 906 fathoms.

Epizoanthus incrustatus occurs growing on shells, which are sometimes, but not always, inhabited by hermit crabs [*Anapagurus laevis* (Norman), *Eupagurus excavatus* (Haddon); *Eupagurus meticulosus* (Bourne, No. 11)].

Sagartia parasitica (Chart XII.) was always found associated with *Eupagurus Bernhardus*, but it is a curious fact that it was only taken on fine sand grounds (I., II., III., IV., V., and VII.), whilst the specimens of the hermit crab, which were not unfrequently taken on the gravels, were always without the anemone. I would not, however, suggest that this is at all a general rule.

Distribution. *Geographical.* A southern form, extending from the Mediterranean to the southern shores of the British Isles. Brittany (Pruvot, No. 98); southern part of

North Sea (*Pommerania*, No. 105); Red Sea (Gosse, No. 30). The species is not recorded from the Irish Sea (Herdman), nor from the Shetland Isles (Norman).

Habitat. Generally on shells inhabited by *Eupagurus Bernhardus.*

Adamsia palliata (Table VI.) occurs on both sand and gravel grounds in the neighbourhood of the Eddystone. It has never been dredged on the Bolt Head or Prawle Grounds. The anemone was always found associated with *Eupagurus Prideauxii.*

DISTRIBUTION. *Geographical. A. palliata* extends further north than *A. parasitica.* It is found in the Shetlands, on the west coast of Scotland, in the Irish Sea, south coast of Ireland (Gosse, No. 30); Brittany (Pruvot, No. 98); Mediterranean (Andres, No. 5).

Paraphellia expansa. Three or four specimens of this species have been obtained on the coarse gravel mixed with fine sand to the westward of the Eddystone (Grounds IX. and XI.). When taken, the anemones were not attached to anything, and appear to have been living buried in the sand.

DISTRIBUTION. *Paraphellia expansa* was first obtained by Haddon (No. 35) on the south-west coast of Ireland, and has since been recorded by Herdman (No. 40) in the Irish Sea. Holt (No. 48) and Haddon (No. 34) record it at depths of 14–40 fathoms on the Irish coast.

Chondractinia digitata was obtained on two grounds only, namely, the outer trawling ground (II.) and the fine sand ground south of the Eddystone (VI.). These are the two deepest fine sand grounds examined. In all cases the anemone was growing on *Cardium echinatum* shells, fixed to the smooth inner side of the shell.

DISTRIBUTION. *Geographical.* Finmark (*fide* Levinsen, No. 66); North Sea (Gosse, No. 30); Kattegat (Levinsen); Shetlands (Norman, No. 90); Cornish coast (Gosse); Bay of Biscay (Roule, No. 100, *Caudan*).

Depth. Deep water (Gosse). 98 fathoms (Roule).

Habitat. On shells of living *Buccinum* and *Tritonium* (Lütken). On *Fusus islandicus, F. berniciensis, F. norvegicus, Buccinopsis Dalei*, other common *Fusi*, and *Buccinum undatum* (Norman, No. 90). On *Fusus antiquus* in the Kattegat (Levinsen).

Corynactis viridis. Found in hauls 29 and 30 only on the Prawle Stony Ground (XVIII.), growing on large stones.

DISTRIBUTION. *Geographical.* South-west coasts of England, of Scotland, and of Ireland (Gosse, No. 30); Shetlands (Norman, No. 90); Irish Sea (Herdman, No. 40); Brittany (Pruvot, No. 98); Mediterranean (*fide* Carus, No. 14).

Depth. Shore to 100 fathoms (Peach, *fide* Norman).

Habitat. On rocks and stones.

ECHINODERMATA.

[*Nomenclature*:—F. Jeffrey Bell, *Catalogue of British Echinoderms, British Museum.*]

Holothuria nigra (Chart VI.) was taken in two hauls only (Nos. 10 and 99), both on the clean shell gravel immediately adjoining and west of the Eddystone rocks (Ground XVI.). Two or three specimens were dredged in each haul.

The species is found in abundance, in a very similar situation, by the side of the ledge of rock running westward from the Plymouth Mewstone. Near this ledge the bottom-deposit is clean shell gravel, and *H. nigra* is generally obtained by working a dredge or trawl over this gravel, keeping parallel to the ledge and close to it. We have found no other locality in the neighbourhood where any but very occasional specimens are taken.

A possible explanation of these facts is that the animal is really a rock-haunting species, but that owing to the tenacity with which it is able to cling it escapes capture on rocky ground by any of the methods of collecting ordinarily used. If this be the case the specimens taken on the shell gravel, as described above, must be regarded as immigrants from the neighbouring rocks.

Habits. In confinement *Holothuria nigra* shows its climbing habit by spending a great deal of its time clinging to the sides of the tank in which it is placed.

The nature of its food is indicated by the fact that when captured the intestine is filled with fine sand and silt containing diatoms and organic remains.

The habit of this species of using the sticky thread secreted by the Cuvierian organs as a means of defence is well known.

DISTRIBUTION. *Geographical.* Norman (No. 92) records the species from Plymouth, South Cornwall, south-west of Ireland, Naples (= H. Poli), Lesina (= H. catanensis), and Bay of Biscay. Bell (No. 7) records specimens from the west of Ireland, from Cornwall, and from Plymouth. Holt (No. 48, p. 280), Herdman (No. 40, Vol. V., p. 201), and Gamble (No. 26) all took *H. nigra* on the west coast of Ireland.

Depth. Herdman found the species between tide-marks, at Inishbofin, on the coast of Connemara, and Gamble in a similar situation at Valencia. The greatest recorded depth for the species is 30 fathoms (Bell, No. 7). In the Plymouth district it is taken in from 16 to 30 fathoms.

Bottom-deposit. Herdman's specimen was taken under a ledge of seaweed-covered rocks on the shore. Holt trawled specimens in 16 to 13 fathoms from a bottom described as sand and rock.

Astropecten irregularis (Chart VIII.). The distribution of this species on the Eddystone to Start Grounds is shown in Chart VIII. The species in this neighbourhood is a typical representative of a fine sandy bottom. It was found in greatest abundance on the clean sand (Ground III.) 3–4 miles E.N.E. of the Eddystone, where the proportion of silt was small (see Table II., p. 525). It was also constantly taken, though in somewhat smaller numbers, on the outer and inner trawling grounds (Grounds I. and II.), where the sand is finer and contains a larger percentage of silt (see Table II.).

But the species is not entirely confined to the fine sand. As will be seen from the chart, it is present, though rare, on the gravel and broken-shell grounds around the Eddystone (IX., XI., XIII., XIV., and XVI.), one or two specimens being taken occasionally on each of these grounds, though by no means in every haul. On the sand immediately outside these gravels (IV., VI., and VII.) the species is also rare.

On the Bolt Shell Gravel (XVII.) and on the Prawle Stony Ground (XVIII.) *Astropecten* has never been taken.

The presence of *Astropecten* on the gravel and broken-shell grounds around the Eddystone would appear to be a good illustration of the way in which the fauna of a particular ground may be influenced by the fauna of surrounding grounds (*cf.* p. 388). It will be seen from the chart that these gravels occupy a comparatively small area, which is almost entirely surrounded by grounds on which the bottom-deposit is composed of fine sand, which is the true home of the species. The few specimens taken on the gravel would therefore appear to be rather of the nature of immigrants from these surrounding grounds.

The Polynoid *Acholoe astericola* is almost invariably found associated with this species, living in its ambulacral groove.

Habits. *Astropecten irregularis* is specially adapted both for progressing rapidly over the surface of the sand and for burrowing beneath it. The conical pointed tube-feet are the organs by means of which both these movements are accomplished. From observation of the species in the aquarium it appears that a great part of its life is spent beneath the surface of the sand. The process of burrowing, which is executed by the rapid movement of the tube-feet, has the appearance of a vertical sinking in the sand. The species remains at rest for long periods, with the central portion of its disc raised in a tall conical protuberance, the apex of which projects above the surface of the sand. The formation of a similar protuberance was described by Cuénot (No. 17, p. 385, and No. 18, p. 55) in the two Mediterranean species, *Astropecten spinulosus* and *squamatus* [= *A. jonstoni* (Delle Chiaje)]. Sladen (No. 106) describes such prominences on the disc of several species of *Astropecten* taken by the *Challenger*, and the same author has described a similar but much more elongated and non-retractile prominence as a family character of the *Porcellanasteridae*.

The food of *Astropecten irregularis*, as of other species of the genus, consists largely of bivalve and Gasteropod molluscs, but small Echinoderms and Crustaceans are also eaten. I have myself found in the stomach of one specimen (haul 104) *Echinocyamus pusillus*, a fragment of *Hippolyte sp.* (?), and *Natica nitida*.

Forbes (No. 22) states that he has found *Venus cassina* in the stomach of this species, and that Ball found in one specimen nine *Natica Alderi* and a *Turritella terebra* (= *T. communis*).

Distribution. *Geographical.* *A. irregularis* has a northern distribution. It occurs off the coast of Norway, in the Kattegat, on all British Coasts, and off the west coast of France (Ludwig, No. 70, p. 15, note 1). It does not occur in the Mediterranean, the statements that it is found there made by several authors resting on a record of Marion's, which Ludwig (*l. c.*, p. 47 and p. 49, note) has shown to be based on a mistaken identification of the species *A. pentacanthus*, var. *serratus*. Studer (No. 108) states that *A. irregularis* was taken in the Gulf of Guinea in 59 fathoms. There is no other record, so far as I am aware, which confirms such a southerly extension of the species.

Depth. The species has a very considerable range of depth. Möbius and Bütschli (No.

88) record it once from 6 fathoms (east of Skagen), and Petersen (No. 95) found it frequently in the Kattegat at depths of 10 fathoms and beyond. He found it once (sta. 226) at a depth of 6½ fathoms, and again at 8½ (sta. 274), both localities being in the same region as that from which Möbius and Bütschli's specimens were obtained. In the North Sea and more open seas around the British Islands the records (Bell, No. 7; Möbius and Bütschli, No. 88; Meissner u. Collin, No. 76) seem to indicate that the species does not flourish in such shallow water as this, there being few less than 20 fathoms, the reason being, in all probability, that the amount of wave-disturbance is too great. At depths below 20 fathoms it is abundant in many localities, up to 500 or even 1000 fathoms (Green and Bell, No. 33; Sladen, No. 106).

Bottom-deposit. Forbes (No. 22) states that he always took *Astropecten irregularis* on sandy ground. From the *Pommerania* expedition (No. 88) it is most frequently recorded from a sandy bottom, occasionally from muddy sand. In the Kattegat (Petersen, No. 95) it is generally distributed upon sand and muddy sand, but is not found on the mud. Meissner and Collin (No. 76) appear to have found it in the North Sea in greatest numbers upon mud and muddy sand, in smaller numbers upon sand. Haddon (No. 34) took the species in the south-west of Ireland, on mud in 47 fathoms, and on coarse sand in 35–40 fathoms. The haul of the trawl at 1000 fathoms off the south-west coast of Ireland, in which *Astropecten irregularis* (*fide* Bell) was captured by Green, was made upon Globigerina-ooze, the trawl being full of this material when it arrived at the surface (No. 33). Koehler (No 61, *Caudan* expedition) obtained a number of specimens from a haul on mud. From these records it is clear that the species is abundant only on fine ground, though the exact meaning attached to the terms sand and mud by the different authors is too uncertain to make it possible to define accurately the kinds of deposit in which it is most numerous.

Luidia Sarsi (Chart VII.). Three specimens of this species only have been taken, one on the fine sand of the outer trawling ground (Ground II., haul 24), and two on the fine gravel west of the Eddystone (Ground XIV., hauls 36 and 73).

Food. Petersen (No. 95) found *Luidia Sarsi* in the Kattegat feeding upon ophiurids, the remains of these animals being taken from their stomachs. Ludwig (No. 70) is unable to give any definite information as to the food of *L. Sarsi*, but has brought together the observations which are known on the food of the allied form *L. ciliaris*, from the stomach of which the following species have been taken:—*Natica sp.* (by Ball), *Spatangus purpureus* (by Couch), *Ophioglypha* and *Echinocyamus pusillus* (by Ludwig). Cuénot (No. 18) states that at Roscoff the star-fish attacks the bait on hooks set for dog-fish.

DISTRIBUTION. *Geographical.* East Atlantic, from Norway (Throndhjemfjord) to Cape Verde Islands, and Mediterranean (*vide* Ludwig, No. 70).

Depth (*vide* Ludwig, p. 98). From 5 fathoms to 706 fathoms in the Mediterranean. On Atlantic Coasts the greatest recorded depth is 374 fathoms (Bell, No. 7, *Porcupine* Exp., Sta. 46).

Bottom-deposit. Ludwig (*l. c.*) states that the species prefers a muddy or sandy bottom, but that it is also found on coarser ground. *L. ciliaris*, on the other hand, is generally taken on hard ground (*l. c.*, p. 449). In the Kattegat Petersen (No. 95) found the species at a number of stations, generally on the mixed sand and mud deposits, occasionally on the mud. Koehler (No 61) took it in the Bay of Biscay (*Caudan* expedition) on gravel and sand, on gravel, and on mud.

Porania pulvillus (Chart VII.) was taken in considerable numbers (six or seven specimens in one haul of the otter-trawl) on the fine gravel to the west of the Eddystone (Ground XIV., hauls 36 and 73), one specimen was taken on the adjoining Ground X. (haul 42), and one on Ground IV. (haul 39).

Habits. No indication of a burrowing habit in this species has been observed, nor is it given to climbing when in confinement.

DISTRIBUTION. *Geographical.* Off the coasts of Scandinavia and Britain (Sladen, No. 106), off the west coast of France (Perrier, No. 94, and Koehler, No. 61).

Porania pulvillus is not mentioned by Möbius and Bütschli (No 88), or by Meissner and Collin (No. 76) in the North Sea, nor by Petersen (No. 95) in the Kattegat, and it does not appear to exist in these localities, its place being taken by *Hippasterias phrygiana.* It does not occur in the Mediterranean (Ludwig, No. 70).

Depth Herdman (No. 40, Vol. VIII., p. 19; Vol. IX., pp. 33 and 34) records specimens from 15 fathoms, 18 fathoms, and 20 fathoms, off the coast of the Isle of Man, and the species seems to be taken at all depths greater than this to 106 fathoms (*Porcupine* Expedition, Sladen, No. 106).

Bottom-deposit. Herdman gives the following records as to the nature of the bottom-deposit on which this species was taken off the coast of the Isle of Man :—On sandy mud, 33 fathoms (*Brissopsis lyrifer*, a typical mud-dwelling species was taken at the same time) [No. 40, Vol. VIII., p. 18]; on broken shell and small gravel, 15 fathoms, (Vol. VIII., p. 19); on "reamy" bottom [*i.e.*, sand and mud (?)], 20 fathoms (Vol. IX., p. 33); on dead shell, sand and shell, and echinoderm spines, 18 fathoms (p. 34); on stones and mud, 19 fathoms (p. 37); on sand, gravel, and shells, 34 fathoms (Vol. X., p. 39). The Prince of Monaco (No. 94) took the species at four stations off the west coast of France on fine sand (74–98 fathoms). The distribution of *Porania pulvillus* appears therefore not to depend directly upon the nature of the bottom-deposit.

Palmipes placenta (Chart VII.). *Palmipes* was taken in largest numbers on Ground V. (haul 90). This is a fine sand ground (see Table II. and compare with samples 91 and 92) containing a considerable admixture of medium sand, together with some coarse sand and gravel. It has, on the other hand, a somewhat high percentage of silt (7 %). In the haul of the otter-trawl made on this ground some ten very fine specimens were taken. The species was also very constantly taken on the sand ground south-west of the Eddystone (Ground VII.), though only one or two specimens were found in each haul of the dredge. It occurred in two hauls on the coarse gravel and sand north-west of the Eddystone (Ground XI., hauls 8 and 9), and single specimens were taken on the sand grounds VIII., III., and I. (haul 82).

DISTRIBUTION. *Geographical. Palmipes placenta* has a distinctly southern distribution. It occurs all over the Mediterranean, on the west coast of France, in the English Channel, all around the Irish Coasts, and on the west coasts of England and Scotland as far north as the Shetlands. Rare on the east coast of Scotland and on the coast of Belgium. Entirely absent from other portions of the North Sea and from the Kattegat (*vide* Ludwig, No. 70, p. 265).

Depth. In Mediterranean generally from 10-55 fathoms, occasionally 220 or 330 fathoms (*vide* Ludwig, p. 266). On British Coasts, from shallow water (seldom less than 10-15 fathoms) to 70 fathoms (Bourne, No. 11) and 100 fathoms (Sladen, No. 106).

Bottom-deposit. Ludwig (*l. c.*, p. 266) has brought together the records under this head. He shows that the species prefers hard ground to mud, and that it occurs both on gravel and on sand mixed with mud. Perrier (No. 94) gives a number of records of the species from fine sand in the Bay of Biscay.

Solaster papposus (Table VI.). This species was not generally abundant on any of the grounds. It was most numerous on Ground V. (haul 90), where the bottom was not very fine sand. There were also several specimens in haul 77 (Ground IV.). Single specimens were taken on many other grounds, both where the deposit was gravel and where it was fine sand.

Habits. *Solaster papposus* creeps on hard ground. Its food consists chiefly of molluscs, which appear to be generally digested outside the body by the everted stomach. Forbes (No. 22, p. 114) states that it frequents oyster and scallop banks, and that Thompson found *Cypraea* and *Turbo crassicor* in its stomach.

DISTRIBUTION. *Geographical.* A northern species, found in the Arctic Ocean and on both sides of the North Atlantic, as far south as Massachusetts and the French Coasts (*fide* Bell, No. 7).

Depth. From shore (Forbes) to 640 fathoms (Bell).

Bottom-deposit. In the Baltic Möbius (No. 86, p. 103) records *S. papposus* from a bottom of stones and sand. In the North Sea Möbius and Bütschli (No. 88) record it from stony ground and from mud ; Meissner and Collin (No. 76) from rocky ground and from sand and mud. In the Kattegat Petersen (No. 95) also found it on sand and mud and on rocky ground. Perrier (No. 94) records it off the coast of Newfoundland on pebbles (cailloux) at a depth of 82 fathoms. As in the case of many wandering echinoderms, the distribution of *S. papposus* does not appear to depend directly on the nature of the bottom-deposit, but rather on the presence of a suitable food-supply.

Henricia sanguinolenta (Chart VII.). The species is nowhere common on the grounds described in this report, generally not more than one, never more than two specimens having been found in one haul, and on each ground it has only been taken in one or two hauls out of the total of those made. The only points which seem to be suggested by its distribution here are that it avoids both the fine sand and the coarse gravel, occurring generally on those grounds which are intermediate in texture. It may be important also that the deposit contains little silt on those grounds upon which the species has been found. It was taken once only on the Prawle Stony Ground.

Habits. *H. sanguinolenta* does not burrow. The fact that its tube-feet are provided with large suckers would at first sight appear to indicate that it is a climbing species and specially adapted to hard and rocky ground. This conclusion is supported by observation of its behaviour in aquaria, and Forbes (No. 22) states that on the east coast he generally found it among rocks at low-water. On the other hand, the species is also found living upon clay (sandy, blue, and Biloculina) and on blue mud, at depths down to 1350 fathoms (Sladen, No. 106, p. 541).

DISTRIBUTION. *Geographical.* Both sides of the North Atlantic, Arctic Ocean, North Sea (Bell, No. 7 ; Sladen, No. 106). Not present in Mediterranean (Ludwig, No. 70).

Depth. Low-water (Forbes) to 1350 fathoms (*Challenger*, No. 106).

Bottom-deposit. Forbes (No. 22) and M'Intosh, among rocks at low-water. Möbius and Bütschli (No. 88, p. 148), on stony ground, on grey calcareous mud, on blue mud with some sand, and on coarse gravel. Möbius (No. 86), in the Baltic, 15–17 fathoms, stones, sand, and sea-weed. Petersen (No. 95), in Kattegat rare, on mixed deposits, chiefly in southern part. Herdman (No. 41, p. 319), Isle of Man, 15–25 fathoms, nullipore ground. Chadwick (No. 16), on the beach at Beaumaris, among roots of *Laminaria.* Holt (No. 48), on soft mud, corals, and weed, on coral and mud, on mud, sand, and stones, and on sand. Sladen (No. 106), on blue mud (1350 fathoms), on rock, on gravel and stones. Perrier (No. 94), on pebbles (cailloux) and on muddy sand. It appears, therefore, that the distribution of *H. sanguinolenta* does not depend directly, to any great degree, upon the nature of the bottom, but is probably influenced chiefly by the food-supply. As to the nature of this food-supply I am unable to give any information.

Asterias rubens (Chart VI.). This species has been taken on almost all the grounds, though it is very much more numerous on some than on others. Its distribution depends almost entirely upon the distribution of *Pecten opercularis,* as will be seen clearly from the tables. Owing to its gregarious habits *P. opercularis* is very much more abundant in some hauls made upon a particular ground than in others, and a study of the records of the individual hauls brings out the connection between the star-fish and the mollusc even more clearly than the summarised results given in Table VI.

Habits. A. rubens creeps on the surface of the sea-bottom, and appears to be almost independent of the nature of the bottom-deposit. It feeds very largely upon molluscs (Forbes, No. 22, p. 87), and on the grounds described in this paper almost entirely upon *Pecten opercularis.* I have directly observed the remains of *P. opercularis* in the mouth of the star-fish. An account of the method adopted by this and allied species in opening various kinds of molluscs has been given by Schiemenz (No. 104).

DISTRIBUTION. *Geographical.* Bell (No. 7) gives "Eastern side of North Atlantic (Senegal to Finmark), Japanese Seas. Presence in Arctic Ocean uncertain, in Mediterranean very doubtful." Ludwig (No 70) does not include *A. rubens* amongst Mediterranean species. It is generally distributed in the Kattegat (Petersen) and Baltic (Möbius).

Depth. 0–110 fathoms (Bell); to 337 fathoms (Möbius and Bütschli, No. 88).

Bottom-deposit. The species is recorded on grounds of every texture, from rocky ground to mud.

Asterias glacialis (Chart VI.). The distribution of *A. glacialis* on the Eddystone grounds is almost exactly the same as that of *A. rubens,* and, like that species, it is always most abundant in those places where *Pecten opercularis* is found in numbers. It is noteworthy, however, that *A. glacialis* was never taken in the hauls south of Bolt Head nor on the Prawle Point Ground. The most easterly station was haul 60 (three miles south-west of Bolt Tail). The importance of this point will be apparent when the geographical distribution of the species is discussed.

Habits. A. glacialis is similar in its habits to *A. rubens,* and, like that species, lives largely upon molluscs. It is perhaps rather more given to climbing than *A. rubens.* In addition to molluscs, *A. glacialis* feeds upon almost any animal which it can capture, as well as upon dead fish, etc. (Ludwig, No. 70). Cuénot (No. 18) found a specimen feeding upon *Portunus puber,* and in the aquarium at Plymouth a specimen was found eating *Polybius Henslowii.*

DISTRIBUTION. *Geographical.* The distribution of *Asterias glacialis* is discussed in detail by Ludwig (No. 70, p. 393). It is a southern species, common in the Mediterranean, and extending along the eastern shores of the Atlantic from Cape Verde Islands to Norway as far north as the coast of Finmark. Ludwig is doubtful as to whether the species really extends to Arctic Seas. A point of great interest in its distribution is its absence from the eastern portion of the English Channel, and from the southern and eastern part of the North Sea. "In the North Sea it is not known either on the east coast of England nor on the east coast of Scotland (Norman, 1865); it is also absent from the Belgian, Dutch, and German Coast, and the neighbouring islands. It is found, however, in the north-east part of the North Sea (Meissner and Collin) and between Scotland and Norway (Möbius and Bütschli). From there it extends into the Skager Rak as far as the Swedish Coast (Düben and Koren, M. Sars, Möbius), but is absent from the Kattegat and from the Baltic" (Ludwig, No. 70, p. 393). According to the same author the species is not found in the English Channel east of a line drawn from Plymouth to Cherbourg.

As was pointed out above, during the course of the present investigation *A. glacialis* was never once taken in the hauls south of Bolt Head nor in those made between Prawle and Start Points (in a total of 24 hauls), although it was quite common in the neighbourhood of the Eddystone. The most easterly station at which it was found was haul 60, three miles south-west of Bolt Tail. The depth was here 23–25 fathoms, and the bottom fine sand. Large specimens of *Asterias glacialis* are noted in my records as fairly plentiful, as were also *Asterias rubens*, *Solaster papposus*, and *Echinus esculentus*, and the haul was evidently made upon or close to a *Pecten* bed, as the presence of *P. opercularis* is recorded, and the shells of this species were taken in quantity.

It would almost seem, therefore, that there is a sharp line of demarcation in the distribution of *Asterias glacialis* in the neighbourhood of Bolt Head. Although it is true that *Pecten opercularis* was never abundant in any of the 24 hauls to the eastward of this line, it was present in several places, together with *Asterias rubens*, and there is no apparent reason why *A. glacialis* should not have been present as well. Indeed, one would rather have expected to find it on a ground such as the Prawle Stony Ground.*

Depth. 0 to 66 fathoms (Bell, No. 7) to 98 fathoms (Ludwig).

Bottom-deposit. A. glacialis is generally found on rocky and stony ground, but occurs also on sand. It is not, however, found upon mud (Ludwig).

Since on the grounds in the neighbourhood of the Eddystone both *Asterias glacialis* and *Asterias rubens* live side by side, under practically identical conditions, the following comparison of the general distribution of the two species, so far as at present known, is of interest:—

	Geographical.	*Depth.*	*Bottom-deposit.*
Asterias rubens.	Eastern side of N. Atlantic from Senegal to Finmark, including North Sea, Kattegat, and Baltic. Arctic Ocean (uncertain). In Japanese Seas. Absent from Mediterranean.	0–337 fathoms.	All kinds of bottom, from rocky and stony ground to mud.

* My colleague, Mr. Holt, who has done a good deal of dredging and trawling in Start Bay and Teignmouth Bay, tells me that the most easterly record he has of *A. glacialis* is of a few specimens four miles S.W. by W. of Bolt Head.

	Geographical.	*Depth.*	*Bottom-deposit.*
Asterias glacialis.	Eastern side of N. Atlantic from Cape Verde to Finmark. Not found in North Sea, Kattegat, and Baltic. Mediterranean, generally distributed. Arctic Ocean, probably absent.	0–98 fathoms.	Rocky and stony ground, and on sand. Never on mud.

Ophiura ciliaris (Chart VIII.). This species has been taken on all the grounds, with the exception of the Prawle Stony Ground (XVIII.) and the fine gravel ground (XV.) It was taken in greatest numbers in the hauls on the gravel and sand, north-west and west of the Eddystone (Grounds IX., XI., XII.), and was moderately abundant also on the fine sand of the trawling ground (I. and II.). On the other grounds one or two specimens only were taken in a haul.

Habits. *Ophiura ciliaris* is not a burrowing species, but is capable of moving with considerable rapidity over the surface of the sand or gravel. Hence its distribution does not depend so directly upon the texture of the bottom-deposit, as in the case of burrowing forms, when once the deposit is sufficiently firm to prevent it sinking, but is probably determined by the presence of a suitable food-supply. The only record I have found of the food of this species is one by the naturalists of the *Pommerania* expedition. Möbius (No. 88) states that Prof. Metzger took from the stomach of a specimen dredged in 9 fathoms a *Nephthys coeca*, which was still alive. In a specimen which I examined from haul 93 I found the remains of a small crustacean.

DISTRIBUTION. *Geographical.* Möbius and Bütschli (No. 88) give Norway, Kattegat, Great Britain, France, Mediterranean, and Madeira. A comparison of the distribution of this species with that of *O. albida* is made on p. 469, where the latter species is discussed.

Depth. Lyman (No. 71) gives the range 5 to 100 fathoms. In the Kattegat Petersen (No. 95) records it once (sta. 180) at $2\frac{1}{2}$ fathoms, once (sta. 47) at 3 fathoms, once at 6 fathoms (sta. 132), and it is common in many parts at greater depths to 70 fathoms (sta. 58). Hoyle (No. 52) records the species from 100 fathoms, off St. Kilda, and Koehler (No. 60, Monaco dredgings) from 136 fathoms in the Bay of Biscay.

Bottom-deposit. Forbes (No. 22) states that this species does not confine itself so much to sandy ground as *O. albida.* Möbius and Bütschli (No. 88) record it in the North Sea most frequently from fine grey sand, once only from blue mud with some sand. Meissner and Collin (No. 76) in the southern part of the North Sea found it on coarse sand with fine stones, on sand, on sand and mud, on sand and shell, and on mud. In the Kattegat (Petersen, No. 95) it occurs on sand and on sand with mud. It is only recorded once from the pure mud (sta. 46, depth 49 fathoms). Chadwick (No. 15) records it from a muddy bottom at 10 fathoms in the Menai Straits, associated with great numbers of *O. albida.* It is also recorded from fine sand and broken shell, and from sandy mud in the Irish Sea (No. 40, vol ix. p. 32). The Prince of Monaco obtained *O. ciliaris* in the Bay of Biscay at five stations, always on sandy ground (No. 60). Haddon (No. 34) found it off the south-west coast of Ireland in 44–47 fathoms on mud, and in 35–40 fathoms on coarse sand. Hoyle (No. 52) found it in Loch Sheildag in 67 fathoms on stiff grey mud.

Ophiura albida (Chart IX.). *O. albida* is much less numerous on the grounds investigated, as well as in the whole of the Plymouth district, than *O. ciliaris*, and its distribution is much more restricted. The only ground upon which it was found at all plentifully was the coarse gravel and fine sand ground (Ground IX.) to the west of the Eddystone. One or two specimens were generally taken on the fine gravel ground (XIV.) between the ground last mentioned and the Eddystone rocks, and several specimens were present on the gravel and mud ground (XIII.) south-east of the rocks. Single specimens were also met with on Grounds VIII., VI., and IV., as well as on the Bolt and Prawle Grounds. On the typical fine sand grounds (I., II., III., and V.) it was never met with, nor was it ever taken on the gravel and sand grounds north-west of the Eddystone (XI. and XII.), its absence being specially noteworthy in this case on account of the very close similarity in the composition of the bottom-deposits, as shown by the figures in Table II. (p. 525), of Ground XI. with that of Ground IX., upon which the species was numerous.

Habits. I know of no difference in the habits of this species and those of *O. ciliaris*, with the exception of the fact stated by Forbes (No. 22, p. 28), that it is less active in confinement than that species. Möbius (No. 88, p. 143) observed this species coil its arms around a living *Nereis diversicolor* and draw it into its mouth.

Distribution. *Geographical.* Möbius and Bütschli (No. 88) give Norway, Kattegat, W. Baltic, British Seas, Faröe, W. France, and Mediterranean. Bell (No. 7) adds to these the Arctic Ocean. Carus (No. 14) gives the Azores as one of the localities of the species, and the same locality is mentioned by Greeff (No. 32). On the whole, therefore, the range of *O. albida* appears to be about the same as that of *O. ciliaris*, with the exception of the northerly extension of the former to the Arctic Ocean. Forbes (No. 22) states that *O. albida* is more common than *O. ciliaris* in British Seas, and this certainly seems to be the case in the Irish Sea and in the North Sea. In the neighbourhood of Plymouth, as already explained, quite the reverse is true, *O. albida* being one of the rarer ophiurids, and very much restricted in distribution. Had *O. albida* been a distinctly northern form and *O. ciliaris* a southern one, it might have been supposed that the two species overlapped in this district, and that the southern form had almost but not completely replaced the northern one. The general distributions of the two species already given, however, makes such an explanation impossible. In this connection Forbes' statement, confirmed by Leslie and Herdman (No. 43), that *O ciliaris* is common at the mouth of the Firth of Forth, whilst it becomes scarce and is replaced by *O. albida* further up, is of interest.

Depth. Lyman (No. 71) gives the range from 5–250 fathoms, showing that the species goes lower than *O. ciliaris*, a fact which may be correlated with its extension to the Arctic Ocean, and due to its adaptation to a lower temperature.

Bottom-deposit. Forbes (No. 22) states that *O. albida* frequents oyster-beds and sandy places, and that it is more confined to the sand than *O. ciliaris.* Möbius and Bütschli (No. 88) record it in the North Sea generally from mud or sand, occasionally from gravel. They state definitely that it is a mud-dweller (p. 146, note under *Ophiocoma nigra*). Meissner and Collin (No. 76) record it also generally from fine sand or mud, occasionally from coarser ground. In the Kattegat Petersen (No. 95) took the species frequently on sand and muddy sand, seldom on the pure mud. For the Irish Sea Chadwick (No. 15) records it as plentiful with *O. ciliaris* on a muddy bottom at 10 fathoms in the Menai Straits. He also mentions it off Port Erin on gravel and stones, and south of Isle of Man (10–20 fathoms) on nullipore and gravel. Haddon (No. 34) found it off south-west coast of Ireland, with *O. ciliaris*, in 44–47 fathoms on mud. Hoyle (No. 52), on the other hand, on the west coast of Scotland, took it in 34 fathoms with a number of smooth, rounded pebbles, *Ebalia tuberosa*—a species invariably found on a coarse ground—being present in the same haul. It would thus seem that *O. albida* is found upon almost, if not quite, as extensive a variety of bottom-deposits as *O. ciliaris*, and its peculiar distribution in the Plymouth district, where it is never taken on the fine sand and is confined to coarse ground, is the more difficult of explanation.

Ophiura affinis. One specimen only on the Bolt Head Shell Gravel Ground (XVII., haul 28).

Habits. With reference to the animals of this species Hodge (No. 47) remarks upon "their excessively lively movements and the wonderful pliability of the rays."

DISTRIBUTION. *Geographical.* East and west coasts of North Atlantic and Mediterranean (*vide* Lyman, No. 71; Hoyle, No. 51; and Bell, No. 7).

Depth. 10–192 fathoms (Lyman and Bell), 267 and 294 fathoms (Möbius and Bütschli, No. 88).

Bottom-deposit. Möbius and Bütschli (*Pommerania*), on mud at 267 and 106 fathoms, on sand, on muddy sand, on sand and shell with small stones. Petersen (No. 95) found it in the Kattegat chiefly on sand and on sand and mud. Meissner and Collin (No. 76), on sand and mud, on coarse sand and stones, on mud and stones, on sand and shell, on mud, on fine dark sand, etc. It is evident that the species, like *O. ciliaris* and *O. albida*, lives on a great variety of grounds.

Ophiactis Balli (Chart IX.). This species is confined to the gravel and stony grounds. It is found hidden away in crevices between masses of *Chaetopterus* tubes, and in similar places. It is entirely absent from the sandy bottoms.

Habits. I can only confirm the statement of Norman (quoted by Bell, No. 7), viz., "it lives on hard ground, in deep water, and has a peculiar habit, delighting to nestle in hollows and crevices of stones, squeezing its disk and twisting its arms so as to conform to all the irregularities of the surface to which it attaches itself."

DISTRIBUTION. *Geographical.* Scandinavian and British Coasts (Hoyle, No. 51), Bay of Biscay (Koehler, Nos. 60 and 61).

Depth. The deepest record is 240 fathoms (Hoyle, No. 50).

Bottom-deposit. Sand and gravel (Hoyle, No. 50), hard ground (Norman). Koehler records it from the Monaco dredgings from 50–100 fathoms on coarse ground, and once from the *Caudan* on coral (*Lophohelia*) from 200–270 fathoms.

Ophiocoma nigra (Chart VIII.). The only ground amongst those investigated where *O. nigra* is at all common is the Prawle Stony Ground (XVIII). On the gravel north-west of the Eddystone a few specimens were taken in one haul only (No. 47), on Ground IX. Occasional specimens were found on the gravels west of the Eddystone (IX., X., XII., XIV., XVI.) and on the Bolt Head Shell Gravel (Ground XVII.). The species is entirely absent from the fine sand grounds.

Habits. Möbius and Bütschli (No. 88, p. 146) state that *O. nigra* is fond of climbing up the vertical walls of a vessel in which it is living, from which they conclude that the species climbs rocks. A similar habit of the species has often been noticed in the tanks in the Plymouth Laboratory. The authors mentioned record *O. nigra* from five of the stations dredged by the *Pommerania*, at four of which it was abundant, and the ground is described as stony, at one it was scarce, and the ground was white, granular sand rich in Foraminifera. As will be seen below, it is in such stony places that the species is generally numerous. It would seem, therefore, that its general habit is to climb about amongst stones. Petersen (No. 95, p. 47) states that the stomachs of his specimens were filled with mud (Bundmateriale), containing vegetable remains.

DISTRIBUTION. *Geographical.* *Ophiocoma nigra* is a northern species. It is found on all British Coasts, in Norway, Kattegat (rare, Petersen, No. 95), and Barent's Sea (*fide* Hoyle, No. 51). I have seen no record of it from more southern waters.

Depth. The greatest depth recorded is 87 fathoms (Hoyle, No. 50, p. 714).

Bottom-deposit. Möbius and Bütschli record *O. nigra* from stony places. Petersen found the species at five stations only in the Kattegat on gravel and stony grounds, stones being recorded from four of the stations. Hoyle's record from 87 fathoms was from a bottom of sand and shells, and the species was associated with large numbers of *Ophiopholis aculeata* and *Ophiothrix fragilis*. Herdman (No. 40, vol. viii., pp. 17 and 20) records it in the Irish Sea, once from shell sand and small gravel and twice from stony ground. In the summer of 1896 I obtained this species in exceptionally large numbers off the mouth of Fowey Harbour, a number of large stones being dredged at the same time.

Ophiothrix fragilis. The distribution of this species on the grounds investigated is shown on Chart VIII. It occurs in by far the greatest numbers on the coarse gravel grounds north-west and west of the Eddystone. It has already been pointed out in the description of Ground X. that *O. fragilis* occurs upon it in very large numbers, so much so that in some hauls (*e.g.*, 89 and 95) the dredge came up half full of specimens of the species, to the almost entire exclusion of any other form. The species is also very abundant on the mixed gravel and fine sand deposits to the north-west and west of this ground (IX., XI., XII.), as well as on the finer gravel between the latter grounds and the Eddystone (XIV.). It is also abundant on the mixed gravel and mud (XIII.) south-east of the Eddystone, a ground the fauna of which in many ways resembles that of the typical coarse gravel of Ground IX. On the fine sand grounds, on the other hand (I., II., III., etc.), *Ophiothrix fragilis* is very scarce, being generally only represented by a few small specimens, which cling about the roots of *Cellaria* or hydroids.

Habits. This is a creeping species which does not burrow. On the shore at low-water it is often found hidden under stones, and it is often seen clinging to stones, shells, and other solid objects brought up with the dredge. On those grounds where the species is found crowded together in large numbers, such as Ground X., the stomachs of the specimens examined have always been found to be filled with fine mud or silt, which, as explained on page 380, is full of organic matter of various kinds. In shallower water the species has been observed to feed on compound ascidians and other similar organisms. On an old bottle recently dredged in the Cattewater, covered with a compound ascidian (*Didemnid*), there were a number of specimens of *O. fragilis* obviously feeding upon the ascidian. I do not think that actively moving animals, such as Polychaetes and Crustaceans, upon which *Ophiura* feeds (see above, pp. 468 and 469), are captured by *O. fragilis*.

Petersen (No. 95) found in stomachs of this species Diatoms, Peridinidae, Polychaete setae, vegetable cells, etc., together with fine sand grains, which evidently means that they were feeding on the fine silt, as they do in this neighbourhood. The Polychaete setae would probably be from the faeces of some other animal.

Distribution. *Geographical.* Norway to Mediterranean (Möbius and Bütschli, Lyman, Bell).

Depth. Bell (No. 7) records a specimen from 767 fathoms and Hoyle (No. 50) one from 516 fathoms. Hence the species, according to our present knowledge, has a somewhat wide range, viz., from the shore to 767 fathoms. It must, however, be noted that both Bell and Hoyle mention the difficulty of distinguishing this species from the deep-water form *O. Luetkeni*, Wyv. Thoms.

Bottom-deposit. Forbes (No. 22) mentions *Ophiothrix fragilis* as being fond of rocky places, but rare in sandy localities. Möbius and Bütschli (No. 88) found it on stony ground in the fjords of Norway, on sand and gravel, and on muddy sand in the North Sea. Meissner and Collin (No. 76) found it very plentiful on mud and sand, on mud, and on fine sand with sandy mud and stones. (The last ground would probably be similar to the Eddystone Ground X, on which the species is so plentiful.) In the Kattegat Petersen (No. 95) found *O fragilis* chiefly on the mixed sand and mud. It was practically absent from the pure sand and from the pure mud. Chadwick (No. 15) records the species in great numbers off the southern shores of the Isle of Man in 10–20 fathoms on a bottom chiefly of nullipore and gravel.

Although these records are somewhat uncertain, owing to the difficulty of interpreting the exact meanings attached by the authors to the terms employed, they appear on the whole to indicate that when the species is found in very large numbers the bottom-deposit is a mixture of coarse gravel or sand with mud, similar to that upon which it is abundant in the neighbourhood of the Eddystone.

Echinus esculentus (Chart V.). Although present on most of the coarser grounds this species was nowhere very numerous, being represented by one or two specimens in a haul of the dredge and five or six in a haul of the otter-trawl. It was taken on all the gravel and shell grounds lying to the westward of the Eddystone, on Grounds IV. and XIII. to the eastward, and on the Bolt Head and Prawle Grounds. It is absent from all the fine sand grounds.

Habits. This is a wandering species, able to travel best upon hard ground. It is gregarious, large numbers being often found together. Its food is very various, and in confinement it will devour almost any dead animal matter. Specimens from moderate depths have the intestine filled with fine sand and silt, which is so common a form of food for Echinoderms. Professor MacBride informs me that in the estuary of the Clyde he has found the species on the shore, and that it there feeds upon red and brown sea-weeds.* In the Plymouth district it always occurs, so far as I am aware, at depths greater than 18 or 20 fathoms, where such sea-weeds do not grow. It is probable that the difference of distribution in the two districts is due to the very much greater effect of wave action in the neighbourhood of Plymouth than in the sheltered waters of the Clyde. Petersen (No. 95) found in the stomach of one specimen remains of Annelids, Barnacles, Polyzoa, Echinus spines, Ostracods, Algae and Hydroids, together with sand.

Distribution. *Geographical.* Eastern side of North Atlantic, North Sea, Mediterranean, Port Natal, and John Adam's Bank (Brazil) (*fide* Bell, No. 7).

Depth. From shore (Forbes) to 110 fathoms (Bell).

Bottom-deposit. Möbius and Bütschli (No. 88) record *Echinus esculentus* from stony and rocky ground (5–30 fathoms). Meissner and Collin (No. 76) give one record only, from a coarse bottom (*Riffgrund*). Petersen obtained it from rocky ground and from sand and mud. Chadwick (No. 15) records it from between tide-marks.

Echinus acutus (Chart V.). Like *E. esculentus* this species was never numerous, and its distribution coincided closely with that of the allied form. On the following grounds, however, upon which *E. esculentus* was taken, no specimens of *E. acutus* were obtained, viz., XVI., XII., XIII., and XVIII. On Ground VII. only one specimen was taken, in haul 54, and it was also represented in one haul only (34), on Ground IV. On Ground XVII. several specimens were obtained in haul 60. It was entirely absent from the sand. On the whole the species was most numerous on deposits made up of a mixture of gravel and muddy sand.

Distribution. *Geographical.* Atlantic from Norway and Halifax to Ascension, North Sea, Mediterranean, off Kermadec Island (*fide* Agassiz, No. 1, and Bell, No. 7).

Depth. To 1350 fathoms [Agassiz]. There is no evidence that the species is ever found between tide-marks. From Koehler's records (*Caudan*, No. 61) it is clear that this is one of the commonest Echinoids at depths of from 80 to 400 fathoms in the Bay of Biscay.

* Compare M'Intosh, *Marine Invertebrates and Fishes of St. Andrews*, p. 95.

Bottom-deposit. Möbius and Bütschli (No. 88) record *E. acutus* on stones and mud (0–50 fathoms) and on sand and shell (48–50 fathoms), and Agassiz (*Challenger*) on coral bottom (425 fathoms), on rock (630 fathoms), and on mud (1350 fathoms). Bell (No. 8) records the species from 55 fathoms, 110 fathoms, and 500 fathoms from Green's *Trawling Cruise*. 500 fathoms is apparently Green's Station VII. (No. 33), where the trawl brought up "one large boulder weighing about 100 lbs., and several smaller ones, subangular and resembling those of the Boulder Clay." Koehler gives a number of records from both Monaco (No. 60) and *Caudan* (No. 61) dredgings in the Bay of Biscay, the species being taken on rock and gravel, on coral, on sand and muddy sand, and several times on mud (80–400 fathoms).

A question of some interest is raised by the distribution of the two species *Echinus esculentus* and *Echinus acutus* in the Plymouth district, which forms a good instance of a phenomenon very frequently met with. We here find two species of very similar structure, yet at the same time showing perfectly definite and constant difference in structure, living side by side upon the same grounds under what seem to be the same conditions, and having apparently exactly similar habits. The one species (in this case *Echinus esculentus*) is very numerous, whilst the other is much less so. The questions are often asked, how have these differences of structure been brought about and what purpose do they serve? Does the slight difference of structure in the less numerous species correspond to some slight difference of habit? or if this is not the case, how does it come to pass that the one species, being apparently less successfully adapted to the prevailing conditions than its more numerous competitor, survives at all?

In the present case it is, I think, possible to give a satisfactory answer to these questions, based on a consideration of the distribution of the two species.

From the records given above it is clear that *Echinus esculentus* is essentially a shallow-water species, which may be found on the shore or down to depths of 100 fathoms. It is most numerous in the laminarian and coralline zones. *Echinus acutus*, on the other hand, is essentially a deep-water species extending to a depth of over 1000 fathoms, and apparently most numerous from 50 to 500 fathoms. If we compare the essential differences of structure we see that each species is specially adapted to the conditions prevailing where it is most numerous, or as we may express it, the conditions prevailing at its centre of distribution. These differences of structure depend chiefly on the fact that whilst *Echinus acutus* is protected by a comparatively small number of very long spines, *E. esculentus* carries a large number of short and stout ones, the latter condition being obviously more advantageous in shallow water, where wave action is often violent, whilst it is not difficult to imagine that the former, viz., a few very long spines, is of greater value in deep water, where there is never any disturbance. Each species must be regarded, therefore, as being specially adapted to the conditions prevailing at its own centre of distribution, and it is at that centre ("centre of creation" of the older writers) that the characters of the species are kept true. In a case like the present, where the centres of distribution of two species of similar habit but slightly different structure are contiguous and the two areas quite continuous, there will be an intermediate region occupied by the two species in about equal numbers, whilst a few specimens of one species may extend quite to the centre of distribution of the other and be found living side by side with their now better adapted rivals. They survive because they are in continuous contact with, and are constantly recruited from, their own centre of distribution, where the characters of the species are kept true. *Echinus acutus* is found living in small numbers side by side with the numerous *Echinus esculentus* in the Plymouth district, because that district is sufficiently near to a deep-sea area where *Echinus acutus* is abundant, and to the conditions of which it is specially adapted. Should this communication in any way be cut off, the species would, in all probability, die out in the district.

Echinus miliaris. Chart V. Present upon practically all grounds. It appeared to be relatively most abundant on Grounds XVI. and XVII., both of which are clean shell gravel. On sandy grounds the species is generally found clinging to shells, hydroids, etc.

Habits. A wandering species inhabiting all kinds of grounds. On fine sand generally found attached to hydroids, shells, etc. It has a curious habit of attaching to itself, by means of its tube-feet, bits of shell, small stones, sea-weed, etc., in such a way that it becomes practically hidden by these objects. It lives on food of almost any kind, animal and vegetable, and does great damage on oyster-banks. A small specimen of this species was kept alive in the Laboratory in a shallow dish of sea-water for many months, being fed upon pieces of red seaweed, which it would eat in large quantities.

DISTRIBUTION. *Geographical.* Northwards to Iceland and southwards to the Mediterranean, North Sea (*fide* Bell, No. 7), Kattegat (Petersen, No. 95), Baltic (Möbius, No. 86).

Depth. From shore to 50 fathoms (Möbius and Bütschli, No. 88).

Bottom-deposit. Forbes (No. 22) records *E. miliaris* as common on oyster-beds and scallop-banks. Möbius and Bütschli found it on stony ground, on shelly ground, on sand, and on mud; Meissner and Collin (No. 76) generally on coarse ground, occasionally on sand and sandy mud.

It is evident that the nature of the bottom-deposit in itself is of no great importance to this species.

Echinocyamus pusillus. On account of the small size of *Echinocyamus*, much importance cannot be attached to the results of the dredgings as furnishing a knowledge of its distribution. It seems to be found most frequently upon coarse ground, especially upon clean shell gravel (*e.g.*, Grounds XVI. and XVII.).

DISTRIBUTION. *Geographical.* Both sides of North Atlantic, Norway, Iceland, Mediterranean, Azores, Florida, Caribbean Islands, North Brazil (A. Agassiz, No. 1).

Depth. Between tide-marks (Forbes, No. 22) to 805 fathoms (A. Agassiz, No. 1).

Bottom-deposit. Möbius and Bütschli (No. 88) record *Echinocyamus pusillus* from stony ground, from shell and sand, and from sand and mud. Meissner and Collin (No. 76) found it at a great number of stations, and apparently upon all kinds of bottom from rough ground to mud. Petersen (No. 95) in the Kattegat took it generally on sand, occasionally on the mixed ground (sand and mud). He found plant remains, diatoms, and foraminifera in the stomach. Herdman (No. 40) records it from nullipore bottom and from shell sand. It thus appears that the species can live under a great variety of conditions as regards the nature of the bottom-deposit.

Spatangus purpureus. Chart V. This, being a burrowing species, is much more restricted in its distribution by the texture of the bottom-deposit than those urchins, such as *Echinus esculentus*, which have a wandering habit. On the grounds examined during the present investigation it is almost entirely confined to clean shell gravel and fine clean gravel. It was most abundant and the specimens were largest on the shell gravel ground south of Bolt Head (Ground XVII.). Next to this ground it was most numerous on the clean shell gravel west of the Eddystone (Ground XVI.) and on the fine gravel just outside this (Ground XIV.), on both of which grounds it was frequently taken. Occasional specimens were found on Grounds VII., VIII., and X., the grounds immediately adjoining the two last-mentioned, and also on the Prawle Stony Ground (XVIII., hauls 45, 63, and 29). The species was never taken on the fine sand nor on the coarse gravel. The bivalve mollusc, *Montacuta substriata*, was generally found attached to the spines of *Spatangus*.

Habits. The way in which *Spatangus* burrows by means of its short, flat bristles was described by Osler in 1826 (*Phil. Trans. Roy. Soc.*, 1826, p. 347). The animal is able to sink almost vertically in the gravel in which it lives, and when half buried, at any rate, can progress forwards through the gravel, leaving a deep furrow behind it. The intestine is generally found to be filled with fine sand and silt (*cf.* Möbius and Bütschli, Petersen).

DISTRIBUTION. *Geographical.* East side of the Atlantic from the Azores to Iceland, North Sea, Mediterranean, Bermuda (*fide* Bell, No. 7).

Depth. 5–530 fathoms (*fide* Bell).

Bottom-deposit. Forbes (No. 22) found *S. purpureus* abundant on scallop-banks off the Isle of Man, generally on the cleanest part of the bank amongst the scallops. Möbius and Bütschli (No. 88) record it on fine sand, on shell and small stones, on coarse gravel, and on sand ; frequent only on the fine sand. Meissner and Collin (No. 76) give seven records, all from coarse ground, viz., on coarse sand and gravel, on shell and small stones, on shell, on stones and coarse sand, on shell and stones, and on coarse sand and stones. Petersen (No. 95) found it in the Kattegat at eight stations, at six of which the bottom-deposit was coarse sand or gravel. Once he records it from 15½ fathoms on sand with a little mud (sta. 437), and once from 70 fathoms on mud and fine sand (sta. 58). Haddon (No. 34) found it on coarse sand at the mouth of Bantry Bay. Bourne (No. 11) on fine sand in 200 fathoms. From the Liverpool district (No. 41, p. 137 ; No. 40, Vol. VIII., p. 20 ; Vol. IX., pp. 34 and 37) it is noted on muddy gravel near Beaumaris, on shells, stones, and echinoderm spines, on dead shells, shell sand, and echinoderm spines, and on "reamy" bottom.

From the above records it is clear that *Spatangus purpureus* lives most frequently in gravel and shell gravel, or in coarse sand, though it is not possible to judge from the great variety in the nomenclature used by the various authors exactly what texture it is intended to indicate. There seems no doubt, on the other hand, that the species may, under certain circumstances, be taken on fine sand and mud, and it will be important to notice in future what exactly are the conditions under which this occurs. Especially it should be discovered, if possible, whether such muddy or sandy grounds adjoin a coarse ground upon which the species is abundant.

Echinocardium cordatum. Chart V. Occasional specimens only of this species have been taken, which may to some extent be due to the fact that the trawl and not the dredge was generally used on fine sand grounds. As the species can bury deeply in the sand, it would not be likely to be captured in this way.

Single specimens were, however, found on the inner and outer fine sand trawling grounds (I. and II., hauls 51 and 104), on Ground VII., haul 76 (sand), and on Ground XV., haul 97 (fine gravel). All the specimens were of a dull white colour, and not bright yellow like those generally taken between tide-marks.

Habits. The habits of this species are similar to those of *Spatangus purpureus*, excepting that it burrows in fine sand, and judging from the situations in which it is found between tide-marks, burrows to greater depths.

Distribution. *Geographical.* Both sides of the Atlantic from Norway to Spain and S. Carolina to Bahia. North Sea, Mediterranean (*fide* Bell, No. 7).

Depth. 0–85 fathoms (Bell, Agassiz, No. 1).

Bottom-deposit. Forbes states that the species abounds in sandy bays, and after storms great numbers are cast on shore. All the authors (Möbius and Bütschli, Meissner and Collin, Herdman, Petersen) record the species from fine sand and muddy sand only, to which it is rigidly confined.

The three heart urchins, *Spatangus purpureus*, *Echinocardium cordatum*, and *Brissopsis lyrifera*, form a good example of the fact that burrowing species are very much restricted by the texture of the deposit in which they dwell. *Brissopsis lyrifera* is as rigidly confined to mud as *Echinocardium cordatum* is to fine sand, whilst *Spatangus purpureus* is almost invariably found upon deposits of coarser texture. This was recognised by Forbes when he proposed for the three genera the English names Bank-Urchin, Mud-Urchin, and Sand-Urchin (No. 22, p. 183).

Polychaeta.

[*Nomenclature:*—Generally that of Saint-Joseph (Nos. 101 and 102).]

The Polychaetes of the earlier hauls were identified by Mr. T. V. Hodgson, those of the later ones by Professor Weldon. The responsibility for the statement that a species occurs upon a particular ground is in all cases my own. Owing to the fact that I was only acquainted with a few of the more common forms at the time when the dredgings were in progress, the information as to the relative abundance of each on the different grounds is less definite and reliable than that given for other groups. Several species are represented by one or two specimens only, but it is probable that if the material had been examined on board the boat at the time it was dredged by someone with a knowledge of them, other specimens would have been found. In all such cases it may, however, be taken for granted that the worm was nowhere abundant.

For geographical distribution I have relied largely on the lists given by Saint-Joseph (Nos. 102 and 103) and by Michaelsen (No. 79).

Polygordius sp. (Chart X.). An undetermined species of *Polygordius* was abundant on the clean shell gravel of the Bolt Head Ground (XVII.), where it formed a characteristic feature of the fauna. The same species was also found in much smaller numbers on the clean shell gravel immediately to the west of the Eddystone reef (XVI.).

Euphrosyne foliosa. Obtained once only on the fine gravel of Ground XIV., west of the Eddystone, in haul 85.

Distribution. *Geographical.* A southern species. Mediterranean, west of France, English Channel (Saint-Joseph, No. 102), Channel Islands to Shetland, especially on west of Great Britain and Ireland (M'Intosh, No. 84). Apparently not in the North Sea, where the northern species, *E. borealis*, Oerst., takes its place.

Depth. To 344 fathoms (*Pola* expedition, *fide* Saint-Joseph).

Aphrodite aculeata (Chart X.). This species was most abundant on the fine sand of Ground V., to the north of the Eddystone, where seven specimens were obtained in one haul of the otter-trawl. One or two specimens were taken on the neighbouring fine sand grounds III. and IV., but the species was never found elsewhere.

Habits. *Aphrodite* buries itself in the sand, but probably not to any considerable depth. In confinement it is seen travelling rapidly at the surface of the sand, leaving deep furrows behind it.

Distribution. *Geographical.* Iceland, United States (Verrill), Faröe, Norway, British Coasts, Mediterranean, Red Sea (*fide* Michaelsen, No. 79, and Saint-Joseph, No. 102).

Depth. Shore (Saint-Joseph) to 530 fathoms (*Knight Errant*), 257 fathoms and 690 fathoms (*Porcupine*, M'Intosh, No. 82).

Bottom-deposit. All the authors record the species from sandy or muddy ground, never from gravel or coarse ground (Möbius, No. 87; Hansen, No. 36; Michaelsen, No. 79; Haddon, No. 34; Hornell, No. 49).

Hermione hystrix. Single specimens were obtained on the coarse gravel of Grounds IX. and X., in hauls 93 and 42 only. The species in the Plymouth district is generally met with on coarse grounds, and has never been found to be abundant.

DISTRIBUTION. *Geographical.* Pas-de-Calais, North Sea, Channel, Atlantic, Mediterranean (Saint-Joseph, No. 102). The *Challenger* obtained two small specimens at Cape Verde Islands (M'Intosh, No. 85) Irish Sea (Hornell, No. 49). *Hermione hystrix* is a distinctly southern species. Claparède and Marion and Bobretzky (No. 73) state that it is extremely abundant in the Mediterranean. According to Malmgren (No. 72) and Michaelsen (No. 79), the corresponding northern species appears to be *Laetmonice filicornis*, Kinberg.

Depth. Occasionally on the shore under stones in the Mediterranean (Marion and Bobretzky); 40–80 fathoms (*Porcupine*, off Algiers, M'Intosh, No. 82).

Bottom-deposit. Hornell states that in the Irish Sea this species is found on shell débris, gravel, etc., never on purely sandy or muddy deposits, which agrees with the distribution found in the Plymouth district. Marion and Bobretzky say that in the Gulf of Marseilles it is especially abundant on zostera beds.

Lepidonotus squamatus (Table VI.) is found occasionally upon grounds of all kinds, but is more numerous on the gravels to the westward of the Eddystone than elsewhere. On Ground IX. (haul 93) it was very abundant.

DISTRIBUTION. A northern species. Coast of Virginia (Verrill), Iceland, Faröe, Norway, England, north-west France (*fide* Michaelsen, No. 79). The *Challenger* dredged one small specimen at the Azores in 450 fathoms, on a bottom of volcanic mud, which M'Intosh (No. 85) refers to this species. The *Porcupine* (No. 82) obtained *Lepidonotus squamatus* on a stony and muddy bottom at 30–40 fathoms off Dingle Bay. Hornell (No. 49) found it most abundant in the Irish Sea in 18 to 20 fathoms.

Eunoe nodosa (Table VI.). One specimen taken in haul 45 on the Prawle Stony Ground (XVIII.) was identified by Prof. Weldon.

DISTRIBUTION. East of North America, Greenland, Iceland, Spitzbergen, Nova Zembla, Kara Sea, Siberia, Norway, Shetland, England, north-west of France, English Channel (*fide* Michaelsen, No. 79).

Lagisca propinqua (Table VI.) is an abundant species, taken both on the fine sand and on the gravel grounds.

DISTRIBUTION. *L. propinqua* has a wide range both in its geographical and bathymetric distribution. It is found on the United States Coasts, Faröe, Shetland, south-east of Scotland, and at Madeira (*fide* Michaelsen, No. 79). It was obtained by the *Knight Errant* in the Faröe Channel, at a depth of 515 fathoms, on a bottom of ooze (No. 85). The *Caudan* took it at three stations in the Bay of Biscay, on coral and mud and on mud, at depths from 355 to 930 fathoms (Roule, No. 101). Hornell found it constant and abundant in the Liverpool district, beneath stones and in rock cavities from mid-tide to 57 fathoms (No. 49).

Lagisca rarispina (Table VI.) was identified by Prof. Weldon in haul 92 on the fine sand Ground I., and in haul 70 on the fine sand Ground VII.

DISTRIBUTION. An Arctic species East of North America, Greenland, Iceland, Siberia, Nova Zembla, Kara Sea, North-West Norway, North of England (*fide* Michaelsen, No. 79). In the North Sea it was taken on bottoms of mud and muddy sand, at depths from 20–24 fathoms, being sometimes abundant (Michaelsen, No. 79). The Norwegian North Atlantic expedition obtained it at a depth of 160 fathoms, on a bottom of grey clay (Hansen, No. 36).

Harmithoe imbricata (Table VI.). Occasional specimens on the fine sand Grounds III. and VII., and on the clean shell gravel of Ground XVI.

Distribution. *Geographical.* East of North America, Greenland, Iceland, Faröe, Spitzbergen, Nova Zembla, Kara Sea, Siberia, South Japan, Norway, Scotland, England, Ireland, north and west of France, Spain [*fide* Michaelsen, No. 79].

Depth and Bottom-deposit. This is a common species between tide-marks, where it is found under stones [Shetlands, Irish Sea, North Sea, Dinard, Plymouth]. The *Valorous* expedition [No 83] obtained it in 20 fathoms (shell sand), 60 fathoms (sand and shell), and 80 fathoms off the coast of Greenland; the *Porcupine* (No. 82) at 60–160 fathoms, east of Cape Gatte; the Norwegian North Atlantic expedition [Hansen, No. 36] at depths of from 35 to 127 fathoms (clay); and the *Caudan* [Roule, 101] in the Bay of Biscay at 98 fathoms on gravel and sand, and at 219 fathoms on mud.

Evarne impar (Table VI.). Specimens were obtained on the fine sand of Grounds I. and VII., on the fine gravel of Ground XIV., to the west of the Eddystone, and on the Prawle Stony Ground. The species was nowhere numerous.

Distribution. Davis Straits (M'Intosh, *Valorous*, No. 83), Iceland, Shetland, North Norway, British Coasts, North France (*fide* Michaelsen). Outside Gibraltar (358 fathoms, M'Intosh, *Porcupine*). Shore (Saint-Joseph, No. 102, and Hornell, No. 49) to 567 fathoms (*Porcupine*, No. 82).

Polynoe scolopendrina. Mr. Hodgson has identified a single specimen of this species in haul 54 on the fine sand of Ground VII.

Distribution. M'Intosh (No. 84) states that the species occurs from Shetland to the Channel Islands, generally in tubes of *Terebella nebulosa*, and that it is abundant on the shore in the Hebrides (No. 81). Saint-Joseph (No. 102) found it on the shore and also in deeper water at Dinard. Irish Sea (Hornell). Adriatic, Trieste, Egypt (*fide* Carus, No. 14).

Halosydna gelatinosa. A single specimen on the typical coarse gravel, Ground IX. (haul 93). The species is not unfrequently taken in the Plymouth district in shallower water. It occurs on the shore at low-water.

Distribution. West Norway, British Coasts, North-West France, west of Morocco (*fide* Michaelsen, No. 79). Hornell (No. 49) records it from the shore at Puffin Island (Irish Sea).

Hermadion assimile. A single specimen in haul 92 on the fine sand of the inner trawling ground (Ground I.).

Distribution. M'Intosh (No. 84) records the species from St. Andrews and from the *Porcupine* dredgings off the west of Ireland, south of England, and Spanish coast. Hornell (No. 49) took it in the Irish Sea in depths of 11 and 21 fathoms amongst the spines of *Echinus esculentus*.

Acholoe astericola is by no means uncommon in the ambulacral groove of *Astropecten irregularis.* Its occurrence is incompletely recorded in Table VI.

Distribution. Hornell (No. 49) gives the distribution from the Mediterranean to Galway. Marenzeller found it in the Mediterranean on *Astropecten aurantiacus*, on *A. bispinosus*, *A. platyacanthus*, and *A. pentacanthus*.

Hyalinoecia tubicola. Chart X. This species is abundant on the coarse gravel mixed with sand and mud in the neighbourhood of the Eddystone, where it forms one of the typical and characteristic features of the fauna. It is specially numerous on Ground IX., which exhibits the coarse gravel fauna in its purest form, and is still plentiful on the gravel of the adjoining Ground XI. It was also taken in several hauls on the *Ophiothrix fragilis* Ground (X.). On the coarse gravel and mud of Ground XIII., south-west of the Eddystone, the fauna of which resembles in most of its features that of Ground IX., *Hyalinoecia* was also abundant. A few specimens were taken on the fine sand grounds adjoining the coarse Eddystone Grounds (III., IV., VII., and VIII.). On the remaining fine sand grounds and on the fine gravels and clean shell gravels the species was entirely absent, nor was it taken on the Prawle Stony Ground.

Habits. What are the habits of *Hyalinoecia tubicola* in the natural state I am unable to say. In confinement it does not burrow, but is capable of somewhat rapid locomotion over the surface of a gravel bottom. The movement is effected by protruding the head and anterior portion of the body from the tube for a distance of about an inch in specimens of the ordinary size, holding to the gravel by the appendages of the most anterior segments and drawing the tube along, the body being bent sharply at right angles at the point where it emerges from the tube. The head is then thrown forward, attached again to the gravel, and the previous movement repeated.

DISTRIBUTION. *Geographical.* North and West Norway, Kattegat, North Sea, British Isles, English Channel, west of France, Mediterranean, Madeira (*fide* Saint-Joseph, No. 102, and Michaelsen, No. 79). The *Challenger* obtained *Hyalinoecia tubicola* at the Azores (50–90 fathoms), and one small, dried specimen from the south of Japan (565 fathoms) is also referred to this species (M'Intosh, No. 85).

Bottom-deposit and Depth. In the Irish Sea the species is taken on pure mud at depths of from 40 to 80 fathoms, where it constitutes one of the characteristic features of the fauna (Herdman, No. 40, Vol. VIII., p. 18; Vol. IX., p. 53). In the Skagerack and Kattegat it also occurs on deposits of pure mud (Levinsen, No. 66). Off the south-west coast of Ireland, Haddon, on the other hand, found it on coarse sand (35–40 fathoms) and on sand (110 fathoms) (Haddon, No. 34). The *Challenger* specimens off the Azores were on volcanic mud (50–90 fathoms), and the one small specimen off the south of Japan was on green mud (565 fathoms). The *Caudan* found *H. tubicola* abundant at 98 fathoms at two stations on gravel and sand, and also at 137 fathoms at one station on mud.

From the above records, combined with my own from the Eddystone Grounds, it would seem that *Hyalinoecia tubicola* is equally at home on pure mud and on gravels mixed with sand and mud. It is probable, however, that further knowledge of its habits and distribution will show that its real centre of distribution is on deposits of one only of these kinds, and that those occurring in deposits of the other kind must be regarded as outlying individuals, which have extended to grounds where the conditions are still such that they can exist, though not such as those to which they are most perfectly adapted.

Lumbriconereis. A large and a small species, which have not been certainly identified, were occasionally taken (see Table VI., p. 531).

Nereis fucata. This species is very frequently met with in *Buccinum undatum* shells inhabited by *Eupagurus Bernhardus.* The actual number of records is not great, as in only a few cases in the hauls made during this particular investigation were the shells opened to seek the worm.

DISTRIBUTION. North America, Great Britain, France (*fide* Michaelsen, No. 79). Generally in *Buccinum* or *Fusus* shells inhabited by *Eupagurus Bernhardus* (Michaelsen, Saint-Joseph, Hornell). Hornell (No. 49) found the worm in ninety per cent. of the shells inhabited by *E. Bernhardus.* He also sometimes took it free.

Nereis procera. Not uncommon on the fine sand grounds, especially on Grounds II., III., VI., and VII. It also was taken on the coarse gravel and fine sand north-west of the Eddystone (Ground XI.) and on the Bolt Head Shell Gravel (Ground XVII.).

DISTRIBUTION. Gulf of Georgia (Ehlers), Madeira (Langerhans), Dinard (Saint-Joseph).

Typosyllis alternosetosa. Several specimens identified by Professor Weldon in hauls 101 and 102 on the fine sand of Ground VI., south of the Eddystone.

DISTRIBUTION. This species has been recorded only from the north coast of France by Saint-Joseph (No. 102).

Ehlersia cornuta. One specimen in haul 87 on Ground XVI.

DISTRIBUTION. Norway, Spitzbergen, Atlantic, Madeira, Mediterranean [*fide* Carus, No. 14].

Eulalia viridis. Identified by Mr. Hodgson in haul 54 on Ground VII.

DISTRIBUTION. Behring Straits, North Sea, Channel, Atlantic, Mediterranean (*fide* Saint-Joseph, No. 102). Kattegat (Levinsen). Michaelsen (No. 79) took it in the North Sea on both coarse and fine grounds (1–44 fathoms). M'Intosh (No. 81) records it from the shore at Shetland, and the *Pommerania* obtained it amongst stones and algae in 4 fathoms (Möbius, No. 87). Common on shore at Plymouth.

Amblyosyllis spectabilis. In haul 27 only on the Bolt Head Shell Gravel (Ground XVII.).

DISTRIBUTION. English Channel.

Polydora caeca. Several specimens in haul 101 on the fine sand south of the Eddystone (Ground VI.).

DISTRIBUTION. Northern Oceans, Mediterranean? [*fide* Saint-Joseph].

Nephthys Hombergii. In haul 91 on the fine sand of Ground III.

DISTRIBUTION. Nova Zembla, Kara Sea, Norway, Faröe, England, France, Madeira, Mediterranean [*fide* Michaelsen, No. 79].

Depth and Bottom-deposit. Saint-Joseph (No. 102) obtained this species at Dinard on the shore only; Hornell (No. 49) in the Irish Sea, common from the shore to 22 fathoms. The Norwegian North Atlantic expedition took it at 142, 148, and 263 fathoms on mud (*clay*) (Hansen, No. 36), and the *Caudan* in the Bay of Biscay on mud at 160 to 220 fathoms and at 98 fathoms (Roule, No. 101).

Glycera convoluta was obtained on the clean shell gravel immediately to the west of the Eddystone rocks (Ground XVI.), where it was a characteristic feature of the fauna. Specimens of *Glycera,* almost certainly referable to this species, were also taken on the Bolt Head Shell Gravel (XVII).

DISTRIBUTION. Channel, Atlantic, Mediterranean (*fide* Saint-Joseph, No. 102). The *Caudan* dredged one specimen in the Bay of Biscay on mud in 98 fathoms (Roule, No. 101). Saint-Joseph states that it occurs on all French Coasts on muddy sand.

Chaetopterus variopedatus. (Following Joyeux-Laffuie, No. 65, and Saint-Joseph, one species of *Chaetopterus* only is recognised as inhabiting European Seas.) Chart X. The most striking feature of the coarse gravel grounds in the neighbourhood of the Eddystone is the abundance of *Chaetopterus,* and the presence of large masses of its leathery tubes has a great influence on the general fauna of the grounds. The species is most abundant on the coarse gravel and sand of Grounds IX. and XI. and on the fine gravel of Ground XIV. to the westward of the Eddystone, and on the gravel and mud of Ground XIII. to the south-east. From these centres of distribution it extends in diminishing numbers on to the surrounding grounds. On the fine sand of Ground VII., where shells are numerous, *Chaetopterus* is still moderately plentiful, and a good many were even present on the fine sand of Ground VI., still further from the centre of distribution. On other fine sand grounds, as well as on the Bolt Head Shell Gravel and the Prawle Stony Ground, the species is either absent or represented only by one or two stray tubes.

Habits. The tubes of *Chaetopterus* are generally attached in the first instance to shells, but they soon attain a size very much greater than that of the shell to which they originally fixed, and they then attach themselves to the gravel itself or to any solid object with which they come in contact. In this way one often finds large clusters of the tubes joined together into masses, with two or three shells fixed firmly to the mass. The fauna which depends directly upon the presence of these masses of tubes has already been described (see p. 414). In addition to the species there mentioned the Polyzoan *Hypophorella expansa*, Ehlers, has been found in *Chaetopterus* tubes taken in the neighbourhood of the Eddystone (Harmer, No. 37), and was probably present in a large proportion of the specimens captured (compare also Joyeux-Laffuie, No. 64). The habits of *Chaetopterus* are well described by Joyeux-Laffuie (No. 65). The animal obtains its food by drawing a current of water through its tube and extracting the floating organisms.

DISTRIBUTION. *Geographical.* Northern Seas, Channel, Atlantic, Mediterranean [*fide* Saint-Joseph, No. 102].

Depth and Bottom-deposit. Joyeux-Laffuie (No. 65) states that on the French coasts *Chaetopterus* is found in shallow water and even occasionally between tide-marks in sheltered situations, where the action of the waves is slight, but that on exposed coasts it occurs only in deeper water. It is often washed ashore in very large numbers after heavy gales. Saint-Joseph (No. 102) found it at Dinard on the shore only. In the Irish Sea it is recorded from the shore at low-water at Beaumaris (Williams, *fide* Hornell, No. 49), on a "reamy" bottom (sand and mud), in 30 fathoms; on dead shells and sand, 22 and 25 fathoms; on stones and mud, 19 fathoms (Herdman, No. 40, Vols. VIII. and IX.).

Pectinaria auricoma (Table VI.). Single specimens of a *Pectinaria* with a curved tube, identified by Mr. Hodgson as *P. auricoma*, are not unfrequently met with. They have occurred on Grounds VII. and VIII. (fine sand with shells) and X. and XII. (coarse gravel and sand) in the neighbourhood of the Eddystone, on the Bolt Head Shell Gravel (Ground XVII.), and the Prawle Stony Ground (XVIII.).

DISTRIBUTION. *Geographical.* North and West Norway, North Sea, British and Irish Coasts, Mediterranean [*fide* Michaelsen].

Depth and Bottom-deposit. M'Intosh [No. 81] found *Pectinaria auricoma* in the Shetlands at depths from 50–100 fathoms; Haddon [No. 34] off the south-west of Ireland on coarse sand in 35–40 fathoms; Möbius [No. 87] in the *Pommerania* dredgings generally on sandy mud, occasionally on coarse ground from 12 fathoms to 217 fathoms. In the North Sea also Michaelsen [No. 79] obtained it generally on mud and fine sand, occasionally on coarser ground. In the Kattegat Levinsen [No. 66] records *P. auricoma* from 12½ to 17 fathoms on mixed deposits (sand or gravel with mud). In the Liverpool district Hornell [No. 49] found *P. auricoma* rarely in 20–22 fathoms, whilst *P. belgica* was common from low-water to 21 fathoms.

Polymnia nebulosa (Table VI.) occurred in small numbers on the gravel grounds around the Eddystone (IX., XIII., and XIV.), and on the sand ground (VII.) immediately to the south of these.

DISTRIBUTION. West Norway, British Coasts, West France, and Mediterranean (*fide* Michaelsen, No. 79).

Nicolea venustula (Table VI.). Occasional specimens almost entirely confined to fine sand grounds.

DISTRIBUTION. Greenland, Iceland, Faröe, Spitzbergen, Nova Zembla, Siberia, Norway, British Coasts, French Coasts, Mediterranean, Red Sea [*fide* Michaelsen, No. 79, and Saint-Joseph, No. 102].

Depth, etc. 2–15 fathoms (Saint-Joseph); 20–22 fathoms (Hornell). On zostera (Michaelsen); on *Rytiphlaea pinastroides* (Saint-Joseph).

Thelepus sp. (Table VI.). A species of *Thelepus* is very common on the grounds investigated. Relying on the character of the uncini it would seem to be *T. setosus*, Saint-Joseph. The differences between this species and the common *T. cincinnatus* are, however, so slight that there is probably much confusion between the two in the literature. In the account of the distribution I therefore give that for each of these species.

On the Eddystone Grounds *Thelepus* is very common on all the fine sand and also on the coarse gravel to the west of the rocks. On the coarse gravel south-east of the Eddystone (Ground XIII.) it was not taken, and only an occasional specimen on the fine gravel of Ground XIV. was seen. It was not present on the clean shell gravel (XVI.), nor on the Bolt or Prawle Grounds.

DISTRIBUTION. *T. setosus*, Saint-Joseph, has been recorded only on the north coast of France (Saint-Joseph, No. 102) at depths of from 2 to 15 fathoms. *T. cincinnatus*, Fabr. North America, Greenland, Iceland, Faröe, Spizbergen, Jan Mayen, Nova Zembla, Kara Sea, Siberia, North and West Norway, North Sea, British Coasts, French Coasts, Mediterranean [*fide* Michaelsen and Saint-Joseph].

Depth and Bottom-deposit (*T. cincinnatus*). The *Pommerania* dredged the species generally on fine sand, sometimes on coarse grounds from 10 to 49 fathoms (Möbius, No. 87) In the Shetlands M'Intosh (No. 81) obtained it from 50 to 120 fathoms, and the *Knight Errant* found it at 540 fathoms (M'Intosh, No. 85). Hornell (No. 49) records it in the Irish Sea from shore to 22 fathoms, becoming more abundant in the deeper water. The Norwegian North Atlantic expedition obtained it at seven stations from 35 fathoms to 658 fathoms, generally on a bottom of clay (Hansen, No. 36). The *Caudan* found it numerous at three stations in the Bay of Biscay, twice at 98 fathoms on gravel and sand, and once at 219 fathoms on mud (Roule, No. 101).

Amphitrite gracilis. An occasional specimen on Grounds VII. (fine sand) and XVII. (Bolt Head Shell Gravel).

Distribution. North America, Greenland, Kara Sea, British Coasts (*fide* Michaelsen, No. 79). Saint-Joseph found it at Dinard on the shore only, living in mud between stones, and not forming a tube.

Polycirrus aurantiacus. Two specimens on the muddy gravel ground (XIII.) south-east of the Eddystone. The species is common in Plymouth Sound (Millbay Channel) and in the estuary of the Yealm.

Distribution. English Channel, west of France, Mediterranean (Saint-Joseph, No. 102). At Dinard in 2–15 fathoms. M'Intosh records it from the Shetlands in 70–80 fathoms. The *Pola* dredged it in 220 fathoms (*fide* Saint-Joseph).

Sabellaria spinulosa. Forming very hard, sandy tubes on shells, etc. Though the records are not numerous the species was common on all grounds where dead shells were numerous.

Distribution. North Sea, Channel, Atlantic (Saint-Joseph). In North Sea, 0–40 fathoms (Michaelsen).

Sabella (*pavonina ?*). Specimens never reaching a length of more than three or four inches, but probably belonging to this species, were common, generally attached to the base of hydroids on both the fine sand and coarse gravel grounds in the neighbourhood of the Eddystone. They were especially abundant on the fine sand, usually associated with *Sertularella Gayi*.

Distribution. *Geographical*. North America, Greenland, North-West and West Norway, British Coasts, North-West France, and west of English Channel (*fide* Michaelsen).

Depth and Bottom-deposit. The *Pommerania* obtained *Sabella pavonina* from 16 to 52 fathoms. At 52 fathoms it was abundant on sandy mud. It was scarce on coarse grounds (Möbius, No. 87). Michaelsen also records it in the North Sea from sandy mud. The Norwegian North Atlantic expedition obtained it on clay at 135 fathoms and at 300 fathoms (Hansen, No. 36). The *Porcupine* dredged it at 725 fathoms (Ehlers, *fide* Saint-Joseph, No 102); the *Caudan* on mud at 98 fathoms in the Bay of Biscay (Roule, No. 101). From these records it is clear that the species is generally found on mud or muddy sand.

Filograna implexa (Table VI.). Large colonies were present only in haul 103 (Ground XIII.), south-east of the Eddystone, probably owing to the fact that the wave action is somewhat less there than on the grounds to the westward of the Eddystone (*cf.* p. 425). Small colonies, chiefly on shells of *Pecten opercularis*, were obtained on Grounds VII., IX., and XIV. The species is characteristic of the coarse grounds rather than of the fine sand.

DISTRIBUTION. *Geographical.* East of North America, Faröe, North and West Norway, White Sea (?), Scotland, England, North and West of France, Mediterranean (*fide* Michaelsen).

Depth and Bottom-deposit. The *Pommerania* dredged *Filograna implexa* in the North Sea on "sand and *Sabellaria* tubes" at 12 fathoms, on sand and shell at 50 fathoms, on mud and on gravel and mud at 106 fathoms, on all of which grounds it was plentiful (Möbius, No. 87). The Norwegian North Atlantic expedition took it on clay at 415 fathoms (Hansen, No. 36), and the *Caudan* in the Bay of Biscay on gravel and sand at 98 fathoms, and on mud at 160 to 220 fathoms (Roule, No. 101). Saint-Joseph and Hornell both record it occasionally from the shore.

Dasychone bombyx (Table VI.). Common on both fine and coarse grounds, attached to shells, etc.

DISTRIBUTION. North and West Norway, British Seas, North Sea, English Channel, Mediterranean (*fide* Saint-Joseph and Michaelsen). The *Caudan* took one specimen on a coral bottom at 220–270 fathoms in the Bay of Biscay. Saint-Joseph found it on the shore and in deeper water.

Protula tubularia. Occasional specimens only on the Eddystone coarse grounds and on two fine sand grounds (VII. and VIII.) immediately adjoining the latter.

DISTRIBUTION. A southern species. Mediterranean, Atlantic, Channel. At Dinard it is found in from 2 to 15 fathoms. The *Pola* dredged it in 515 fathoms (*fide* Saint-Joseph, No. 102).

Serpula vermicularis. Not uncommon on all grounds where shells are present upon which it can fix.

DISTRIBUTION. North-West and West Norway, Faröe, British Coasts, English Channel, Atlantic to Madeira, Mediterranean (*fide* Michaelsen and Saint-Joseph). The species was not obtained in the North Sea itself by either the *Pommerania* or by Michaelsen. The Norwegian North Atlantic expedition took it in 142 and 223 fathoms on grey clay and on sandy clay (Hansen, No. 36). The *Caudan* found it abundant on gravel and sand at 98 fathoms, abundant at three stations on mud from 104 fathoms to 219 fathoms, and at two stations on coral at 219 to 273 fathoms (Roule, No. 101). It would seem that this is a deep-water species, with its centre of distribution at depths of 100 to 300 fathoms, of which occasional individuals reach to the shore. This would explain the fact that although it has an extended distribution both north and south, it is not frequently taken in the North Sea.

Hydroides norvegica (Gunn). This serpulid is the common species growing on shells and on the stems of hydroids on all grounds where shells are present. On Grounds I. and II. it is found chiefly on *Cardium echinatum* shells. On many grounds it occurs on *Buccinum undatum* shells inhabited by *Eupagurus Bernhardus.*

DISTRIBUTION. Norway, North Sea, Atlantic, Mediterranean (*fide* Michaelsen and Saint-Joseph). The species occurs on all kinds of grounds to deep water (300 fathoms, Norwegian North Atlantic expedition, Hansen, No. 36).

Potamoceros triqueter is much less common than *Hydroides norvegica*, but occurs on both fine and coarse grounds.

DISTRIBUTION. Iceland, Faröe, North and West Norway, North Sea, British Coasts, French Coasts, Mediterranean (*fide* Michaelsen, No. 79, and Saint-Joseph, No. 102).

Hornell (No. 49) found the species common on the shore, more sparingly in deeper water to 18 fathoms, in the Irish Sea. The *Pommerania* records also agree with the view that this species is most common in shallow water. Michaelsen records it, however, as plentiful in the North Sea to depths of 70 fathoms. On the whole it seems probable that *H. norvegica* has its centre of distribution in deep water, whilst that of *P. triqueter* is near shore.

Spirorbis sp. A species of *Spirorbis* is common on the hydroid *Sertularia abietina*, which is taken on Grounds II., XVII., and XVIII.

NEMERTINA.

The specimens have for the most part been named either by Mr. T. H. Riches or by Mr. W. I. Beaumont. For geographical distribution Bürger's Naples Monograph has been relied on.

CRUSTACEA.

Nomenclature:—A good list of synonyms is given by Bonnier (No. 10), whose nomenclature has in most cases been used. In the identification of this group I have received much help from Mr. T. V. Hodgson.

For geographical distribution Norman (No. 93) and Gourret (No. 31) have been chiefly made use of. The records of the smaller crustacea, *Amphipoda*, *Isopoda*, etc., are very imperfect. For the *Amphipoda* Sars's *Crustacea of Norway* has been relied on for geographical distribution, and for the *Cirripedia* Darwin's monograph.

Homarus vulgaris. Two specimens of the common lobster were trawled on the fine sand of the inner trawling ground (I.) in haul 81. Although the lobster generally frequents rocky places, it is not unusual for one or two specimens to be captured when trawling on sand.

DISTRIBUTION. *Geographical.* West Norway to 62° N., Sweden, Kattegat, British and French Coasts, Portugal, Mediterranean (not common). (Norman, No. 93; Bonnier, No. 10; Gourret, No. 31.)

Depth. Shore to 50 fathoms (?). (Lo Bianco, No. 68.)

Bottom-deposit. Rocky places. Gourret states that the lobster was formerly abundant at Marseilles, but that in 1888 it was only occasionally taken on the zostera beds.

Pandalus brevirostris, Rathk. Chart XII. Numerous on Grounds III. and IV., present on VII. and IX. This species is generally abundant only where hydroids or especially *Cellaria* abound, amongst which it is found hiding.

DISTRIBUTION. *Geographical.* West Finmark, Norway, Sweden, Denmark, British Seas, Bay of Biscay (Norman, No. 93; Bonnier, No. 10). Carus (No. 14) gives it as a Mediterranean species, but I have found no other reference to its having been taken there.

Depth. 5 to 89 fathoms (A. O. Walker).

Bottom-deposit. Metzger (No. 78) records *Pandalus brevirostris* on sand and shell, on stones, and on stones and algæ in the North Sea (5–28 fathoms). Pruvot (No. 98) at Roscoff on sand from the coastal region. Meinert (No. 75) on mud and sand and on mud and small stones in the Kattegat. The distribution of the species therefore appears to have little direct connection with the nature of the bottom-deposit. It will probably depend largely on the distribution of hydroids and such polyzoa as *Cellaria*.

Eupagurus Bernhardus. Chart XII. This hermit crab is present on grounds of all kinds, though it is most abundant on the sand and on the gravel and sand grounds where the fauna is generally rich. Its absence from Ground XIII., the gravel and mud one mile south-east of the Eddystone, is somewhat unexpected, but it must be noted that only one haul was made here (103). It is noteworthy that on the fine sand grounds (I., II., III., IV., V., and VII.) the anemone *Sagartia parasitica* was often associated with the hermit, whilst on all the other grounds the anemone was absent (*cf.* p. 459). *Eupagurus Bernhardus* was found occupying the shell of *Buccinum undatum* on all grounds excepting on the Bolt Head Shell Gravel (Ground XVII.), where specimens were taken (in hauls 106 and 107) in *Fusus islandicus* shells. The *Buccinum* shells often had *Hydractinia echinata* upon them.

DISTRIBUTION. *Geographical.* East Finmark, Norway, Sweden, Kattegat, Baltic, British Coasts, Mediterranean (apparently not frequent).

Depth. Shore to 200 fathoms (Pocock, No. 96).

Bottom-deposit Metzger (No. 78) records *E. Bernhardus* in the North Sea on sand, on gravel, on shell, and on mud, generally however, on fine ground. Meinert (No. 75) in the Kattegat on all kinds of ground, on clean sand, on mixed deposits, and on pure mud.

The distribution of this species is evidently little influenced by the nature of the bottom-deposit.

Eupagurus Prideauxii (Chart XII.) differs somewhat in distribution on the grounds investigated from *E. Bernhardus*, in that it is never found on the fine clean sand of the outer and inner trawling grounds (I. and II.). In other respects its distribution is practically the same as that of *E. Bernhardus.* It is invariably associated with the anemone *Adamsia palliata.*

DISTRIBUTION. *Geographical.* Mediterranean, Portugal, Bay of Biscay, English Channel, Irish Sea, West of Scotland, Shetlands, Norway to Arctic Circle (Marion, No. 74; Gourret, No. 31; Bonnier, No. 10; Walker, Nos. 111 and 112; Hoyle, No. 52; Norman, No. 93). It is not recorded by Metzger in the North Sea, nor by Meinert in the Kattegat.

Depth. From 10 or 20 fathoms to 140 fathoms (Gourret, Milne-Edwards and Bouvier, No. 80).

Bottom-deposit. Milne-Edwards and Bouvier (No. 80) record *E. Prideauxii* five times from fine sand, or muddy sand, and twice from sand, gravel, and broken shell, at depths from 30 to 140 fathoms in the Bay of Biscay. Marion (No. 74) records it in the Mediterranean on coralline gravel, on muddy sand, and muddy gravels. Walker (No. 111) in the Irish Sea on nullipore ground and on muddy gravel (20 fathoms).

Eupagurus cuanensis (Table VI.) is never found in large numbers on the grounds examined. It is confined for the most part to the gravel grounds in the neighbourhood of the Eddystone, but it was present in only comparatively few hauls. It is recorded once from the Bolt Head Shell Ground in haul 28. It is often found living in shells covered by *Suberites domuncula.*

DISTRIBUTION. *Geographical.* South and West Norway, Sweden, Kattegat, Irish Sea, English Channel. Bay of Biscay, Mediterranean (Norman, No. 93; Meinert, No. 75; Walker, No. 112; Bonnier, No. 10).

Depth. Shallow water to 200 fathoms (Walker, No. 112, p. 80).

Bottom-deposit. On nullipore ground in Irish Sea (A. O. Walker), on shell sand, 30–50 fathoms, off Concarneau (Bonnier). Meinert records it in the Kattegat on clean sand, on clean gravel, and on pure mud, as well as on the mixed deposits, sand, mud, and gravel, or gravel, mud, and small stones.

Anapagurus laevis (Table VI.). This species was sometimes taken in considerable numbers. It was more frequent on the fine sand than *Eupagurus cuanensis*, but it was also taken on Grounds XI. and IX., where the deposit is a mixture of gravel and sand. It was most numerous in hauls 104 (Ground II.), 93 (Ground IX.), and 90 (Ground V.). Its absence from Ground XIII. (gravel and mud) is noteworthy, as this ground in many ways resembles IX., where the species was numerous. On the Bolt Head Shell Gravel it was present in 27 only, a haul which in other respects gives indications of being partly a fine sand ground. On the Prawle Stony Ground it was taken in several hauls. On Ground IX. *Anapagurus* was common in shells of *Turritella communis*, and was also inhabiting shells of *Natica nitida*, *Mangelia gracilis*, and *Nassa incrassata*.

DISTRIBUTION. *Geographical.* Mediterranean, Azores, Bay of Biscay, English Channel, Irish Sea, South-West Ireland, North Sea, Shetlands, Norway, Kattegat (Marion, Milne-Edwards and Bouvier, Bonnier, Walker, Haddon, Metzger, Norman, Meinert). It is not recorded from the southern part of the North Sea.

Depth. 5 fathoms (Metzger, No. 78) to 383 fathoms (Marion, No. 74).

Bottom-deposit. Marion records *Anapagurus laevis* on deep mud in the Mediterranean (273 to 383 fathoms); Pruvot (No. 98) on coastal sand and on deep coral and mud (Mediterranean); Milne-Edwards and Bouvier (No. 80) on fine sand and on muddy sand in the Bay of Biscay (74–98 fathoms), on gravel, sand, and broken shell at the Azores (71 fathoms); Metzger (No. 78) on stones (5–20 fathoms), on gravel and shell (12 fathoms), on sand, on sandy mud, and on grey mud (50–80 fathoms) in the northern part of the North Sea. Norman says it is common on the Haddock (soft) grounds in the Shetlands. Haddon (No. 34) records it on coarse sand at the mouth of Bantry Bay (35–40 fathoms), and Meinert (No. 75) on mud with sand or gravel (70–22 fathoms) in the Kattegat.

It seems evident from the above records, and my own observations tend to confirm this, that *Anapagurus laevis* occurs most frequently on sand or mud grounds.

Porcellana longicornis (Table VI.). Like *Galathea dispersa* this species is found on all the grounds, and was taken in practically every haul, often in large numbers.

DISTRIBUTION. *Geographical.* Norway, Sweden, Denmark, British Seas, Mediterranean (Norman, No. 93). Gourret (No. 31) states that it extends to the Canary Isles.

Depth. From low-water (Bell, No. 9) to 100 fathoms (Bonnier, No. 10). Milne-Edwards and Bouvier (No. 80) do not record it from any haul in the Bay of Biscay deeper than 10 fathoms.

Bottom-deposit. The species is recorded from all kinds of bottom, though, as in the case of many other very common and widely distributed species, very few records are to be found.

Galathea dispersa was taken on all the grounds and almost in every haul. It was most rarely found on the clean shell gravel grounds, viz., Ground XVI., west of the Eddystone, and the Bolt Head Shell Gravel Ground (XVII.). It was most abundant where hydroids were numerous.

DISTRIBUTION. *Geographical.* Norman (No. 93) gives South and West Norway, British Seas, and Mediterranean. Milne-Edwards and Bouvier (No. 80) found it commonly in the Bay of Biscay.

Depth. 5–140 fathoms (Milne-Edwards and Bouvier).

Bottom-deposit. The synonymy of the species is too doubtful to permit of a detailed list of references. Milne-Edwards and Bouvier took the species upon all kinds of ground in the Bay of Biscay.

Stenorhynchus longirostris. Chart XI. This species is most plentiful on Grounds IV., III., and V., where the bottom-deposit is fine sand (see Table VI.). It is less common on the still finer sands (Grounds I. and II.). It is present, though not numerous, on all the gravels west of the Eddystone with the exception of the clean shell gravel immediately adjoining the rocks (Ground XVI.). It is scarce on the Bolt Head Shell Gravel and on the Prawle Stony Grounds (XVII. and XVIII.).

The species is scarce or absent on those grounds on which branched hydroids of more or less luxuriant growth are scarce or absent respectively. It appears to be specially abundant where the prevailing hydroid is *Sertularella Gayi* (*e.g.*, Grounds III., IV., and V.), less abundant where *Halecium halecinum* is the most characteristic representative of the group, as on the West Eddystone gravels. My notes are, however, not sufficiently full to establish this connection in detail for all the hauls.

Habits. The habit of this species of decking itself with bits of hydroids and polyzoa for the sake of protection is well known. When placed in a small aquarium with pieces of hydroid it will generally be found clinging to the hydroid. Whether or not it spends most of its time in a similar position in its natural haunts, or whether it is generally travelling about on the intervening patches of sand, I am not able to say, though from what I have seen of its habits in confinement I incline to the former view.

DISTRIBUTION. *Geographical.* *Stenorhynchus longirostris* has a distinctly southern distribution. It occurs in the Mediterranean (Marion, No. 74; Gourret, No. 31; Norman, No. 93), Canaries and Portugal (*fide* Gourret), north coast of Spain (A. Milne-Edwards and Bouvier, No. 80), west coast of France (ditto and Bonnier, No. 10), north coast of France, Belgian Coast (*fide* Metzger, No. 78), south coast of Devon and Cornwall, Irish Sea (scarce, A. O. Walker), Clyde (Hoyle, No. 53). The *Pommerania* took it once in the North Sea (south-east of Yarmouth), and it is not recorded from Norway nor from the Kattegat. Bell (No. 9) states that Embleton includes it in his list of Crustacea from Berwickshire and North Durham. It is not recorded in Firth of Forth by Leslie and Herdman (No. 43).

Depth. From 10 fathoms (Gourret) and 15 fathoms (A. O. Walker, No. 40, Vol. IX., p. 33) to 230 fathoms (*Travailleur*, No. 80, p. 5, footnote).

Bottom-deposit. Milne-Edwards and Bouvier (No. 80), on gravel, sand, and broken shell and on fine sand, more frequently on gravel and coarse ground (5 stations) than on fine sand (2 stations) [Bay of Biscay and north-west of Spain, 30 to 150 fathoms]. Metzger (No. 78) on sand and shell (south-east of Yarmouth, 23 fathoms). Pruvot (No. 98), on mud and sand below 25 fathoms. Marion and Gourret (No. 31), on sandy mud and deep mud (20–100 fathoms). *Stenorhynchus longirostris* appears to be most frequent amongst hydroids from about 20 to 50 fathoms. Its place is taken in shallower water by *Stenorhynchus phalangium*, and in the North Sea this species seems to replace it even in 30 to 50 fathoms (see p. 518). Its distribution appears to be only indirectly influenced by the nature of the bottom-deposit.

Inachus dorsettensis. Chart XI. On the whole the distribution of *Inachus* on the grounds under examination corresponds closely with that of *Stenorhynchus longirostris*, though it has never been met with in such great numbers as the latter species is when at its maximum. On the gravels to the west of the Eddystone it is more frequent than *Stenorhynchus*, though generally not represented by more than a few specimens in a haul.

Habits. *Inachus dorsettensis* is usually taken with its legs and often most of its carapace covered with growing sponges, compound ascidians, and polyzoa (*Scrupocellaria scruposa*). Occasionally specimens of *Balanus* are also attached to the carapace. It is a more sluggish animal than *Stenorhynchus longirostris*, and it does not seem to spend its time clinging to branching hydroids as that species probably does.

Distribution. *Geographical.* Mediterranean, Portugal, West France, British Seas, Kattegat, West Norway to latitude 62° N. Only taken by the *Pommerania* in North Sea at one station (*fide* Norman, No. 93; Gourret, No. 31; Meinert, No. 75; Metzger, No. 78; Bonnier, No. 10). Apparently not common in Irish Sea (A. O. Walker, No. 112).

Depth. From about 6 fathoms (Gourret) to 136 fathoms (Milne-Edwards and Bouvier, No. 80).

Bottom-deposit. A. Milne-Edwards and Bouvier (*Monaco* expeditions) record the species from two stations on sand and gravel, and from seven stations on fine sand and on muddy sand. Metzger (*Pommerania*) records it once on sand and shell. Pruvot, No. 98 (at Roscoff), from the lower littoral gravel. Gourret (at Marseilles), on gravels, on muddy sand, and on sandy gravel. Meinert (No. 75) (*Hauch* expedition), generally on gravel mixed with sand and mud; occasionally on pure mud or on clean sand. It thus appears that the species may occur on both gravel and sandy grounds, though according to the results of the Monaco dredgings it is more frequent on sand. I find no record of its having been taken on fine mud, but on grounds harder than this it appears to be distributed without immediate reference to the bottom-deposit.

Maia squinado was only taken in two hauls, both on fine sand grounds, in haul 56 on Ground III. and in haul 82 on Ground I. It is common amongst the rocks outside Plymouth Sound.

Distribution. *Geographical.* Mediterranean (general and common), Canaries, Portugal, West France, North France, southern and western coasts of England, and south coast of Ireland (Gourret, No. 31; Bonnier, No. 10; Pruvot, No. 98; Bell, No. 9). Not recorded from North Sea nor from Irish Sea.

Depth. Shore (Gourret) to 50 fathoms (Bonnier).

Hyas coarctatus. Several specimens were taken on the fine sand south of the Eddystone (Ground VI., hauls 101 and 102), one specimen on the sandy ground east of the Eddystone (Ground IV., haul 39), and one on the fine sand Ground I. (haul 50). The species was taken in no other hauls.

Habits. Most of the specimens were females carrying ova. They were more or less completely covered with compound ascidians, polyzoa (*Scrupocellaria scruposa* and *Bicellaria ciliata*), and large *Balanus*. In one case several specimens of *Ascidiella scabra* were attached.

Distribution. *Geographical.* An Arctic species, attaining both its maximum size and abundance within the Arctic circle. It is one of the three species of Crustacea Brachyura which are found in high latitudes (Norman, No. 93). It is circumpolar in distribution (Meinert, No. 75). The species occurs on the eastern and western sides of the Atlantic as follows:—Greenland, Labrador, Newfoundland, Norway, Sweden, North Sea (northern part, seldom in south), Irish Sea, South-West Ireland, English Channel, Brittany (*vide* Norman, Milne-Edwards and Bouvier, Meinert, Metzger, A. O. Walker, Pocock, Bell, Pruvot). It does not extend into the Kattegat (Meinert), nor is it taken on the west coast of France (Bonnier).

Depth. Shore (A. O. Walker, No. 112) to 250 fathoms (Pocock, No. 96).

Bottom-deposit. From the Irish Sea (A. O. Walker) *Hyas coarctatus* is recorded in stony places (0–10 fathoms), on small gravel and shells (15 fathoms), on sandy mud (30 fathoms), and on nullipore gravel (15–18 fathoms). Milne-Edwards and Bouvier (No. 80) record it from north of the Great Bank of Newfoundland on fine sand and small pebbles. Metzger (No. 78), in the North Sea, notes it generally on mud and sand. Pruvot (No. 98), on the Brittany coast on gravel, and Meinert (No. 75), in 70 fathoms north of Skagen, on mud and fine sand. In the case of this species also it seems clear that the nature of the bottom-deposit is not a very important factor in directly determining its distribution.

Eurynome aspera (see Table VI.). The only haul in which several specimens of this species were taken was haul 93 (Ground IX.), on the mixed gravel and sand west of the Eddystone. It was present in small numbers (one or two specimens in a haul) on nearly all the other grounds, both fine sand and gravel. The only grounds from which it is not recorded at all are V., X., XV., and XVI.

Habits. Not a burrowing species (Garstang, No. 29).

Distribution. *Geographical.* A southern species, especially abundant in the Mediterranean, where it is common on all kinds of ground from the shore to a depth of 140 fathoms. It is found on the coast of Portugal, west and north coasts of France, English Channel, Irish Sea, south-west of Ireland, Shetlands (rare, Norman, No. 90), south and west of Norway; not recorded from North Sea, seldom in Kattegat (Marion and Gourret, Bonnier, Milne-Edwards and Bouvier, Walker, Pocock, Norman, Metzger, Meinert).

Depth. In Mediterranean, shore to 140 fathoms (Gourret, No. 31); south-west of Ireland, 315 fathoms (Pocock, No. 96). Shallowest depth recorded on British Coasts, 15 fathoms (Walker, No. 111).

Bottom-deposit. Gourret records *Eurynome aspera* in the Mediterranean from all kinds of ground, on gravel, on sand, on muddy sand, and on mud. A. Milne-Edwards and Bouvier (No. 80) found it on fine sand or muddy sand nine times, on sand with gravel three times in the Bay of Biscay and north-west of Spain. Walker (Nos. 111 and 112) records it in the Irish Sea from nullipore ground, from "reamy" bottom (*i.e.*, mud and gravel), and from broken shell and small stones. In the Kattegat (Meinert, No. 75) it was taken generally on gravel mixed with small stones or with sand, more rarely with mud. It was seldom taken on pure mud. This is another example of a wandering species, the distribution of which does not depend directly to any great extent upon the nature of the bottom-deposit.

Portunus depurator. Chart XIII. Abundant only on Ground VI. (three miles east of the Eddystone), which is a sandy ground with many shells. The species was also present on Grounds III., VI., and VIII., which are also fine sand, and scarce on XIV. and XIII., fine gravel and coarse gravel with mud respectively. In Plymouth Sound it is abundant on stony ground in 5 fathoms.

Habits. A gregarious species (Bell), which can swim rapidly. It does not appear to burrow like many other species of this genus.

DISTRIBUTION. *Geographical.* Mediterranean, Portugal, west coast of France, Channel Islands, English Channel, Irish Sea (abundant), Clyde area, Shetlands (rare, Norman), North Sea (once only, *Pommerania*), Kattegat (chiefly on deep mud), Norway to Arctic circle (*vide* Gourret, Bonnier, Bell, Walker, Hoyle, Norman, Metzger, Meinert).

Depth. 3 fathoms (Walker) to 104 fathoms (Hoyle, No. 53).

Bottom-deposit. In the Irish Sea Walker (Nos. 111 and 112) records it as abundant on stony ground in 3–7 fathoms. Metzger (North Sea, No. 78), on sandy mud in 69 fathoms. Pruvot (Mediterranean, No. 98) on sand, on gravel, and on mud. Marion (Mediterranean, No. 74), on mud and on muddy sand in 34–50 fathoms. Meinert (Kattegat, No. 75), generally on pure mud, occasionally on mud with sand or gravel, occasionally on clean sand. In this case again the species is found upon deposits of very different texture. In shallow water (3–10 fathoms) it appears to inhabit chiefly stony ground.

Portunus pusillus (Chart XIII.) was most numerous on the Gravel Grounds IX. and XI. to the west of the Eddystone. It was very rarely obtained on the fine gravel ground XV., and on the fine sand grounds IV., VI., and VII.. Occasional specimens were found on the Bolt Head Shell Gravel and on the Prawle Stony Ground. The species was never taken on the fine sand grounds I., II., III., and V.

On the whole, therefore, on the grounds under investigation, *Portunus pusillus* lives principally on gravel, a few wandering on to the sand grounds immediately adjoining the gravel.

DISTRIBUTION. *Geographical.* Mediterranean, Canary Isles, Portugal, Bay of Biscay, English Channel, Irish Sea, Shetlands, Norway to Lat. 62°, Sweden, Kattegat, North Sea (Milne-Edwards and Bouvier, Norman, No. 93, Gourret, Bonnier).

Depth. Shore (rare, Bonnier, No. 10) to 98 fathoms (Milne-Edwards and Bouvier, No. 80).

Bottom-deposit. Milne-Edwards and Bouvier record *Portunus pusillus* from the Bay of Biscay on nullipore ground, on fine sand, and on muddy sand. Metzger (No. 78), on stony ground, on sandy mud, on gravel, and on sand. Pruvot (No. 98) mentions it on sand and gravel, and on gravel. Bonnier (No. 10), on muddy sand. Gourret (No. 31), on mud, on gravel, and on muddy gravel, and Meinert (Kattegat, No. 75), generally on mud mixed with gravel and stones, occasionally on fine sand.

Corystes cassivelaunus (Chart XIII.) is found practically exclusively upon clean fine sand, and is abundant on Grounds I. and III., or, speaking more accurately, on the portions of those grounds which adjoin each other. The hauls in which it was most plentiful are 91, 72, 57, and 92, which it will be seen all lie near together. One specimen only was taken on Ground II. (haul 22), and it was also met with on Ground XVII. (Bolt Head Shell Gravel) in haul 27 only, probably because this haul extended on to the fine sand. The species is entirely absent from all the Eddystone Gravel Grounds.

Habits. The habit of *Corystes cassivelaunus* of burrowing in fine sand was recorded by several of the older naturalists (Couch, Gosse, Robertson), and recently Garstang has made a special study of the species in relation to this matter. He found that the crabs burrowed at once in fine sand, but would not burrow in gravel. They came out of the sand and became active at night.

DISTRIBUTION. *Geographical.* Mediterranean, Bay of Biscay, English Channel, Irish Sea, West Ireland, southern part of North Sea only (not north of Scarborough) (Marion and Gourret, Pruvot, Bonnier, Walker, Metzger).

Depth. Between tide-marks (Walker) to 30 fathoms (E. J. A.).

Bottom-deposit. Corystes cassivelaunus is recorded by Marion and Gourret (Mediterranean, Nos. 74 and 31) on mud, rare: by Pruvot (No. 98), on mud and on sand; by Metzger (North Sea, No. 78), on sandy mud and on fine sand; by Holt (West Ireland, No. 48), on sand and on soft mud; by Walker (Irish Sea, Nos. 111 and 112), on sand.

Corystes cassivelaunus is a good example of a burrowing species whose distribution is directly controlled by the texture of the bottom-deposit.

Atelecyclus heterodon (Chart XIII.) was abundant on two grounds, on Ground XIII., one mile east of the Eddystone, where the bottom-deposit is medium gravel mixed with a considerable amount of mud (see Table II., Sample 103), and on Ground IX., three miles west of the Eddystone, where the deposit is coarse gravel mixed with fine sand (see Table II., Sample 94). On the muddy gravel the specimens were both large and numerous, on the sandy gravel they were numerous, though comparatively small. On the other grounds in the neighbourhood of the Eddystone occasional specimens only were taken, generally in not more than one haul, as follows: (*Cf.* Chart XIII.), Ground XI. (one in 47, one small one in 84), Ground X. (haul 42, small in 95), Ground VII. (hauls 38 and 100), Ground XV. (one in haul 97), and Ground IV. (in 34 only). One specimen was also taken on the fine sand of the inner trawling ground (I.) in haul 82. On the Bolt Head Ground (XVII.) the species was taken only in hauls 27 and 28, which are the two hauls on this ground furthest from the shore, and differ in other respects from the remaining hauls. One or two specimens only were taken in these hauls, and the bottom is described from observation of the contents of the dredge as shells, broken shell, gravel, and sand. (At the time the hauls were made the taking of proper samples of the deposit with the canvas bag dredge had not been commenced.) On the Prawle Stony Ground (XVIII.) *Atelecyclus* was taken in haul 45 only on a bottom described as gravel, stones, and shells. (No sample taken.)

Habits. A burrowing species (Garstang, No. 29).

DISTRIBUTION. *Geographical.* Mediterranean, Portugal, Bay of Biscay, Brittany, English Channel, South-West and West Ireland, Irish Sea, Shetlands (common), North Sea (northern portion), Norway to Arctic circle (Marion and Gourret, Pruvot, Bonnier, Bell, Holt, Walker, Norman (No. 93), Metzger). It does not appear to have been recorded from the southern part of the North Sea, nor from the Kattegat.

Depth. Shallow water to 400 fathoms (Bourne, No. 11). Milne-Edwards and Bouvier give several records between 50 and 100 fathoms.

Bottom-deposit. Marion (Mediterranean, No. 74) found small specimens of *Atelecyclus* on the mud at 100 fathoms. Gourret (Mediterranean, No. 31) records it from mud and under stones. Milne-Edwards and Bouvier (Bay of Biscay, No. 80), from muddy sand and from fine sand (50–100 fathoms). Walker (Irish Sea, No. 112), from broken shells and small stones (22 fathoms). Metzger (North Sea, No. 78), from sand and shells (50 fathoms). Pruvot (Brittany, No. 98), from gravel and (Mediterranean) from mud, from sand (30 fathoms) and from rocks and mud (shore).

These records are not very conclusive as to the nature of the ground which *Atelecyclus* usually frequents, but combining them with my own observations there seems to be reason for supposing that it likes muddy ground, but that the mud is generally mixed with a coarser deposit. Occasionally it is found on fine sand.

Ebalia tumefacta (Chart XI.) is abundant on the coarse gravel mixed with fine sand, which is found on the west side of the Eddystone (Grounds IX. and XI.). It is constantly present, though in much fewer numbers, on clean shell gravel grounds (XVI. and XVII.). One specimen was taken on the fine sand, Ground II., haul 23, but this was quite exceptional.

DISTRIBUTION. *Geographical.* Mediterranean, Portugal, Bay of Biscay, British Coasts, Norway to Arctic circle (Gourret, No. 31 ; Norman, No. 93).

Depth. 25 fathoms (Metzger) to 98 fathoms (Milne-Edwards and Bouvier).

Bottom-deposit. Goodsir (*fide* Bell, No. 9, p. 143) states that this species is generally found on stony bottoms and on fishing-banks. Metzger (No. 78) records it once from the *Pommerania* dredgings in the North Sea on a bottom of sand and shells (25 fathoms). Walker (No. 112) records it on nullipore ground in the Irish Sea, and Pruvot (No. 98) on gravel at Roscoff and on coastal mud and sand in the Mediterranean. Gourret (No. 31) found it on very muddy sand (26–36 fathoms, Mediterranean) ; Bonnier on shell sand and coral bottom ; Milne-Edwards and Bouvier in the Bay of Biscay on muddy sand.

Ebalia tuberosa. Chart XI. The distribution of *E. tuberosa* on the area under examination is almost exactly the same as that of *E. tumefacta.* Single specimens have, however, been taken in addition on Grounds VII., XIII., and VI. A. O. Walker (No. 112, p. 98) has drawn attention to the fact that these two species are almost invariably taken together, and has expressed a doubt as to their specific distinction. The differences between them are certainly very slight.

DISTRIBUTION. *Geographical.* Mediterranean, Portugal, Bay of Biscay, British Coasts, Norway to Arctic circle (Gourret, No. 31 ; Norman, No. 93).

Depth. Shallow water (2 fathoms, Gourret) to 90 fathoms (Milne-Edwards and Bouvier).

Bottom-deposit. A. O. Walker (Nos. 111 and 112) records the species in the Irish Sea on nullipore ground, on broken shell and small stones, on stones and mud, and on shells, sand, and gravel. Milne-Edwards and Bouvier (No. 80) on muddy sand and on grey sand ; Gourret (No. 31), on muddy gravel, on muddy sand, and on gravel. Bonnier (No. 10), at Concarneau, records it from the same grounds as *E. tumefacta.*

Ebalia Cranchii (Chart XI.) is only recorded on one ground in the neighbourhood of the Eddystone, viz., Ground XI. (hauls 8 and 9). It has been taken also on the Bolt Head Shell Gravel and on the Prawle Stony Ground, but only in small numbers.

DISTRIBUTION. *Geographical.* Mediterranean, Bay of Biscay, British Seas, Norway, Kattegat (Gourret, Bonnier, Norman, Meinert).

Depth. 8 fathoms to 550 fathoms (Bonnier, No. 10).

Bottom-deposit. Gourret (No. 31) records the species in the Mediterranean from muddy gravel and sand, from coralline gravel, from muddy gravel, and from muddy sand. Bonnier (No. 10) found it at Concarneau on the same kind of bottom as *E. tumefacta.* Pruvot (No. 98), on gravel, on mud and sand. Milne-Edwards and Bouvier (No. 80), on gravel, sand and broken shell, on fine sand, and on grey sand. Metzger (No. 78) records it in the North Sea three times on sand and shell, once on fine grey sand, and three times on mud and sand. Walker (Nos. 111 and 112) records it in the Irish Sea from shell sand and small gravel, and Haddon (No. 34) on the south-west coast of Ireland on coarse sand. In the Kattegat Meinert (No. 75) mentions it as occurring occasionally on pure mud, generally on mud with gravel or sand. The species therefore clearly is most plentiful on coarse deposits.

Gonoplax angulata. Chart XIII. (Following Fisher and Bonnier, *G. angulata* and *G. rhomboides* are here treated as one and the same species.) One specimen of this species only was obtained, on Ground V. (haul 90), four miles north-east of the Eddystone. As will be seen from Table II., the bottom-deposit on this ground consists of sand of a somewhat coarser texture than the majority of the fine sands examined, but containing at the same time a high percentage of silt (7 per cent.).

Habits. According to Cranch "they live in excavations formed in the hardened mud," and "their habitations, at the extremities of which they live, are open at both ends." It is probably on account of this habit that specimens of the species are so seldom captured.

DISTRIBUTION. *Geographical.* Mediterranean, Canary Islands, Bay of Biscay, English Channel, Irish Sea, South-West Ireland (Gourret, Bonnier, Bell, Walker, Holt). It is not recorded from the North Sea or from Norway.

Depth. Shallow water to 50 fathoms (Bonnier, No. 10).

Bottom-deposit. A. O. Walker records *Gonoplax* on fine mud (45 fathoms) in the Irish Sea; Holt (No. 48), on sand (45–48 fathoms) on the west coast of Ireland. Cranch (*fide* Bell, No. 9) found it in hardened mud (shore ?); Marion (No. 74), on mud; Gourret (No. 31), on muddy gravel and on mud. Bonnier (No. 10) states that at Concarneau the species is frequently taken by lobster fishermen in their pots.

MOLLUSCA.

Nomenclature:—Lamellibranchiata and Gasteropoda, Forbes and Hanley, *History of British Mollusca.* For geographical distribution I have relied largely on Gwyn Jeffrey's *British Conchology* and on Locard (*Travailleur et Talisman. Mollusca.* No. 69).

Pholas parva. One specimen only, on the Prawle Stony Ground (XVIII.) in haul 4. The animal was found, along with numerous specimens of *Pholadidea papyracea*, boring in red trias rock.

The species is recorded boring in new-red sandstone, marl, clay, and submarine peat (Jeffreys, No. 55). Montague found it in decayed wood at Salcombe (Forbes and Hanley, No. 25). It appears to be a southern species, and has been recorded from Malaga and Algiers. There are also records from the Irish Sea.

Pholadidea papyracea. Like *Pholas parva* this species was taken in one haul only, viz., haul 4 on the Prawle Stony Ground. It was plentiful in pieces of red trias rock.

The species is recorded by Forbes and Gwyn Jeffreys from new red sandstone or trias, peat, submarine forest, sandstone, and hard clay. It has been obtained from the English Channel, Irish Coasts, and west of Scotland (*fide* Jeffreys, No. 55). The *Talisman* expedition took it in 60 fathoms west of Morocco (Locard, No. 69). It is found from low-water mark (South Devon Coast) to 80 fathoms (off the coast of Antrim) [Jeffreys].

Saxicava rugosa (Table VI.). The variety *arctica* was found on grounds of all kinds attached to shells and similar objects, or to the roots of hydroids.

Habits. The varieties *arctica* and *minuta* do not bore like the common *Saxicava*, but are found attached to shells, etc., in deeper water.

Distribution. *Geographical.* Locard (No. 69), who regards *S. arctica* as a distinct species, gives its distribution as coast of Finmark, Norway, England, France, Bay of Biscay, and Mediterranean. The boring variety is found in all parts of the world.

Depth. Shore to 700 fathoms (var. *arctica*, Dauzenberg, No. 20).

Pandora obtusa [=*P. inaequivalvis*, var. *obtusa* of Gwyn Jeffreys]. One living example only taken in haul 75 (Ground VII.). The bottom-deposit is one of the coarser kinds of fine sand, and a large stone is recorded in this particular haul.

Distribution. *Geographical.* Gwyn Jeffreys (No. 55) distinguishes two varieties of *Pandora inaequivalvis*; var. *tenuis*, with a southern range from Algeria to Guernsey, and north to Shetlands; var. *obtusa* ranging from Spitzbergen to the Canaries.

Depth. Low-water to 100 fathoms, var. *tenuis*; between 85 and 100 fathoms (Shetlands) [Gwyn Jeffreys]. Var. *obtusa*, 7–50 fathoms.

Bottom-deposit. In sand, Channel Islands, at low-water; often among *Zostera marina* (Jeffreys). Usually on muddy ground (Forbes, No. 25). In the British Association Report (1850) Forbes records the species once from mud, twice from mud and stones, once from sand and gravel, twice from gravel, and once from nullipores.

Lyonsia norvegica. Taken once only alive in haul 7 on the Bolt Shell Gravel (Ground XVII.). Shells were taken on Grounds XI., XIII., and VII., all of them coarse grounds in the neighbourhood of the Eddystone.

Distribution. *Geographical.* Sea of Okhotsk, Iceland, Scandinavia, France, Mediterranean, Madeira (Jeffreys).

Depth. Shallow water (4 fathoms, Jeffreys; 7 fathoms, Holt, No. 48) to 100 fathoms (Forbes, *Brit. Assoc. Rep.*, 1850).

Bottom-deposit. Sand (Jeffreys); shells, mud, corals, and weed (Holt); on shells, stones, and mud (Herdman, No. 40, Vol. IX., p. 37); on sand and mud, on stones and mud, on gravel, and on sand (Forbes, *Brit. Assoc. Rep.*, 1850); on mixed deposits (sand or gravel and mud) [Petersen, No. 95]. From these records I should judge that the species was most frequent upon muddy gravel or sand.

Solen ensis has been represented by shells only. It is not unlikely that the species occurs in water of 30 fathoms, though from what is known of its habits on the shore there is little chance of its being captured by a dredge.

Solecurtus candidus. Shells only have been occasionally taken.

Distribution. Gwyn Jeffreys (No. 55) states that *Solecurtus candidus* is a very active species which lives in sand exposed at low-water spring tides, and also at various depths from 20–85 fathoms. Forbes and Hanley (No. 25) say that it probably buries deeply in pure sand. It is a southern species, extending from the English Channel to the Canary Islands and Madeira, and is also present in the Mediterranean (Jeffreys).

Psammobia ferroensis. Shells only have been taken of this species.

Psammobia costulata. One specimen only on the clean shell gravel (Ground XVI.) immediately west of the Eddystone reef.

Distribution. Mediterranean, Madeira, Canaries, British Seas, Norway (Jeffreys).

Tellina crassa. One living specimen only was obtained in haul 99 and one in 87, both on the clean shell gravel close to the Eddystone rocks (Ground XVI.).

Distribution. *Geographical.* North Sea, French Coast, Gibraltar, and Gulf of Tunis (Jeffreys, No. 55).

Depth. Low-water to 55 fathoms (ditto).

Bottom-deposit. Forbes and Hanley say that the species generally lives in the upper part of the coralline zone in gravelly sand. At Herm, in the Channel Islands, it is found in sand at low-water, and also in the Isle of Man. Forbes (No. 24, *Brit. Assoc.*, 1850) records it once on sand (35–40 fathoms) and once on gravel (40 fathoms). In the Liverpool district it is recorded on small gravel with some melobesia (No. 40, Vol. IX., p. 33). The species appears therefore to prefer coarse ground.

Tellina donacina. Shells only in haul 9 (Ground XI.).

A southern species, not extending further north than the west coast of Scotland; south to Azores, Mediterranean, Red Sea (Locard, No. 69). The *Challenger* dredged it on volcanic mud in 450 fathoms off the Azores (Smith, No. 107).

Lutraria elliptica. Shells of this species were fairly common on all shelly grounds. They were generally old and much bored by *Cliona.*

The species extends from Finmark to the Mediterranean, and occurs in soft mud from low tide to 15 fathoms (Jeffreys). As the animal generally burrows very deeply in the mud, it is most unlikely that it would be captured by a dredge.

Tapes virginea. Although shells of this species, often very fresh, were exceedingly common on all shelly grounds, living examples were only rarely taken. These occurred on the fine gravel (XIV., hauls 41 and 88), on the clean shell gravel (XVI., haul 87), and on the Prawle Stony Ground (XVIII., haul 29).

Distribution. *Geographical.* Norway to Mediterranean, but its capital is in the Celtic province (Forbes).

Depth. Shore to 145 fathoms (Jeffreys).

Bottom-deposit. Forbes (No. 24, *Brit. Assoc.*, 1850) gives five records of the species living on sand, one on shell and nullipores. Metzger records it from the *Pommerania* expedition six times on stony or gravelly ground.

Venus verrucosa. One living specimen only was taken in haul 76 on Ground VII. The haul was apparently a mixed one, showing some characters of Ground XIV. (fine gravel), and some of VII. (sand with many shells).

DISTRIBUTION. *Geographical.* A southern species extending north to south and west Ireland, and south to Mediterranean, Canaries, Madeira, Cape Verde, and the Cape of Good Hope (Locard, No. 69).

Depth. Generally in littoral and laminarian zone; seldom beyond coralline zone (Locard). The *Talisman* took it off the Canaries in 100 fathoms.

Venus casina. Shells only of this species were taken.

A southern species extending from West Norway to the Mediterranean, Madeira, and Canaries, 5–115 fathoms (Jeffreys).

Venus striatula [= *Venus gallina*]. Shells only taken.

From Iceland to Mediterranean. Sandy ground, low-water to 85 fathoms (Jeffreys, No. 55). Forbes (No. 24) records it frequently on sand, and on sand and mud; Metzger (No. 77) records it nine times on sand and shell or on sand and mud, and twice on mud; Heincke (No. 39) finds it frequent in the neighbourhood of Heligoland, chiefly on clean sand ground; and Petersen (No. 95) records it in the Kattegat on sand or on mixed deposits.

Venus fasciata (Table VI.). A few living specimens, chiefly on coarse grounds, viz.:—Ground XI., haul 9; Ground XVI., haul 13; Ground, XVII., hauls 6 and 68; and Ground XVIII., haul 45.

DISTRIBUTION. *Geographical.* From the North Cape to the Mediterranean (Jeffreys, No. 55).

Depth. Shore to deepest water around British Coasts (Jeffreys); 100 fathoms (Hoyle, west of Scotland, No. 52).

Bottom-deposit. Chiefly on gravel and gravelly sand in coralline zone (Forbes and Hanley). Metzger (No. 77) records it three times in the *Pommerania* dredgings, all on coarse ground. From the Liverpool district (No. 40, Vol. IX., p. 33) it is recorded on small gravel and shell. Petersen (No. 95) took it in the Kattegat on gravel and on sand.

Venus ovata. The shells of this species were very plentiful on all gravel and shell grounds. It was not, however, taken alive.

DISTRIBUTION. *Geographical.* From Finmark to Mediterranean and Azores.

Depth. Shallow water to 1046 fathoms (*Porcupine* expedition).

Bottom-deposit. Forbes and Hanley state that the species has a preference for gravelly sand. Forbes (*Brit. Assoc.*, 1850) records it from all kinds of bottoms; generally, however, gravel or sand. Heincke states that it is the commonest lamellibranch near Heligoland, and is frequent in muddy sand with shells and small stones at 16–32 fathoms. He also finds it on coarse sand and mud. Metzger (No. 77) took it in the North Sea nine times on coarse ground and four times on fine sand. Petersen (No. 95) found it in the Kattegat on mixed deposits (on gravel and mud, and on sand and mud).

Artemis exoleta. Two specimens were taken in haul 99 on the clean shell gravel (Ground XVI.) close to the Eddystone rocks. Shells of the species were also very numerous in the same haul, as well as on several other shelly grounds.

DISTRIBUTION. *Geographical.* Finmark to Mediterranean.

Depth. Shore to 70 fathoms (Forbes, No. 24).

Bottom-deposit. Sandy ground (Forbes and Hanley). Forbes (*Brit. Assoc. Rep.*, 1850) records it on shell and sand, on gravel, on nullipores, and on mud, as well as on sand.

Cyprina islandica. Shells only were taken on the grounds examined. These were present on the ordinary shell and gravel grounds, and also on Ground II., a fine sand ground upon which shells were not numerous.

DISTRIBUTION. *Geographical.* Lapland, Iceland, Finmark, Norway, British Seas, French Coast, Bay of Biscay: also on the coast of New England. This is a distinctly northern species [*fide* Locard, No. 69].

Depth. Shallow water to 1150 fathoms (*Porcupine*).

Bottom-deposit. Generally on muddy sand (Jeffreys, Forbes and Hanley, Metzger, Heincke, No. 30).

Circe minima. One specimen in haul 76 on Ground VII., south-west of the Eddystone. This haul was probably first on gravel and then on fine sand with shells.

DISTRIBUTION. *Geographical.* Finmark to Mediterranean, Azores, Madeira, and Canaries (Jeffreys, No. 55, and Dauzenberg, No. 20). Not recorded by Metzger in the North Sea, nor by Petersen in the Kattegat.

Depth. 5 to 704 fathoms (Jeffreys and Dauzenberg).

Bottom-deposit. Forbes and Hanley state that *Circe minima* occurs on nullipore and broken shell. Forbes (*Brit. Assoc.*, 1850) records it generally on sand, on gravel, on nullipore, and on shell, once on sandy mud. The *Challenger* took the species off the Azores in 450 fathoms on volcanic mud (Smith, No. 107).

Astarte sulcata. Taken in three hauls only, viz., 95 (on Ground X.), 73 (on Ground XIV.), and 103 (Ground XIII.). Several specimens were captured in haul 95; in the other two hauls only one in each. Shells were found on Grounds X., XIV., and XVI.

The bottom-deposit on the grounds where the living specimens were obtained is in all cases gravel, mixed with fine sand and mud (see Table II.).

DISTRIBUTION. *Geographical.* Lapland, Finmark, Norway to the Canaries. Rare in the Mediterranean (Locard, No. 69).

Depth. 7 to 1380 fathoms (*Porcupine*).

Bottom-deposit. Forbes and Hanley and Gwyn Jeffreys state that the species lives in muddy sand and in sand and mud. Forbes (*Brit. Assoc.*, 1850) records it generally from coarse ground (nullipore, shell, gravel), as well as from sand, sandy mud, and once from mud. Metzger (No. 77) records it in the *Pommerania* dredgings seven times on coarse ground, once on mud. Herdman dredged it in Kors Fjord in 89 fathoms, the dredge coming up half full of mud and stones (No. 40, Vol. VI. p. 80). The same author also records the species 1½ miles west of Contrary Head in the Isle of Man on muddy sand with stones, and where there were many ophiurids. This ground must be very similar to the grounds upon which the species was taken near the Eddystone. Haul 95, where it was most abundant, was on Ground X., the special feature of which is the abundance of *Ophiothrix fragilis*, which generally nearly filled the dredge.

Cardium echinatum. Chart XIV. Although only one living specimen of the species was obtained, the distribution of the shells is in this case so characteristic that there can be little doubt that it affords some indication of the distribution of the living molluscs. The one living specimen was obtained in haul 75 on Ground VII., south-west of the Eddystone. As has been pointed out already (see p. 389), fresh shells of *Cardium echinatum* are a characteristic feature of the fine sand of the outer and inner trawling grounds (I. and II.), where they are constantly taken, and are the only shells of any size found on those grounds. Similar fresh shells are also frequent on the fine sand ground (VI.) three miles south of the Eddystone. The shells are somewhat less numerous on Ground VII., where the sand is coarser, and they are occasionally taken on the various gravel grounds west of the Eddystone, but on these latter the valves are generally separate, old, and worn. From what we know of the habits of the species in other localities the conclusion seems justified that the animal really lives on the fine sand (Grounds I., II., and VI.), but that it lives too deeply buried in the sand to be captured by the dredge.

DISTRIBUTION. *Geographical.* Greenland, Scandinavia, British and French Coasts, Mediterranean, and Canaries (Jeffreys, No. 55).

Depth. 5–100 fathoms (Jeffreys).

Bottom-deposit. Forbes and Hanley (No. 25) give muddy ground, sandy mud, and muddy gravel. Metzger (No. 77), in the *Pommerania* dredgings, records young living specimens (10–15 mm.) on sandy mud and empty shells on fine sand. Heincke (No. 39) states that large empty shells are frequent on muddy ground, on which small living specimens are generally taken. In the Liverpool district fresh, large shells are abundant. An immense number of shells and some live specimens were thrown up at Southport, where the shore is sandy, in January, 1891 (No. 40, Vol. VI., p. 110).

Two species closely allied to *Cardium echinatum* have been distinguished by conchologists, namely, *C. aculeatum* and *C. tuberculatum.* The three species are said to differ somewhat in the relative proportions and solidity of the shell and in the length of the spines. These latter, which furnish the most characteristic distinguishing features of the three species, are long, curved, and sharp in *C. aculeatum,* short and stout in *C. echinatum,* and more like tubercles in *C. tuberculatum.* With regard to the habits of the two latter species the following quotation from Mr. A. R. Hunt's paper (No. 54) on "The Influence of Wave Currents on the Fauna inhabiting Shallow Seas" is important:—"The large cockle, *Cardium aculeatum,* is abundant in fine muddy sand off Paignton in Torbay. In this deposit the long spines of this species are of service to increase its holding powers. An allied species, *C. tuberculatum,* whose shell is rough and ribbed but not spined, dwells in hard sand at and below low-water mark off the same place. The two species are not commonly found living together, though I have found specimens of *C. aculeatum* that had been washed in from sea, and their spines denuded in the process, living side by side in hard ground with *C. tuberculatum.* In both these species the rough shells tend to prevent the molluscs being readily dislodged by the waves. Each species keeps to the ground best suited to it. The spines of *C. aculeatum* would apparently be too great an impediment in burrowing in the hard sand, whereas the spineless shell of *C. tuberculatum* would afford insufficient hold in the soft sand. A very slight advantage from form or sculpture might be of great importance in saving the cockles from local extinction; for in the case of Torbay the struggle for existence is so severe that both species are occasionally washed on shore in sufficient quantities to be carted away for manure."

Cardium echinatum is an intermediate form standing between *C.*

aculeatum and *C. tuberculatum*, and specimens are constantly taken, which are very difficult to distinguish from one or other of these forms. The fine sand in which *Cardium echinatum* lives on the Eddystone Grounds could hardly be described as fine, muddy sand, as it contains a comparatively small quantity of silt, and it seems probable that the species lives in sand intermediate in texture between that described by Hunt as occupied by *C. aculeatum* and by *C. tuberculatum*. The case is one of those in which it is extremely difficult to decide whether we are dealing with one species, which grows in a different manner according to the nature of the ground which it occupies, or with three closely-allied species, each specially adapted to sand of a particular texture. Such questions can only be settled by experimental breeding of the species.

Cardium norvegicum. The distribution of this species is shown on Chart XIV. and should be contrasted with that of *Cardium echinatum* (fresh shells). The species is most abundant on Ground XIV., which is a fine gravel ground. It extends on to the grounds immediately surrounding this, but is not abundant on the coarse gravel mixed with fine sand, one living one only being taken on Ground IX. Living specimens were also taken on Ground IV., which in other features indicates the influence of fine gravel as well as sand.

DISTRIBUTION. *Geographical*. Finmark, British Coasts to Mediterranean, Azores (Locard, No. 69), Madeira, and Canaries (Jeffreys, No. 55).

Depth. 10 or 15 to 1200 fathoms (*Talisman*, No. 69).

Bottom-deposit. Forbes and Hanley state that the species occurs on sandy or gravelly bottoms; Forbes (No. 24, *Brit. Assoc.*, 1850) records it from shell; Gwyn Jeffreys says that it is found on sandy and nullipore bottoms. Metzger (No. 77) gives three records from the *Pommerania* dredgings, viz., on stony ground, on fine sand with small balls of mud, and on fine sand with pieces of shell. From the Liverpool district the species is recorded from small gravel and shells (No. 40, Vol. VI., p. 110). Petersen (No. 95) says that in the Kattegat the species seems to prefer sand to soft, mixed grounds.

From the above records it is, I think, clear that this species is found especially on coarse ground, such as broken shell and nullipore ground. *C. norvegicum*, which has a perfectly smooth shell, may therefore be regarded as completing the series presented by *C. aculeatum*, with long spines, living in fine muddy sand; *C. echinatum*, with stout spines, living in fine sand; and *C. tuberculatum*, with tubercles, living in "hard" sand.

Montacuta substriata. This mollusc was invariably found attached to the spines of *Spatangus purpureus*, the position in which it is commonly found. Gwyn Jeffreys states that it sometimes occurs also on *Echinocardium cordatum* and on other sea-urchins.

DISTRIBUTION. Finmark to Mediterranean.

Kellia suborbicularis. Table VI. This species, taken on Grounds VII., IX., X., and XIV., west of the Eddystone, was generally found living in fine mud in the interior of dead lamellibranch shells, the valves of which had remained together.

DISTRIBUTION. *Geographical.* Finmark to Mediterranean and Canary Islands (Jeffreys). Kerguelen Islands (*Challenger*, No. 107).

Depth. Low-water to 809 fathoms (*Porcupine*).

Bottom-deposit. Both Forbes and Hanley, and Gwyn Jeffreys mention the habit of this species of living in the mud inside dead bivalves. Jeffreys also states that it is sometimes found under stones at the lowest range of spring tides, sometimes in the excavations made by other animals in rocks

Modiola sp. Small specimens of *Modiola*, which I am inclined to regard as young *Modiola modiolus*, were frequently taken attached to shells and at the roots of *Cellaria*, hydroids, etc. *Modiola barbata* has also been recorded.

Nucula nucleus. Two living specimens only were taken, one in haul 76 (Ground VII.) and one in haul 103 (Ground XIII.). The former haul (76) is probably a mixed haul, first on fine gravel and then on somewhat coarse sand. Haul 103 is on gravel mixed with a good deal of mud. Empty shells were taken on Grounds VI., XIII., and XIV.

DISTRIBUTION. *Geographical.* Lofoten Islands; British Coasts, etc., to Morocco and the Mediterranean (Locard, No. 69).

Depth. 3 fathoms (Jeffreys) to 219 fathoms (No. 61, *Caudan* expedition).

Bottom-deposit. Forbes and Hanley (No. 25) state that *Nucula nucleus* frequents coarse bottoms (7–10 fathoms) and gravel, or muddy gravel to 90 fathoms. Forbes (No. 24, *Brit. Assoc.*, 1850) records it from gravel, from stony ground, from nullipores, from sand, and occasionally from mud. Gwyn Jeffreys says it is common on sand and gravel. Metzger (No. 77) records it on sand and shell, on mud and sand, on fine sand and on mud. Heincke (No. 39) states that at Heligoland the species is very common on fine muddy sand with shells and small stones, where it is associated with *Venus ovata*, *Cardium fasciatum*, and *Trochus tumidus*. Petersen (No. 95) records it from mixed deposits (muddy sand and gravel). On the whole, therefore, we may conclude that the natural home of the species is upon gravels and coarse sand mixed with mud. The following species (*N. nitida*) is found largely on fine sand as well as on coarser ground.

Nucula nitida. This was only taken once, viz., on the outer Eddystone Trawling Ground (II.) in haul 104. It was obtained in the sample of fine sand brought up with canvas bag dredge. This explains why it was not seen in the other hauls on Ground II. Several living specimens were buried in the fine sand (for the composition of this sand see Table II.), and its shells were very numerous.

DISTRIBUTION. *Geographical.* Greenland, Norway, British Coasts to Mediterranean (Jeffreys, No. 55).

Depth. Low tide-mark to 86 fathoms (Jeffreys); to 100 fathoms (Hoyle, No. 52).

Bottom-deposit. Forbes and Hanley state that the species occurs on sand in shallow water, whilst Gwyn Jeffreys says only that it is found with *Nucula nucleus*, but is neither so generally diffused nor so plentiful. Forbes (*Brit. Assoc.*, 1850), gives several records, the majority (eight) being on coarse ground, whilst four are on sand or on sandy mud. Metzger (No. 77) mentions it twice in the *Pommerania* dredgings on grey calcareous mud and on mud. Petersen (No. 95) says that in the Kattegat *Nucula nitida* is never found on the mud ("clay"), is occasionally met with on sand and mud, but that it prefers clean sand. Heincke (No. 39) states that near Heligoland it is frequent on pure mud, or mud with a little sand mixed, and that it only occasionally occurs with *N. nucleus*.

It must be admitted that the above records are not very consistent, and cannot be held to afford much confirmation of the idea that *N. nucleus* is a coarse ground species (gravel, broken shell, nullipores, etc.) whilst *N. nitida* prefers fine sand.

Arca tetragona. A few small specimens attached to shells, etc., on the Bolt Head Shell Gravel (XVII.) and on the Prawle Stony Ground (XVIII.).

DISTRIBUTION. *Geographical.* Finmark to Mediterranean, Azores and Canaries (Jeffreys).

Depth. Shore to 450 fathoms (*Challenger*, No. 107); to 704 fathoms (*Monaco* expedition, No. 20).

Bottom-deposit. Crevices of rocks and chinks of old shells (Forbes and Hanley).

Pinna pectinata. Shells only of this species were obtained. Small single valves were moderately frequent on the Eddystone Grounds.

DISTRIBUTION. *Geographical.* British Coasts to Mediterranean and Canaries. On British Coasts it appears to be only common in the western portion of the English Channel.

Depth. Low spring tides to 320 fathoms (*Porcupine*).

Bottom-deposit. In muddy and sandy gravel (Jeffreys). According to Forbes and Hanley, Montagu found the species in Salcombe Bay at low spring tides, sticking in the gravel with the valves upright, the broader end about one inch above the surface.

Pectunculus glycimeris. Chart XV. Both living specimens and shells of this species were abundant on the Bolt Head Shell Gravel (Ground XVII.) and on no other ground. One small living specimen was obtained on the Prawle Stony Ground (XVIII.) in haul 29, and another small one in haul 97 on the fine gravel (Ground XV.) east of the Eddystone. Shells were occasionally taken on the gravels west of the Eddystone (see Table VI.), but they were never abundant. *Tubiclava cornucopiae* is often found growing on the posterior end of living examples of this bivalve (see p. 445).

DISTRIBUTION. *Geographical.* Lofoten Islands to Mediterranean, Madeira, and Canaries.

Depth. 7 fathoms (Jeffreys) to 250 fathoms (*Porcupine*).

Bottom-deposit. Forbes and Hanley say of this species that it is gregarious and prefers a nullipore bottom. Forbes (*Brit. Assoc.*, 1850) gives records from sand, gravel, nullipores, and mud and stones. Gwyn Jeffreys says it occurs on sandy and shelly gravel and on nullipores. *Pectunculus glycimeris* is not recorded by Metzger in the North Sea, nor by Petersen in the Kattegat. In the Liverpool district it is recorded on nullipore ground (No. 41, p. 319), on stones, sea-weeds, and dead shells (No. 41, p. 323), on shells, stones, and echinoderm spines (No. 40, Vol. VIII., p. 20), and on shells, sand, and gravel (No. 40, Vol. IX., p. 34). It is clearly very generally confined to coarse grounds.

Lima Loscombii. Chart XV. This species was most numerous in haul 10 on the clean shell gravel north-west of the Eddystone (Ground XVI.), and several living specimens were taken in haul 46 on the coarse gravel and sand of Ground XI. In both these hauls the shells were also numerous. Single living specimens were taken in hauls 35 and 41 (Ground XIV.), haul 75 (Ground VII.) and haul 93 (Ground IX.), all of them coarse grounds to the west of the Eddystone.

In one haul on the Bolt Shell Gravel (haul 27, Ground XVII.) several specimens of the species were taken, but it was not captured alive in other hauls in the neighbourhood of Bolt Head and Prawle.

No specimens were taken on any of the fine sand grounds.

DISTRIBUTION. *Geographical.* Greenland, Iceland, Scandinavia to the Mediterranean, Azores, and Madeira (Jeffreys, No. 55, and Locard, No. 69). Tristan da Cunha (*Challenger*).

Depth. Shore at low-water (Forbes and Hanley) to 1480 fathoms (*Porcupine*).

Bottom-deposit. Forbes and Hanley state that *Lima Loscombii* occurs on gravel, on nullipores, and on scallop-banks. Forbes (*Brit. Assoc.*, 1850) gives eight records, all on gravel, on shell, on nullipore, or on stony ground. Gwyn Jeffreys says it lives on sandy or gravelly ground. Metzger (No. 77) records it once only in the *Pommerania* dredgings (Hongesund Schären) on stony ground. In the Liverpool district it is recorded on nullipore ground (No. 41, p. 319) and on "reamy bottom" (*i.e.*, sand or gravel mixed with mud). Petersen (No. 95) found it in the Kattegat eight times on muddy gravel, four times on sand and mud, and four times on mud or pure mud ("Slik" or "Ren Slik"). The *Challenger* (No. 107) took it off the Azores in 450 fathoms on volcanic mud.

From the above records it appears that the species is usually found on coarse ground often, if not generally, mixed with mud, but that it may occur also on mud.

With regard to the nest-building habit of *Lima* Gwyn Jeffreys says that this species (*L. Loscombii*) seldom makes a nest, although specimens in nests have been seen both by himself and by Sars. He remarks further that "in all probability this habit depends on the nature of the sea-bottom. When the latter is soft mud the *Lima* can partly bury itself, and does not require to be otherwise protected from its voracious enemies. The haddock seems fond of it, the shells being often found in its stomach."

Pecten maximus. Chart XIV. Moderately abundant on the various gravel grounds in the neighbourhood of the Eddystone, two or three specimens being generally taken in each haul of the dredge. It was most numerous on Ground IX., where the bottom-deposit is coarse gravel mixed with fine sand. The species was entirely absent from the fine sand grounds and from the Bolt Head shell gravel. On the Prawle Stony Ground one small specimen only was obtained (in haul 4).

DISTRIBUTION. *Geographical.* Norway, British Seas, France, etc., to Azores, Madeira, and Canaries (Jeffreys, No. 55; Locard, No. 69). The species does not appear to be common in the North Sea. Metzger (No. 77) gives no records from the *Pommerania* North Sea dredgings, and Heincke (No. 39) does not record it from Heligoland. Forbes and Hanley state that Bean took only three alive during very many years at Scarborough. It is scarce in the Kattegat (No. 95).

Depth. Shallow water (Forbes and Hanley, 3 fathoms) to 848 fathoms (Locard, No. 69, Azores).

Bottom-deposit. Forbes (*Brit. Assoc.*, 1850) records living *Pecten maximus* twice from shell, once from gravel, once from sand. Metzger (*Pommerania* expedition) gives one record (Sölsvig, 0–20 fathoms) on stones and bivalve shells. Petersen (No. 95) found it three times in the Kattegat on gravel and small stones, on shell gravel, and on gravel, mud, and stones. In the Liverpool and Isle of Man districts *P. maximus* is recorded on nullipore ground, on fine gravel, on muddy sand and stones, and on sand and shell fragments (No. 40, Vol. IX., pp. 33 and 34; No. 41, p. 319). In the record on muddy sand and stones it is stated that many ophiurids were present, which indicates a similarity with the gravels to the west of the Eddystone, where we have obtained the species. In the Isle of Man haul, on sand and shell fragments, *Pectunculus glycimeris* was also taken. On the grounds described in the present report *P. glycimeris* was only numerous on the Bolt Head shell gravel, and on this ground *P. maximus* was never taken. The above records show that *Pecten maximus* is generally found on coarse ground, especially where there is a considerable admixture of mud.

Pecten opercularis. Chart XIV. This, as is well known, is a gregarious species often occurring in large shoals or flocks. These shoals are often of comparatively limited size, so that two hauls near together, and taken on what have been regarded as the same ground, have differed very much in the number of *P. opercularis* captured. The species was taken in larger or smaller numbers on each of the eighteen grounds into which the district examined has been divided, and Chart XIV. indicates roughly the relative frequency upon the different grounds. The species is most numerous on the Eddystone gravels and on the sand immediately outside these. The largest beds occurred on Grounds IV., IX., and XIV. On the fine sand of the outer trawling ground (Ground II.) many specimens were captured in one haul only, viz., haul 24. On the Bolt shell gravel and on the Prawle Stony Ground *P. opercularis* was never numerous, and was generally not taken at all.

On all the Eddystone Grounds young *Pecten opercularis* from about 0·5 mm. breadth were abundant, attached to hydroids (especially *Halecium halecinum* and *Sertularella Gayi*), wherever these were common, both on gravel and on fine sand bottoms.

Distribution. *Geographical.* Norway to Mediterranean, Azores, Madeira, and Canaries (Locard, No. 69).

Depth. 5 fathoms (Forbes and Hanley) to 1457 fathoms (*Porcupine*).

Bottom-deposit. The records, which are fairly numerous for this species, indicate that the mollusc may occur on both coarse and fine bottoms, on gravel, on sand, or on mud. In the Kattegat Petersen (No. 95) found *P. opercularis* chiefly on the mixed deposits and not on the pure mud. On the latter *P. radiatus* was the frequent species.

Pecten tigrinus (Table VI.). Living specimens of this species were not abundant, one or two in a haul being the largest number taken. Shells also were not very numerous. The living specimens were for the most part taken on coarse ground.

Distribution. *Geographical.* Iceland, Scandinavia, British Seas to Vigo Bay (Jeffreys, No. 55).

Depth. 7 fathoms (Jeffreys) to 106 fathoms (*Pommerania*, No. 77).

Bottom-deposit. Forbes and Hanley state that the species is found on shells, gravel, and sandy mud. Forbes (No. 24, *Brit. Assoc.*, 1850) gives seven records on nullipore, on gravel, or on shell, three on sand, one on sandy mud, and one on mud. Gywn Jeffreys says that the species is found on a sandy bottom mixed with gravel. Metzger (No. 77) records it three times on stony ground, once on sand, and once on mud. Petersen (No. 95) found *Pecten tigrinus* (living) in the Kattegat three times on gravel or shell, five times on sand and mud, and once on mud. In the Liverpool district it is recorded on shell and gravel (No. 40, Vol. IX., p. 33). The species may be found on either gravel, on sandy mud, or on mud, and its distribution seems to be little influenced by the nature of the deposit.

Anomia ephippium and *Anomia patelliformis.* These two species are found on all grounds where they can find suitable places of attachment.

These they find least frequently on the fine sand grounds. *Anomia* is taken attached to stones, shells—both living and dead—worm tubes, and various crabs, especially *Inachus dorsettensis* and *Hyas coarctatus*.

DISTRIBUTION. *Geographical.* *A. ephippium*—Iceland, Finmark, Lapland, Norway, West Europe to Madeira and Azores; Labrador, Brazil, Cuba, and Corea (*fide* Locard, No. 60). *A. patelliformis*—Lofoten Islands to Azores, North-East America (ditto).

Depth. *A. ephippium*—Low-water (Jeffreys) to 1118 fathoms (*Lightning*, *fide* Locard, No. 60). *A. patelliformis*—10 fathoms (Jeffreys) to 771 fathoms (*Porcupine*).

Bottom-deposit. The authors for the most part state simply that the animals are found attached to stones and shells.

Chiton asellus. On all grounds where there are suitable objects, shells, stones, etc., upon which it can fix. Least frequent on the fine sand grounds. A favourite locality is on *Lepralia foliacea* when that polyzoan is present.

DISTRIBUTION. *Geographical.* Greenland, Iceland, Scandinavia, British Seas, Vigo Bay, Mediterranean (Jeffreys).

Depth. Laminarian zone to 145 fathoms (Jeffreys).

Bottom-deposit. The authors all state that *C. asellus* is common on shells and stones.

Chiton discrepans. Two specimens (flesh-coloured) were found on the Prawle Stony Ground (XVIII.), on red trias rock, in haul 4.

Gwyn Jeffreys states that this species is found in the Channel Islands, Cornwall, French Coast, and in the Mediterranean, from low-water to 25 fathoms.

Dentalium entalis (Chart XV.) has been obtained on all fine sand grounds upon which the dredge, fitted with a canvas bag, has been used, with the exception of haul 104 on the fine sand of the outer trawling ground (Ground II.). It is seldom captured by the ordinary dredge or by the trawl. Occasionally only on gravel grounds.

DISTRIBUTION. *Geographical.* Iceland, West Europe to Mediterranean, State of Maine, and North-West America (Jeffreys).

Depth. 3 fathoms (Jeffreys) to 300 fathoms (Herdman, No. 40, Vol. VI., p. 82).

Bottom-deposit. Forbes (No. 24, *Brit. Assoc.*, 1850) records it thirteen times from gravel, shell, or nullipore bottom, seven times from sand, six times from sandy mud, five times from mud. Metzger (No. 77) records it generally from muddy sand in the North Sea. Petersen (No. 95) in the Kattegat from deposits containing a considerable admixture of mud ("stærkt lerblandet Bund"). Herdman records it from mud at 200 fathoms in Norway (*l. c.*, p. 80).

Pileopsis hungaricus. This species has been taken only on the gravels west of the Eddystone (Grounds XI., IX., X., and XIV.) and on the Bolt Head Shell Gravel (XVII.). It is found attached to shells.

DISTRIBUTION. *Geographical.* Iceland, Finmark to Gibraltar, and Mediterranean (Jeffreys).

Depth. 7–145 fathoms (ditto).

Bottom-deposit. The authors agree in stating that the species occurs on rocky and stony ground or on shells.

Emarginula reticulata (Table VI.) = *E. fissura* of Jeffreys. Very constant, but seldom in great numbers, on all the grounds where shells (upon which it creeps) are plentiful.

Distribution. *Geographical.* Finmark to Mediterranean and Canaries (Jeffreys, No. 55, and Locard, No. 69).

Depth. Shore to 809 fathoms (*Porcupine*).

Bottom-deposit. Forbes (*Brit. Assoc.*, 1850) gives many records, all on coarse ground. Metzger (No. 77) found it on stony ground and Petersen (No. 95) on mixed deposits. Gwyn Jeffreys says it occurs everywhere on shells and stones from low-water to 145 fathoms.

Emarginula rosea. Once only, in haul 8, on Ground XI.

Distribution. *Geographical.* South Coast of England, French Coast, and in the Mediterranean (Jeffreys).

Depth. 7–25 fathoms (Jeffreys).

Bottom-deposit. Forbes (*Brit. Assoc.*, 1850) gives two records, on gravel and nullipores and on shell.

Trochus granulatus. On the Eddystone Grounds this species was taken on IX., XI., and XIII., all of them with a bottom-deposit of coarse gravel mixed with sand or muddy sand. One specimen was also taken on the Bolt Head Shell Gravel (XVII.) in haul 27, where the bottom is recorded as shells, broken shells, gravel, and sand.

Distribution. *Geographical.* Scottish and English Coasts, France, Spain, Canaries, Madeira, and Mediterranean (Jeffreys, No. 55; Locard, No. 69).

Depth. Coralline zone to 2105 fathoms (*Travailleur*, Locard).

Bottom-deposit. Forbes (No. 24, *Brit. Assoc.*, 1850) gives three records, on shell, on mud and stones, and on gravel.

Trochus zizyphinus. The small deep-water variety of this species was occasionally taken, viz., on Grounds XIV. (fine gravel) and XVII. and XVIII., the Bolt Head Shell Gravel Ground and the Prawle Stony Ground respectively.

Distribution. *Geographical.* Finmark to Canaries and Mediterranean.

Depth. Shore to 450 fathoms (*Challenger*, No. 107).

Bottom-deposit. The chief habitat is on sea-weeds and rocks on the shore and in the laminarian zone. Records from deeper water by Forbes (*Brit. Assoc.*, 1850) are from all kinds of bottom. The *Challenger* specimen was from volcanic mud off the Azores.

Turritella communis. Chart XV. Both shells and living specimens of this species were numerous on Ground IX. (hauls 93 and 94), which has a bottom-deposit composed of a mixture of coarse gravel and fine sand. The only other haul in which living specimens were taken was haul 39 on Ground IV. (three miles east of Eddystone).

Distribution. *Geographical.* Lofoten Islands to Mediterranean (Jeffreys, No. 55).

Depth. 5–100 fathoms (Jeffreys). Forbes and Hanley say that it occurs in immense numbers in some places in 7–10 fathoms In 219 fathoms (Koehler, No. 61).

Bottom-deposit. Forbes and Hanley (No. 25) state that the species lives especially in muddy and weedy localities. Forbes (*Brit. Assoc.*, 1850) gives nine records on mud mixed with stones, gravel, or sand; eight on gravel or stones or nullipores; four on sand. Metzger (No. 77) gives five records from the *Pommerania* dredgings on sandy mud, one on mud, one on stones, and one on sand, shells, and small stones. Petersen (No. 95) found the species in the Kattegat on mixed deposits (sand or gravel with mud) and on mud, but not on clean sand. The Liverpool Biological Society (No. 40) give three records, on sandy mud (30 fathoms), on mud in 34 fathoms, and on the deeper mud in 50 fathoms, where it is a characteristic species.

From the above records it is clear that *Turritella communis* generally frequents a bottom of soft mud, or one in which there is a considerable proportion of mud mixed with coarser deposits. Under these circumstances it seems rather strange that it should have been abundant near the Eddystone on Ground IX., whilst it was absent on Ground XIII. As will be seen from Table II., the bottom-deposits on these two grounds are both coarse gravel, mixed in the one case (IX., haul 94) with fine sand, in the other (XIII., haul 103) with mud; that is to say, the percentage of silt in the latter case is very much greater than in the former. We should have expected to find *Turritella* abundant on the more muddy ground, but this is not the case.

Aporrhais pes-pelecani. This mollusc was only twice obtained living, once in haul 87 on the clean broken shell of Ground XVI., and once in haul 55 on the coarse gravel mixed with fine sand of Ground X., both on the west side of the Eddystone. Shells were frequently taken on many other grounds, especially on the gravels to the west of the Eddystone. These shells were sometimes occupied by hermit crabs, sometimes by *Phascolion strombi.*

DISTRIBUTION. *Geographical.* Iceland, Finmark, British Coasts to Gibraltar and Mediterranean (Jeffreys, Locard).

Depth. 5 fathoms (Jeffreys) to 200 fathoms (Herdman, No. 40, Vol. VI., p. 80).

Bottom-deposit. Forbes and Hanley say that *Aporrhais pes-pelecani* is found on gravelly bottoms. Forbes (*Brit. Assoc.*, 1850) gives seven records on coarse ground, two on sand, one on sandy mud, and three on mud. Metzger gives four records from the *Pommerania* dredgings, viz., on fine sand and shell, on sand, on muddy sand, on shell and small stones. Petersen found the species frequently all over the Kattegat, generally on the mixed deposits (muddy sand or muddy gravel), occasionally on pure sand, seldom on mud. Heincke (No. 39) found it at Heligoland only on muddy sand with some gravel. Herdman found *Aporrhais pes-pelecani* in Norway on mud and stones and on mud (200 fathoms). In the Liverpool district Herdman records a very large number of living specimens opposite Fleshwick Beach in 13 fathoms (No. 40, Vol. VIII., p. 18). In his subsequent paper on the floor deposits of the Irish Sea (No. 44) the same author describes a sample of the bottom-deposit off Fleshwick Bay in 12 fathoms, which, I presume, refers to the spot where these specimens were taken. This deposit consisted of slaty gravel mixed with shells, and with fine material consisting of sand and a very fine "sand flour." Herdman also records the species west of Fleshwick Bay, ¼ mile off shore, in 13 fathoms, on fine sand and broken shell (No. 40, Vol. IX., p. 32). From these records it seems probable that the distribution of *Aporrhais pes-pelecani* is not directly influenced by the nature of the bottom deposit, and that the animal can live upon any kind of bottom, provided the food supply and other conditions are satisfactory. It appears, however, that it is upon muddy gravel that the species finds the conditions most suited to its needs and that it is most abundant With reference to the peculiar shape of the shell of this animal, the following suggestion, due to Mr. A. R. Hunt from his paper, "On the Influence of Wave Currents on the Fauna inhabiting Shallow Seas" (No. 54), is worth quoting in full :—"The Gastropod *Aporrhais pes pelecani* is a sluggish mollusc that frequents exposed areas of sand a few fathoms below the surface of the water. Its long wing-like processes, jutting out on one side of the shell, though affording the animal a broad base on which to rest, appear at first sight to be a source of danger in case it were overturned. They are in reality self-acting pieces of mechanism that will, in the majority of instances, ensure the mollusc being ultimately left in its normal posture should it encounter wave currents sufficiently strong to upset it. On examining a specimen of *Aporrhais pes-pelecani* it will be seen that, when on its back, it lies indifferently on either side of a line drawn between two points, of which the end of the middle wing-like process is one, and one of the nodules on the body-whorl the other. The shell will rock freely backwards and forwards across this line; and experiment proves that a very moderate alternate current will suffice to replace the shell in its normal position. I have tried this experiment over and over again, not only with *Aporrhais*, but also with heavy foreign shells furnished with spines, processes, and more or less developed lips, such as *Murex*, *Pterocerus*, and *Strombus*. In many cases the righting action of wave currents is most marked."

Eulima polita. Living specimens of *Eulima polita* were obtained twice, once in haul 84, on the coarse gravel mixed with fine sand of Ground XI., and once in haul 103, on Ground XIII., where the bottom-deposit is coarse gravel mixed with mud.

DISTRIBUTION. *Geographical.* Finmark to Ægean (Jeffreys).

Depth. 2–80 fathoms (Jeffreys).

Bottom-deposit. Forbes and Hanley state that *Eulima polita* frequents sandy bottoms. Forbes (*Brit. Assoc.*, 1850) gives seven records from coarse ground (shell, nullipore, gravel, etc.) and two from sand. Gwyn Jeffreys says it is found on muddy sand. Metzger (No. 77) records it once on stony ground.

Natica nitida (= *N. Alderi* of Jeffreys). One specimen only in haul 46, on Ground XI., bottom coarse gravel with fine sand.

DISTRIBUTION. *Geographical.* Lofoten Islands to Mediterranean (Jeffreys, No. 55).

Depth. Low-water to 135 fathoms (Locard, No. 69).

Bottom-deposit. Forbes (No. 24, *Brit. Assoc.*, 1850) gives thirteen records from coarse ground, five from sand, three from mud. Gwyn Jeffreys says it occurs everywhere in sand. Metzger (No. 77) gives eleven records on coarse ground, twelve on sand, fine sand, or sandy mud. It appears, therefore, that the species frequents coarse and fine ground about equally.

Lamellaria perspicua. A few specimens of this species were obtained on Grounds VII. and XI. in the neighbourhood of the Eddystone and on the Bolt Head shell gravel (XVII.). It is generally found crawling on hydroids.

DISTRIBUTION. *Geographical.* Norway to Azores, Madeira, and Mediterranean. Also Canadian and United States Atlantic Coasts (Jeffreys).

Depth. Low-water to 704 fathoms (Dauzenberg, No. 20).

Bottom-deposit. Most abundant on sea-weeds, etc., in tidal and laminarian zones.

Nassa incrassata. This was taken alive on the Prawle Stony Ground (XVIII.).

DISTRIBUTION. *Geographical.* Iceland to Azores and Mediterranean (Jeffreys).

Depth. Low-water to 145 fathoms.

Bottom-deposit. The authors agree that the species frequents stony ground, especially in the tidal and laminarian zones.

Buccinum undatum (Chart XV.). The common whelk was numerous on the gravel and coarser sand grounds in the neighbourhood of the Eddystone and on the Bolt Head Shell Gravel. It was entirely absent from the fine sand of the outer and inner trawling grounds, and was only taken once on the Prawle Stony Ground (haul 45).

As will be seen from Chart XV., the species was absent also from the clean shell gravel close to the Eddystone rocks (Ground XVI.), and was very scarce on the fine gravel of Ground XIV. As this latter was a very rich ground, the almost entire absence of whelks is noteworthy.

DISTRIBUTION. *Geographical.* Both sides of the North Atlantic from the North Cape and Iceland to Rochelle and Massachusetts. In the stomach of *Trigla gurnardus* in the Gulf of Lyons (*fide* Jeffreys).

Depth. Low-water to 180 fathoms (*Porcupine*, *fide* No. 33).

Bottom-deposit. Forbes (No. 24, *Brit. Assoc.*, 1850) records *Buccinum undatum* from all kinds of bottom-deposits, and the other authors agree with this. Heincke (No. 39) says that near Heligoland it is specially common on sandy mud and on pure mud. Petersen (No. 95) found it common all over the Kattegat. The animal is able to burrow in sand (Jeffreys).

Fusus islandicus (= *F. gracilis* of Jeffreys). Taken only in hauls 105 and 107 on the Bolt Head Shell Gravel, where several living specimens and a number of shells were obtained.

DISTRIBUTION. *Geographical.* A northern species. White Sea (?), Russian Lapland, Iceland, Faröe Islands, Norway, Sweden, Kattegat,* British Seas, North of France, Loire-Inférieure. Rare in the South of England, common on northern fishing banks (Jeffreys).

Depth. 20–145 fathoms (Jeffreys).

Bottom-deposit. Forbes (*Brit. Assoc.*, 1850) found it on shell, on stones, on sandy gravel, and on sand; Metzger on sandy mud, and on sand, shells, and stones.

Cypraea europaea (Table VI.). Not uncommon in the neighbourhood of the Eddystone, on the coarser sand grounds, and on the Prawle Shell Gravel, especially amongst hydroids and *Cellaria.*

DISTRIBUTION. *Geographical.* Drontheim to Gibraltar and Mediterranean (Jeffreys).

Depth. 0–100 fathoms.

Bottom-deposit. Forbes (No. 24, *Brit. Assoc.*, 1850) gives ten records, all on coarse ground, and Gwyn Jeffreys says the species occurs on stony and coral grounds. Metzger (No. 77) gives two records, one on stony ground and one on sand.

Ovula patula (Table VI.). Single specimens were taken on Grounds II., VIII., and XVIII. The species is generally found on *Alcyonium digitatum.*

DISTRIBUTION. *Geographical.* British Coasts, Gulf of Lyons (?) (Jeffreys).

Depth. Coralline zone (Jeffreys).

Bottom-deposit. On *Alcyonium* (Forbes and Hanley).

Dondersia banyulensis, Pruvot. A few specimens of this species, which is very conspicuous owing to its bright red colour, were obtained always upon colonies of *Lafoea dumosa.* It is recorded on Grounds III., IV., and X.

The species was first described by Pruvot (No. 97), who found it always on *Lafoea dumosa.* It is relatively abundant at Banyuls, in the Mediterranean, in 25–165 fathoms, and a few specimens were obtained at Roscoff, in Brittany, in 44 fathoms.

Proneomenia aglaopheniae (Kowalevsky et Marion). This Neomenian was met with not unfrequently coiled around the stem of *Aglaophenia myriophyllum,* though it was present on only a small proportion of the total number of specimens of the hydroid which were taken. It is recorded on Grounds III., VII., VIII., XI., XII.

* Petersen does not record it. Jeffreys gives it on the authority of Jonas.

Proneomenia aglaopheniae was described by Kowalevsky and Marion (No. 62) from specimens obtained at Marseilles, and has since been taken by Pruvot (No. 97) at Banyuls (33-44 fathoms). In both cases the animal was coiled around the stem of *A. myriophyllum.* The specimens from the Eddystone Grounds are, so far as I am aware, the only ones which have been taken outside the Mediterranean.

NUDIBRANCHIATA (Table VI., p. 533). By far the most numerous nudibranchs taken were *Doto fragilis* and *Lamellidoris oblonga.* The former species was abundant on grounds where hydroids were plentiful, especially on the coarse gravels to the westward of the Eddystone, where *Halecium halecinum* was the characteristic species. On the fine sand grounds *Doto pinnatifida* and *Doto coronata*, which were not taken on the gravel, were also met with. *Lamellidoris oblonga* is associated always with *Cellaria fistulosa* and *sinuosa*, and is present on the grounds where these species are abundant. (*Cf.* Garstang, *Jour. Mar. Biol. Assoc.*, III., p. 220.) Occasional specimens only of other nudibranchs were taken, as will be seen from Table VI., and also from the descriptions of the grounds.

Most of the specimens were identified by Mr. W. I. Beaumont. With regard to the geographical distribution of these forms I am unable to add anything to the information given by Norman in his *Revision of the Mollusca* (No. 91).

POLYZOA.

For nomenclature and for geographical distribution (Table VI., p. 534) I have relied entirely upon Hincks (*History of British Marine Polyzoa*). The specimens in several of the earlier hauls were identified by Mr. T. H. Taylor. The distribution of only a very few of the species of Polyzoa on the grounds investigated offers any points of interest.

Cellaria fistulosa and *Cellaria sinuosa.* Both these species are abundant on the fine sand grounds in the neighbourhood of the Eddystone (Grounds I., III., IV., VI., VIII.), where they form a marked and characteristic feature of the fauna. Whenever the trawl is used on these grounds masses of *Cellaria* are taken, and the polyzoan, which is attached either to small pieces of shell or directly to the sand by means of its root-fibres, affords a fixing-place for the smaller hydroids (*e.g.*, *Clytia Johnstoni*) and for the nudibranch *Lamellidoris oblonga.* At the bases of the colonies the polyzoon *Scrupocellaria scruposa* is often attached, and very small specimens of *Ophiothrix fragilis* find a hiding-place. The extreme scarcity of *Cellaria* on the fine sand of the Outer Trawling Ground (II.) is noteworthy (*cf.* p. 393), as well as its scarcity on Ground V., to the north of the Eddystone. On the gravels to the westward of the Eddystone only occasional pieces of these polyzoa are met with, whilst it has never been taken on the shell gravel grounds. (Chart XVI.)

Scrupocellaria scruposa. After the two species of *Cellaria* this is the most abundant branched polyzoan. It is plentiful both on the fine sand grounds and on the gravels in the neighbourhood of the Eddystone. It is generally attached to the tubes of polychaetes (*e.g.*, *Thelepus*, *Chaetopterus variopedatus*) or to the base of *Cellaria*. It is rarely met with on the shell gravel grounds and on the Prawle Stony Ground.

Bicellaria ciliata is not unfrequently met with attached to hydroids of various kinds. The most common species of *Bugula* is *B. avicularia*, and *B. flabellata* is also occasionally taken. *Cellepora avicularis* and *Cellepora ramulosa* are abundant on the fine sand grounds attached to hydroids. *Incrusting Polyzoa* are plentiful on all grounds where mollusc shells are numerous (see Table VI.).

TUNICATA.

Nomenclature:—Herdman, "Revised Classification of the Tunicata," *Journ. Linn. Soc.*, XXIII., 1891.

In the identification of the Tunicata I have received much help from my colleague, Mr. W. Garstang.

Molgula oculata. Specimens of this species were only occasionally taken, covered in each case with broken shell gravel. They occurred on the clean broken shell of Ground XVI. immediately to the westward of the Eddystone rocks, and on the coarse gravel of Ground XI. to the north-west of the Eddystone. The species is one which is usually taken only on coarse ground.

Molgula simplex. Specimens which we have identified as *M. simplex* occurred somewhat frequently on *Chaetopterus* tubes, though they were not recorded in many of the hauls, owing to their only having been identified at a somewhat late stage in the investigation. The specimens were usually 5 or 6 mm. in diameter. The species probably occurs on all the *Chaetopterus* grounds.

Forbesella tesselata. One specimen only on the fine gravel ground XV.

Styelopsis grossularia. The small squat variety of this species was not unfrequently met with on shells, especially *Pecten* shells, on the gravels to the westward of the Eddystone and on the Bolt Head Shell Gravel.

Polycarpa varians, Heller = (*P. pomaria*, Sav.). This species is very much restricted to one area, west and south-west of the Eddystone, where, however, it is abundant, and forms a striking and characteristic feature of the fauna. It is very abundant on Grounds IX. and XIV., on both of which the bottom-deposit is gravel, and also on those hauls on Ground X. which are not entirely occupied by *Ophiothrix fragilis.* The species extends south of these grounds to Ground VII., where in some hauls it is still moderately plentiful. On the gravel to the north-west of the Eddystone (Ground XI.) specimens were taken only in haul 47, whilst on the gravel to the south-west (Ground XIII.) only one or two very small ones were seen, although on both these grounds the general fauna is very similar to that of Ground IX. The specimens were found in most cases attached directly to the gravel, with which their bases were covered when they came up, but were sometimes also attached to shells.

The only other record of the species was of two small specimens attached to a shell in haul 92 on the fine sand of Ground I., so that it may be regarded as practically absent from all fine sand grounds, as well as from the Bolt Head and Prawle Grounds. (Chart XVI.)

Ascidiella venosa. Occasional specimens only were taken. These were on Grounds IV., XI., and XVI.

Ascidiella scabra. Although some specimens of *A. scabra* have been met with on almost every ground examined, when the question of abundance is considered it is found that the species has a very definite and characteristic distribution. It occurs in greatest abundance on the fine sand grounds, being specially numerous where the hydroid *Sertularella Gayi* is plentiful, its favourite situation being at the base of the stem of the hydroid. On the coarse grounds near the Eddystone, where *Sertularella* seldom occurs, specimens of *Ascidiella scabra* are only rarely seen, and are then attached either to shells, to the tubes of *Chaetopterus*, or on the backs of *Inachus dorsettensis.* On the Bolt Head Shell Gravel one or two were seen in hauls 20 and 107 only, and the species was never taken on the Prawle Stony Ground. (Chart XVI.)

Ascidia depressa (Garstang, *Journ. Mar. Biol. Assoc.*, Vol. II., p. 125). Not uncommon on the Bolt Head Shell Gravel, attached to shells. With the exception of an occasional specimen on the Prawle Stony Ground the species was not elsewhere taken.

Ascidia mentula. Taken once on the Bolt Head Shell Gravel.

Ciona intestinalis. Occasional specimens attached to shells on Grounds II., VII., XIV., XVII., and XVIII., being most frequent on XVII., the Bolt Head Shell Gravel.

Compound Ascidians. These have not been identified. A species of *Botryllus* was not uncommon, and a *Didemnid* was plentiful on *Cellaria.*

Fishes.

As the trawl was only used on a few of the grounds, the list of fishes is very incomplete. I shall enter into no discussion on the subject of their distribution, as my colleague, Mr. Holt, is engaged in a study of the distribution of the fishes on all the grounds in the Plymouth district, and those met with in the present investigation, which were for the most part identified by him, will be included in his general account.

For the Geographical Distribution, as given in Table VI., I have relied on Smitt's *Scandinavian Fishes* and on Günther's *British Museum Catalogue*.

Section VII.

GENERAL CONSIDERATIONS.

The Association of Species with one Another. In the descriptions of the grounds investigated, as well as in the accounts of the distribution of individual species, numerous instances of the definite association of one species with another have been pointed out. Many of these are examples of the kind of association which is already well known, *e.g.*, *Sagartia parasitica* with *Eupagurus Bernhardus*, *Adamsia palliata* with *Eupagurus Prideauxii*, *Montacuta substriata* with *Spatangus purpureus*, etc. Others, such as the frequent association in one group of *Thelepus sp.*, *Sertularella Gayi*, *Ascidiella scabra*, and *Sabella* (*pavonina ?*) (*cf.* p. 390), or of *Chaetopterus variopedatus*, *Halecium halecinum*, *Plumularia Catharina*, etc. (p. 414), have not been previously described in detail, and are probably of a less definite nature. It will be of interest and importance not only to compare such groups with those found in other localities, but also to compare the whole fauna found upon similar bottom-deposits in different districts. Unfortunately the published data upon which any such comparison can be founded are neither numerous nor altogether satisfactory. The most promising reports from which the general nature of the fauna at particular spots can be ascertained are those giving the results of the dredgings and trawlings of the German expedition in the *Pommerania*, which worked in the North Sea in 1872 and 1873. In these the numbers of the stations at which each species was obtained are given, and by working through the reports of the specialists in each group one can compile a list of the fauna at any particular station. Unfortunately there is a good deal of internal evidence to indicate that, in the case of the more common species especially, the list of stations at which each was taken is by no means complete, and the lists of the fauna obtained at particular stations derived from the reports are, therefore, not as perfect as could be desired, nor can one be sure that the common and prevailing species are mentioned.

I give below the lists for five stations where the fauna was evidently in many ways similar to that found on some of the Eddystone Grounds.

Such indications as the reports afford, as to which were the abundant and characteristic species, are also mentioned, but in this respect the information is very imperfect. There are few indications as to the attachments of fixed species, and it is not made clear in most cases which species were definitely associated with each other. This was almost inevitable in the case of an expedition covering a very large area, and when the animals belonging to different groups were divided amongst a number of specialists not in immediate communication with each other. In the case of the Eddystone to Start Grounds, described in the present report, where the area dealt with is limited, and where the species have nearly all been identified in the same laboratory, it has been much more easy for one individual to obtain some knowledge of the whole fauna and co-ordinate the different groups. I must, however, emphasise the fact that lists of the species found upon a ground are of very little service in giving an idea of the character of its fauna unless information is added as to the relative abundance of each animal, and so far as possible as to its relations with other organisms and with the bottom-deposit.

Comparison with North Sea and Irish Sea Faunas. Lists of the fauna at five stations dredged by the *Pommerania* expedition in the North Sea, compiled from the reports of the expedition:—

STATION 111.

Pommerania Expedition, August 20th, 1872.

9 a.m. 1½ miles E.S.E. of Lowestoft.

Depth, 16 fathoms; *Bottom-deposit*, Small stones.

[M = many; P = present in moderate numbers; F = few.]

ACTINOZOA.

Alcyonium digitatum

HYDROZOA.

Bimeria vestita
Hydractinia echinata
Tubularia indivisa (M)
Clytia Johnstoni
Campanularia flexuosa
Calycella syringa
Filellum serpens
Halecium halecinum (M)
Sertularella polyzonias
Diphasia attenuata
Sertularia abietina (M)
,, argentea (M)
Hydrallmania falcata (M)
Antennularia antennina (M)
,, ramosa
Plumularia setacea

POLYCHAETA.

Thelepus cincinatus (M)
Sabellaria alveolata (M)
Sabella penicillus (F)
(= *S. pavonina*)
Polynoe squamata (F)
Nereis pelagica (P)
Nephthys caeca (M)

CRUSTACEA.

Dryope crenatipalmata
Amathilla Sabinei
Mysis inermis
Gastrosaccus sanctus
Pandalus annulicornis
Virbius fasciger
Porcellana longicornis
Stenorhynchus rostratus
(= *S. phalangium*)

MOLLUSCA.

Pecten varius (*var.* alba)
Modiola modiolus
Natica Alderi (= *N. nitida*)
Murex erinaceus
Pleurotoma rufa

Doto fragilis
Doris tuberculata
,, pilosa
Thecacera pennigera

POLYZOA.

Bugula plumosa
Flustra foliacea
Alcyonidium gelatinosum
Lepralia annulata

TUNICATA.

Phallusia virginea
(= *Ascidiella virginea*)

Station 83.

Pommerania Expedition, August 7th, 1872.

3 p.m. 1¼ miles E.S.E. of Peterhead.

Depth, 30 fathoms; *Bottom-deposit*, Sand, with shells and small stones.

Echinodermata.

Ophioglypha affinis (P)
Ophiopholis aculcata (P)
Luidia Savignyi (P)
Astropecten Mülleri (F) (= *A. irregularis*)
Echinocardium flavescens (F)
Spatangus purpureus (*see* p. 235)
Strongylocentrotus droebachiensis (M)

Hydrozoa.

Hydractinia echinata
Tubularia indivisa
,, larynx (M)
Clytia Johnstoni
Campanularia flexuosa
Cuspidella grandis
Halecium halecinum
,, Beanii
Sertularella polyzonias
Diphasia rosacea
,, tamarisca
Sertularia abietina (M)
,, argentea (M)
Hydrallmania falcata (M)
Thuiaria thuia
,, articulata
Antennularia ramosa (M)
Plumularia pinnata
,, Catharina
,, echinulata

Polychaeta.

Polynoe cirrata (P)
Glycera capitata (F)

Crustacea.

Anceus maxillaris
Arcturus longicornis
Hyas coarctatus

Mollusca.

Anomia ephippium
Pecten sinuosus } Shell only
,, Islandicus } Shell only
,, tigrinus } Shell only
,, Testae } Shell only
Modiola modiolus
Montacuta substriata
Astarte sulcata
Venus fasciata
,, casina
,, ovata
Tapes edulis (= *T. virginea*)
Lucinopsis undata
Tellina crassa
Psammobia ferroensis
Mactra solida
Chiton albus
Puncturella Noachina
Trochus tumidus
,, millegranus (one shell)
Turritella ungulina (= *T. communis*)
Natica Alderi (= *N. nitida*)
Fusus antiquus
,, gracilis (= *F. islandicus*)

Eolis aurantiaca
Tritonia plebeia

Station 85.

Pommerania Expedition, August 8th, 1872.

Firth of Forth, E.N.E. of Isle of May.

Depth, 30 fathoms; *Bottom-deposit*; Coarse sand and stones.

Echinodermata.

Asteracanthion rubens (F) (= *Asterias rubens*)

Hydrozoa.

Perigonimus repens (on Turritella)
Hydractinia echinata
Tubularia larynx (M)
Clytia Johnstoni
Halecium halecinum
Diphasia rosacea
Sertularia argentea (M)
Hydrallmania falcata (M)
Thuiaria thuia
Antennularia ramosa (M)
Plumularia pinnata
,, Catharina

Polychaeta.

Thelepus cincinnatus

Crustacea.

Callisoma Kröyeri

Mollusca.

Turritella ungulina (= *T. communis*)
Fusus antiquus
Fusus gracilis (= *F. islandicus*)
,, propinquus
,, Jeffreysianus

Eolis Drummondii
Tritonia Hombergii

Polyzoa.

Alcyonidium hirsutum
,, parasiticum

Tunicata.

Phallusia virginea (= *Ascidiella virginea*)

Station 115.

Pommerania Expedition, August 20th, 1872.

2° 50′ N. 52° 22′ N.

Depth, 23 fathoms; *Bottom-deposit*, Sticky blue-grey mud with shells.

Actinozoa.

Sagartia troglodytes
,, parasitica on Buccinum

Hydrozoa.

Hydractinia echinata
Tubularia indivisa
Obelia dichotoma
Campanularia verticillata
Filellum serpens
Halecium halecinum
Sertularella polyzonias
Diphasia attenuata
Sertularia argentea
Hydrallmania falcata
Antennularia antennina
Plumularia setacea

Mollusca.

Pecten varius
,, opercularis (*var.* lineata, abundant)
Arca lactea, shell
Venus gallina
Donax vittatus
Syndosmya prismatica
Cultellus pellucidus
Ensis (Solen) ensis—Young?
Buccinum sp. (see p. 140)

Polyzoa.

Flustra truncata
(= *F. securifrons*, Pallas)
Membranipora pilosa

Station 84.

Pommerania Expedition, August 7th, 1872.

7 p.m. 3½ miles S.E. of Peterhead.

Depth, 50 fathoms; *Bottom-deposit*, Sand and shells.

[M = many; P = present in moderate numbers; F = few.]

Porifera.

Suberites domuncula

Echinodermata.

Ophioglypha texturata (P)
(= *Ophiura ciliaris*)
Luidia Savignyi (P)
Solaster endeca (P)
Echinus miliaris (M)
,, acutus (P)
Strongylocentrotus droebrachiensis (P)

Hydrozoa.

Tubularia indivisa
,, larynx (M)
Clytia Johnstoni
Campanularia flexuosa
Lafoea dumosa
Calycella syringa
Filellum serpens
Coppinia arcta on *Hydrallmania falcata*
Diphasia rosacea
Sertularia abietina (M)
Hydrallmania falcata (M)
Thuiaria thuia
Antennularia ramosa (M)
Plumularia pinnata

Polychaeta.

Eumenia crassa (F)
Thelepus cincinnatus (M)
Pectinaria auricoma (P)
Sabellaria alveolata (M)
Protula protensa (M)
(= *P. tubularia*)
Filograna implexa (M)
Hydroides norvegica (M)
Aphrodite aculeata (P)
Polynoë cirrata (F)
,, squamata (F)
Lumbriconereis fragilis (F)
Nereis pelagica (F)
Phyllodoce maculata (F)

Crustacea.

Naenia rimapalmata
Megamoera semiserrata
Mysis ornata
Pandalus annulicornis
Hippolyte Lilljeborgi
Crangon Allmani
Galathea squamifera
Pagurus Bernhardus
,, pubescens
Inachus dorsettensis
Hyas coarctatus
Stenorhynchus rostratus
(= *S. phalangium*)
Atelecyclus septemdentatus
(= *A. heterodon*)

Mollusca.

Stilifer Turtoni
Fusus gracilis
(= *F. islandicus*, F. & H.).

Polyzoa.

Gemellaria loricata
Flustra foliacea
Crisia eburnea

Tunicata.

Ciona intestinalis

The first four of these hauls appear to have been made on grounds similar in many respects to the Eddystone Gravel Grounds and to the Prawle Stony Ground. The fifth (Sta. 84) was clearly on a fine sand ground with shells, similar to the sand bordering the Eddystone gravels. Imperfect as the lists doubtless are, one cannot but be struck by the fact that on the whole we are dealing with the same species as those found on the grounds examined during the present investigation, arranged possibly in a somewhat different manner, with a few forms added and a few taken away.

Some of the more striking differences may be pointed out, in order to indicate the nature of the information which one would wish future investigators to supply when dredging in similar localities. The constant abundance of *Tubularia indivisa* and *Tubularia larynx*, both on the coarse and fine grounds in these North Sea hauls, is noteworthy. Fragments only of *T. indivisa* were obtained on the Eddystone to Start Grounds (viz., on the Prawle Stony Ground, attached to a large stone), and so far as our experience goes the species in this neighbourhood is confined to rocky situations. A knowledge of the exact conditions on the North Sea Grounds, and of the kind of material to which the hydroid is generally attached,* might throw light upon this difference.

Halecium halecinum is present and sometimes abundant on each of the coarse North Sea Grounds, whilst it is absent from the sand. This is similar to its distribution on the Eddystone Grounds, but on these latter it is in by far the larger number of cases attached to the tubes of *Chaetopterus*, a species which is not recorded in the *Pommerania* reports. Schulze makes the general statement that *H. halecinum* was attached to shells, worm tubes, etc., but there is no indication as to whether any particular worm takes the place which *Chaetopterus* occupies on the Eddystone Grounds.

Amongst the Crustacea one may notice that in the North Sea hauls *Stenorhynchus rostratus* (= *S. phalangium*) takes the place of *S. longirostris*, and that, as on the Eddystone Grounds, *Stenorhynchus* and *Inachus* are present on the fine grounds, but rare or absent on the coarse.

The almost entire absence of *Pecten opercularis* and the entire absence of *P. maximus* on these particular North Sea Grounds is noteworthy, and there is no species which obviously takes the place which they occupy on the corresponding Eddystone Grounds. On the other hand *Fusus antiquus* on the North Sea Grounds seems to take the place of *Buccinum undatum* on the Eddystone Grounds. A similar change of a striking nature (confirmed by other hauls of the *Pommerania*) is the fact that *Flustra foliacea* seems to exactly take the place usually occupied by *Cellaria fistulosa* and *sinuosa* in the neighbourhood of Plymouth.

* *T. larynx* is stated by Schulze to be attached to shells and to other hydroids, *e.g.*, *Tubularia indivisa*. No statement is made as to the attachment of the latter species.

Differences of this kind are of very great interest, but our knowledge of them is far too slight at the present time to make any satisfactory explanation possible.

In the Presidential Address to the Biological Section of the British Association, at the Ipswich meeting, Herdman gives a list of the species obtained in a single haul of a trawl in the Irish Sea. (*Rep. Brit. Assn.*, 1895, p. 713.) This haul was recorded in order to find the number of species and genera represented on the ground, and unfortunately no information is given as to the relative abundance of each species. It is therefore impossible to get a good idea of the characteristic nature of the fauna on the ground. On the whole it resembles that found on the grounds to the west of the Eddystone, both the gravel and fine sand faunas being represented. It is of interest to note that *Chaetopterus* and *Halecium halecinum* are both recorded and that *Fusus antiquus* is present, whilst *Buccinum undatum* is absent.

In the *Proceedings of the Liverpool Biological Society* (No. 40) Herdman also records several grounds where ophiurids occur to the almost entire exclusion of other species, a condition of things similar to that occurring on Ground X., to the west of the Eddystone (*cf.* pp. 416 and 499).

Geographical Distribution. Following Michaelsen (No. 79), three of Forbes' geographical provinces have been recognised, under the names Arctic, Boreal, and Lusitanian. The Boreal province contains the greater part of Forbes' Celtic. The Arctic province (A.) Michaelsen regards as bounded on the south by a line commencing at Cape Race in Newfoundland, running parallel to the south-east coast of Greenland, cutting off the north corner of Iceland, and then striking the Scandinavian coast at the Lofoten Islands. The Boreal province (B.) lies south of this line, and comprises the temperate portion of the east coast of North America, the greater part of Iceland, the greater part of the Scandinavian Coast, the North Sea and the Baltic, and the British Seas with the exception of the south coast. The Lusitanian province (L.) extends from the English Channel to the Canaries and Azores, and includes the Mediterranean.

In Table VI., p. 529, the distribution of each species in the three provinces has been indicated by the letters A. B. and L. Our knowledge of the true centres of distribution of the species is still too imperfect in the majority of cases to make it possible to say whether a species which is found in two provinces is equally at home in both, or whether its centre of distribution occurs in one of the provinces and the species must be regarded merely as an immigrant into the other.

Species extending from the Arctic Seas to the Mediterranean, Azores, and Canary Islands are indicated by the letters A.L.; those which are found in the Arctic and extend throughout the Boreal region by A.B.;

whilst those which have only been recorded from the Boreal by B. The letters L.B. denote species extending from the Mediterranean to the north of Norway, Iceland, and often to the eastern coast of America. The letter L. indicates that the species has its centre of distribution in the Lusitanian province, but such species may extend up the western coasts of the British Isles to Shetland, or even to the southern parts of Scandinavia.

In Table VII., p. 536, the total number of species falling under each of these heads is given for the various groups of animals obtained during the present investigation, all of which, therefore, live at a depth of about 30 fathoms between Start Point and the Eddystone. In each case also the percentage of animals belonging to the group, living in each region, is added.

Regarding this fauna as a whole, it will be seen that the prevailing element is southern, or Lusitanian; 56 per cent. falling under the heads of L. and L.B., and 30 per cent. under L. alone, whilst only 26 per cent. come under A.B. and B. Eight per cent. of the recorded species occur in the Arctic and Boreal regions only, whilst 18 per cent. have a very wide range, extending from the Arctic to the Mediterranean.

Looking at the figures for each group (excluding those in which the number of species is too small to give reliable results), it may be noticed that the fishes and Crustacea show the southern element most markedly, whilst the Hydrozoa and Polyzoa are remarkable for the number of species which have a very extended range.

In a subsequent paper I hope to compare the figures obtained for species living at 30 fathoms with similar ones for species extending from the shore to about 15 fathoms.

Table I. List of Hauls.

The entries under the head of "Nature of bottom" in this table are in most cases the notes made on board the vessel at the time the dredge came on deck.

No. of haul.	Date.	No. of ground.	Locality.	Direction towed.	Nature of bottom.	Instrument used.
1	July 30, 1895	XVII.	Prawle Point, bearing N. by E., 2½ miles off	S. by E.	Coarse gravel and shells	Dredge
2	July 30, 1895	XVIII.	Prawle, bearing N., 3 miles off	S. by E.	Rocks. Trawl fast	Otter Trawl
3	July 30, 1895	XVIII.	Prawle Point, N. by W., 3 miles off	S. by E.	Stones or rocks. Trawl torn	Otter Trawl
4	July 30, 1895	XVIII.	Prawle, N. by W., 4½–5 miles	S. by E.	Broken shells and stones	Dredge
6	Aug. 2, 1895	XVII.	Bolt Head, N., 5 miles	Easterly	Broken shell	Dredge
7	Aug. 2, 1895	XVII.	Bolt Head, N. by W., 5 miles	Easterly	Broken shell and some gravel	Dredge
8	Aug. 16, 1895	XI.	Eddystone, bearing S.E. ½ S., 3 miles off	S.E. ½ S.	Gravel and shells	Dredge
9	Aug. 16, 1895	XI.	Eddystone, bearing S.E. ½ S., 2½ miles off	S.E. ½ S.	Gravel finer than in 8	Dredge
10	Aug. 16, 1895	XVI.	Eddystone, S.E. ½ S., ½ mile	...	Fine, clean broken shell	Dredge
13	Aug. 16, 1895	XVI.	Eddystone, E. ½ N., ½ mile	...	Fine broken shell, some large shells	Dredge
14	Aug. 16, 1895	XVI.	Eddystone, N., 1 mile	...	Bottom similar, shells broken into finer pieces, and with some mud	Dredge
20	Aug. 31, 1895	XVII.	Bolt Tail, N.N.E., 3 miles off	...	Stones, shells, and gravel	Dredge
21	Aug. 31, 1895	XVII.	Bolt Head, N.E. by N., 1 mile off	...	Broken shell with a few small stones	Dredge
22	Aug. 31, 1895	II.	10 miles S. of Plymouth Mewstone	...	Fine sand	Otter Trawl
23	Sept. 9, 1895	II.	12 miles S. by W. of Plymouth Mewstone	W.	Fine sand	Otter Trawl
24	Sept. 9, 1895	II.	Eddystone, bearing N.W., 6 miles (? weather foggy)	W.	Fine sand	Otter Trawl
25	Sept. 9, 1895	II.	End of last haul	W.	Fine sand	Dredge
27	Sept. 17, 1895	XVII.	Prawle, N., 4–5 miles	S.W.	Shells, broken shells, gravel, and sand	Dredge
28	Sept. 17, 1895	XVII.	1 mile W. of haul 27	W.	Shells, broken shells, gravel. Not so much sand and mud as 27	Dredge
29	Sept. 17, 1895	XVIII.	Prawle, bearing N.W. Start, bearing N.E. by N.	E.	Large red stone, loose stones, gravel and broken shell	Dredge
30	Sept. 17, 1895	XVIII.	Prawle, W.N.W. Start, N.N.E.	E.	Large stone, many medium and small stones. Gravel	Dredge
31	Sept. 26, 1895	...	Eddystone, N. by E., 1–1½ miles	S. by W.	Rocky ground. Dredge broken	Dredge

No. of haul.	Date.	No. of ground.	Locality.	Direction towed.	Nature of bottom.	Instrument used.
32	Sept. 26, 1895	VII.	Eddystone, N. ½ W., 1½ miles	S.W.	Stones. Rough ground	Dredge
33	Sept. 26, 1895	XV.	Eddystone, N.W., 2 miles	S.W.	...	Dredge
34	Sept. 26, 1895	IV.	Eddystone, W. by S., 3 miles	W. by S.	Sand	Otter Trawl
35	Sept. 30, 1895	XIV.	Eddystone, E. ½ N., ¾ mile	S.W.	Broken shell and a little gravel	Dredge
36	Sept. 30, 1895	XIV.	Eddystone, E. ½ N., ¾ mile	S.W.	Broken shell and a little gravel	Otter Trawl
38	Sept. 30, 1895	VII.	Eddystone, N.E., 1¼ miles	S.W.	A little broken shell and mud	Dredge
39	Sept. 30, 1895	IV.	Eddystone, W. by S., 3 miles	W.	Sand	Otter Trawl
40	Sept. 30, 1895	IV.	Eddystone, W. by S., 3 miles	W.	Sand	Fine mosquito net
41	April 7, 1896	XIV.	Eddystone, S.E. ½ S., 1½ miles	S.E.	Gravel and shells	Dredge
42	April 7, 1896	X.	Eddystone, S.E. by E., 2½ miles	E.	Gravel, fine sand, and shells	Dredge
43	April 8, 1896	XVII.	Bolt Head, N., 4 miles	E.	Gravel and broken shell	Dredge
44	April 8, 1896	XVII.	Prawle, N. by E., 3 miles	E.	Gravel (coarser than last) and shells	Dredge
45	April 8, 1896	XVIII.	Prawle, N. ½ W., 4 miles	E.	Gravel, stones, and shells	Dredge
46	Aug. 4, 1896	XI.	Eddystone, S.E. ½ S., 3 miles	S.E.	Shells, gravel, and coarse sand	Dredge
47	Aug. 4, 1896	XI.	Eddystone, S.E. ½ S., 2 miles	S.E.	Sand (?)	Dredge
48	Aug. 4, 1896	VIII.	Eddystone, S E. ½ S., 1 mile	S.E.	Sand and mud	Dredge
49	Aug. 4, 1896	III.	Eddystone, W. by S., 3 miles	E.	Sand	Otter Trawl
50	Aug. 6, 1896	I.	7½ miles (log) S. by E. of Mewstone Buoy	W. by S.	Fine sand	Dredge
51	Aug. 6, 1896	I.	Eddystone, W. by N. ½ N., Mewstone, N.N.E.	W. by S.	Fine sand	Dredge
53	Aug. 20, 1896	III.	Eddystone, S.W. ½ S., 3 miles	W.N.W.	Fine sand	Dredge
54	Aug. 20, 1896	VII.	Eddystone, N.E., 1¼ miles	W.	Shells and sand	Dredge
55	Aug. 20, 1896	X.	Eddystone, E. by S. ½ S., 1½ miles	W.	Sand, stones, and shells	Dredge
56	Aug. 28, 1896	III.	Eddystone, S.W. ½ S., 3 miles	E.S.E.	Fine sand	Beam Trawl
57	Aug. 28, 1896	III.	Eddystone, W. by N., 4 miles	N.N.W.	Fine sand	Beam Trawl
58	Oct. 21, 1896	XIV.	Eddystone, E., 1 mile	W.	Gravel and broken shell. Shells	Dredge
59	Oct. 21, 1896	XIV.	Eddystone, E., 1¼ miles	W.	Gravel and broken shell. Shells	Dredge
60	Oct. 1, 1896	XVII.	Bolt Tail, N.E., 3 miles	S. ½ E.	Sand	Dredge
61	Oct. 1, 1896	XVII.	Bolt Head, N., 2-3 miles	S. ½ E.	Sand and shells	Dredge
62	Oct. 1, 1896	XVII.	Prawle, N.E. by N., 3 miles	S. ½ E.	...	Dredge

No. of haul.	Date.	No of ground.	Locality.	Direction towed.	Nature of bottom.	Instrument used.
63	Oct. 1, 1896	XVIII.	Prawle, N.N.W. ½ N., 3 miles	S.	Stones and shells	Dredge
64	Oct. 2, 1896	XVIII.	Prawle, N.W. ½ W., 2–3 miles	W.	Stones	Dredge
65	Oct. 2, 1896	XVIII.	Prawle, N.N.W., 2–3 miles	W.	Stones	Dredge
66	Oct. 2, 1896	XVIII.	Prawle, N., 3 miles	E.	Stones	Dredge
68	Oct. 2, 1896	XVII.	Bolt Head, N. by E., 2 miles	E.	Shells and gravel	Dredge
69	Oct. 21, 1896	VII.	Eddystone, E., 1½ miles	W.	Sand	Dredge
70	Oct. 21, 1896	VII.	Eddystone, N.E., 1½–1¾ miles	W.	Sand	Dredge
71	Oct. 21, 1896	VII.	End of last haul	W.	Sand	Dredge
72	Sept. 10, 1897	III.	Eddystone, W., 4 miles	W. by N.	Fine sand	Beam Trawl
73	Sept. 15, 1897	XIV.	Eddystone, E. ¾ S., 1 mile	W.N.W.	...	Otter Trawl
74	Sept. 15, 1897	XIV.	Eddystone, E. by S., 1 mile	W.N.W.	Gravel and shells	Dredge
75	Sept. 15, 1897	VII.	Eddystone, E.N.E., 1 mile	W.S.W.	Large stone	Dredge
76	Sept. 15, 1897	VII.	Eddystone, N.E. by E., 1 mile	W.S.W.	Gravel and small shells	Dredge
77	Sept. 30, 1897	IV.	Eddystone, W. by S., 3 miles	W. by S.	...	Beam Trawl
78	Sept. 30, 1897	...	Eddystone, N., 1 mile	...	Rock. Dredge empty	Dredge
79	Sept. 30, 1897	VII.	A little to west of 78	...	Red stones, shells	Dredge
80	Sept. 30, 1897	VII.	½ mile west of 79	...	Clean shells (probably sand)	Dredge
81	Oct. 12, 1897	I.	6⅜ miles (log) south of Mewstone Buoy	N.W.	Fine sand	Beam Trawl
82	Oct. 12, 1897	I.	8 miles south of Mewstone	N.W.	Fine sand	Beam Trawl
83	Jan. 7, 1898	XII.	Eddystone, S. by E. ¼ E., 3 miles	W.S.W.	Gravel and sand. See Table II.	1. Dredge 2. Canvas bag
84	Jan. 7, 1898	XI.	Eddystone, S.E. by S., 2¼ miles	W.S.W.	Gravel and sand, cleaner than 83. See Table II.	1. Dredge 2. Canvas bag
85	Jan. 7, 1898	XIV.	Eddystone, S.E. by S., 1 mile	W.S.W.	Fine gravel and shell. See Table II.	1. Canvas bag 2. Dredge
86	Jan. 11, 1898	XVI.	Eddystone, S.E. by S., ½ mile	W.	One large stone	Dredge
87	Jan. 11, 1898	XVI.	Eddystone, S.E. by S., ¾ mile	W.	Fine broken shell. See Table II.	1. Canvas bag 2. Dredge
88	Jan. 11, 1898	XIV.	Eddystone, E., ¾ mile	W.	Fine broken shell, with some gravel	Dredge
89	Jan. 11, 1898	X.	Eddystone, S.E. by S., 1½–2 miles	N.E.	?	Dredge
89B	Jan. 11, 1898	VIII. ?	At end of 89	N.E.	Fine sand. See Table II.	Canvas bag
90	Jan. 14, 1898	V.	Breakwater Light, N.W. ¼ N., 6 miles	E.S.E.	Fine sand. See Table II.	1. Beam trawl 2. Canvas bag

No. of haul.	Date.	No of ground.	Locality.	Direction towed.	Nature of bottom.	Instrument used.
91	Jan. 17, 1898	III.	Eddystone, W. by S., 3½ miles	E. by N.	Fine sand. See Table II.	1. Otter trawl 2. Canvas bag
92	Jan. 17, 1898	I.	Eddystone, W. by S., 5 miles	E. by N.	Fine sand. See Table II.	1. Otter trawl 2. Canvas bag
93	March 3, 1898	IX.	Eddystone, E. ½ S., 3 miles	E. ½ S.	Gravel and shell	Dredge
94	March 3, 1898	IX.	Middle of course of haul 93	...	Coarse gravel and fine sand. See Table II.	Canvas bag
95	March 3, 1898	X.	Eddystone, E., 2 miles	...	Gravel and broken shell	Dredge
96	March 3, 1898	X.	Middle of course of haul 95	...	Coarse gravel and sand. See Table II.	Canvas bag
97	April 21, 1898	XV.	Eddystone, W., 2 miles	...	Medium and fine gravel. See Table II.	1. Dredge 2. Canvas bag
98	May 16, 1898	XVI.	Eddystone, N.E., 1 mile	S.E. by S.	Rock	Dredge
99	May 16, 1898	XVI.	Eddystone, N.E., 1¼ mile	S.E. by S.	Stones and shells	Dredge
100	May 16, 1898	VII.	Eddystone, N.E., 2 miles	S.E. by S.	Large stones and sand	Dredge
101	May 26, 1898	VI.	Eddystone, N.E., 2½ miles	E.	Fine sand	Dredge
102	May 26, 1898	VI.	Eddystone, N., 2½ miles	E.	Fine sand. See Table II.	1. Dredge 2. Canvas bag
103	May 26, 1898	XIII.	Eddystone, N.W., 1 mile	E.	Gravel and mud. See Table II.	1. Dredge 2. Canvas bag
104	June 15, 1898	II.	South of Mewstone Buoy, 10 miles (log)	...	Fine sand. See Table II.	1. Beam trawl 2. Canvas bag
105	Sept. 28, 1898	XVII.	Bolt Head, N.N.E., 1 mile	E.	Shell gravel. See Table II.	1. Dredge 2. Canvas bag
106	Sept. 28, 1898	XVII.	Bolt Head, N., 2 miles	E.	Shell gravel. See Table II.	1. Canvas bag 2. Dredge
107	Sept. 28, 1898	XVII.	Bolt Head, N., 2½–3 miles	E.	Gravel and shell	Dredge
109	Nov. 17, 1898	VII.	Eddystone, E.N.E., 2 miles	W.	Fine sand. See Table II.	1. Canvas bag 2. Dredge

Table II. Texture of Bottom-Deposits.

Showing the percentage weights of each grade of Gravel and Sand found in the samples of bottom-deposit taken from the different grounds.

	Number of Ground.		I.	II.	III.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.		Mud from Sound.
	Number of Haul.		92	104	91	90	102	109	89 B	94	96	84	83	103	85	97	87	105	106	
Grade.		Size of Mesh of Sieve.	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
I.	Stones	Left on sieve of mesh 15 mm.	—	—	—	—	—	—	—	0·9	—	—	—	—	—	—	—	1·4	0·7	—
II.	Coarse Gravel	5 mm.	—	—	—	2·7	0·2	—	1·3	44·4	35·3	47·6	27·9	13·4	4·1	13·4	17·3	23·1	33·8	—
III.	Medium Gravel	2·5 mm.	—	—	—	2·3	0·2	0·01	1·5	14·0	14·3	14·5	28·3	29·0	17·5	20·5	31·7	15·4	18·8	0·5
IV.	Fine Gravel	1·5 mm.	0·2	0·1	0·5	2·4	0·3	0·2	2·8	10·2	9·1	7·5	14·1	17·0	28·1	18·2	19·3	8·3	12·6	0·7
V.	Coarse Sand	1 mm.	0·8	0·2	2·5	3·2	1·3	1·2	6·3	7·5	8·9	4·0	6·0	6·2	21·0	16·0	10·5	7·3	7·3	0·9
VI.	Medium Sand	0·5 mm.	4·8	2·1	13·2	13·7	10·8	24·0	29·2	5·5	16·3	5·9	7·3	6·9	23·4	19·7	14·9	25·7	19·9	3·6
VII.	Fine Sand	Passes through 0·5 mm. sieve	90·9	95·8	82·7	68·8	85·4	72·7	56·8	16·2	12·1	17·7	8·3	10·4	5·2	9·0	5·2	18·3	6·7	69·8
VIII.	Silt	Does not settle in 1 minute	3·4	1·9	1·1	6·8	1·7	1·9	2·0	1·2	3·9	2·8	8·2	17·1	0·6	3·1	1·1	0·5	0·3	24·4

TABLE III., *showing the percentages of Carbonate of Lime (or where distinguishable, of shell) in each grade of gravel or sand in the samples of bottom-deposit from the fine-textured grounds I. to VIII.*

Number of Ground.	I.		II.		III.		V.		VI.		VII.		VIII.	
Number of Haul.	92		104		91		90		102		109		89B	
	$CaCO_3$		$CaCO_3$		$CaCO_3$		$CaCO_3$		$CaCO_3$		$CaCO_3$		$CaCO_3$	
Number of Grade.	As % of Individual Grade	As % of Whole Sample	As % of Individual Grade	As % of Whole Sample	As % of Individual Grade	As % of Whole Sample	As % of Individual Grade	As % of Whole Sample	As % of Individual Grade	As % of Whole Sample	As % of Individual Grade	As % of Whole Sample	As % of Individual Grade	As % of Whole Sample
I.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
II.	—	—	100·00	—	—	—	34·62	0·93	41·38	0·08	—	—	24·44	0·32
III.	—	—	95·00	—	—	—	26·50	0·61	15·00	0·03	93·00	0·01	44·14	0·66
IV.	82.43	0·16	93·75	0·09	64·70	0·32	57·50	1·38	39·60	0·15	72·72	0·01	58·00	1·62
V.	74·40	0·59	57·68	0·12	28·80	0·72	39·60	1·26	24·75	0·32	61·17	0·73	60·00 (estimated)	3·78
VI.	58·00	2·78	64·37	1·35	18·70	2·47	39·60	5·42	27·00	2·91	38·75	9·30	62·73	18·32
VII.	14·63	13·29	14·44	13·83	12·65	10·46	19·20	13·21	13·00	11·10	26·87	19·53	42·00	23·86
Silt	17·41	0·59	21·43	0·41	14·85	0·16	14·67	0·10	16·25	0·27	30·00	0·57	22·86	0·05
Totals	—	17·41	—	15·80	—	14·13	—	22·91	—	14·86	—	30·15	—	48·61

TABLE IV., *showing the percentages of Carbonate of Lime (or, where distinguishable, of shell) in each grade of gravel or sand in the samples of bottom-deposit from the coarse-textured grounds IX. to XVII.*

Number of Ground.	IX.		X.		XI.		XII.		XIII.		XIV.		XV.		XVI.		XVII.			
Number of Haul.	94		96		84		83		103		85		97		87		105		106	
	$CaCO_3$		$CaCO_3$		$CaCO_3$		$CaCO_3$		$CaCO_3$		$CaCO_3$		$CaCO_3$		$CaCO_3$		$CaCO_3$		$CaCO_3$	
Number of Grade.	As % of Individual Grade	As % of Whole Sample	As % of Individual Grade	As % of Whole Sample	As % of Individual Grade	As % of Whole Sample	As % of Individual Grade	As % of Whole Sample	As % of Individual Grade	As % of Whole Sample	As % of Individual Grade	As % of Whole Sample	As % of Individual Grade	As % of Whole Sample	As % of Individual Grade	As % of Whole Sample	As % of Individual Grade	As % of Whole Sample	As % of Individual Grade	As % of Whole Sample
I.	69·93	0·63	—	—	—	—	—	—	—	—	—	—	—	—	—	—	54·43	0·76	100·00	0·70
II.	10·21	4·53	13·48	4·76	18·73	8·88	15·52	4·33	38·47	5·15	56·00	2·30	15·28	2·05	58·80	6·29	34·21	7·90	43·75	14·78
III.	25·50	3·57	33·00	4·72	58·00	8·41	51·00	14·43	90·50	26·24	39·50	6·91	30·50	6·25	86·50	25·26	54·00	8·21	47·50	8·93
IV.	22·55	2·30	60·08	5·46	64·90	4·86	60·12	8·47	81·60	13·87	30·55	8·58	59.95	10·91	79·60	19·34	64·80	5·38	78·75	9·92
V.	13·33	1·00	59·43	5·29	63·80	2·55	62·29	3·73	74·40	4·61	22·80	4·79	77·70	12·43	66·60	8·92	75·00	5·47	73·80	5·39
VI.	29·14	1·60	52·00	8·47	52·52	3·10	61·21	4·46	53·71	3·70	19·20	4·49	56·40	11·11	66·00	10·16	57·00	14·65	57·70	11·48
VII.	23·83	3·86	32·06	3·88	35·47	6·28	47·83	3·97	40·15	4·17	13·80	0·71	37·90	3·41	33·60	2·18	26·10	4·77	22·20	1·49
Silt	18·66	0·22	15·50	0·60	20·67	0·58	16·50	1·35	21·16	3·44	14·67	0·09	16·92	0·52	19·80	0·10	24·00	0·12	27·00	0·08
Totals	—	17·71	—	33·18	—	34·66	—	40·74	—	61·18	—	27·87	—	46·68	—	72·25	—	47·26	—	52·77

TABLE V.

Showing the samples of bottom-deposit arranged according to average grade of texture, and the total percentage of carbonate of lime in each.

No. of Sample.	Average Grade.	Percentage $CaCO_3$.
94	3·66	17·71
84	3·704	34·66
106	3·803	52·77
83	3·946	40·74
96	4·081	33·18
87	4·151	72·25
97	4·471	46·68
105	4·498	47·26
85	4·597	27·87
103	4·638	61·18
89B	6·386	48·61
90	6·561	22·91
109	6·749	30·15
91	6·814	14·13
102	6·849	14·86
92	6·971	17·41
104	6·998	15·80

Table VI.

Showing the distribution and abundance of each species on the grounds investigated, and its geographical distribution.

M = many ; P = present in moderate numbers ; F = few ; Fo, Po, Mo = Few in some hauls, *none* in others, etc.
m., p., f. = many, present, few, small specimens only.
P indicates that the species is present, but gives no information as to its abundance.
Geographical distribution. A = Arctic ; B = Boreal ; L = Lusitanian.

	Fine sand.								Coarse gravel with sand or mud.					Fine gravel.		Shell gravel.		Stones.	
	i. Inner Eddystone Trawling Ground.	ii. Outer Eddystone Trawling Ground.	iii. Outer East Eddystone sand.	iv. Inner East Eddystone sand.	v. 4 miles N.E. ½ N. of Eddystone.	vi. South Eddystone fine sand.	vii. South Eddystone intermediate sand.	viii. 1 mile N.W. ½ N. of Eddystone.	ix. West Eddystone coarse gravel.	x. *Ophiothrix fragilis* ground.	xi. North-west Eddystone coarse gravel.	xii. Edge of the Hand Deeps.	xiii. 1 mile south-east of Eddystone.	xiv. West Eddystone fine gravel.	xv. East Eddystone fine gravel.	xvi. West Eddystone clean shell gravel.	xvii. Bolt Head shell gravel.	xviii. Prawle stony ground.	Geographical distribution.
Foraminifera.																			
Truncatulina lobatula (*Walker and Jacob*)	On stems of hydroids wherever these are present.																		A.L.
Porifera.	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	
Suberites domuncula, *Olivi* ...	—	*P*	Fo	—	—	—	P	—	—	—	—	—	—	P	—	—	—	—	
Cliona celata, *Grant*... ...	F	—	—	P	—	—	P	—	*P*	*P*	*P*	*P*	*P*	M	*P*	—	*P*	*P*	
Hydrozoa.																			
Tubiclava cornucopiae (*Norman*)	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	P	—	B.
Hydractinia echinata (*Fleming*)	P	P	Po	Po	P	F	Fo	—	P	—	—	—	—	F	—	—	—	—	A.B.
Eudendrium rameum (*Pallas*)...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	F	—	A.L.
,, ramosum (*Linn.*) .	P	F	M	P	F	—	P	—	F	—	—	P	—	—	—	—	—	—	A.L.
,, capillare, *Alder* ...	—	—	—	F	—	—	F	—	—	—	—	—	—	—	—	—	F	P	B.
,, sp.	—	—	P	P	—	—	F	—	—	Fo	*P*	P	—	—	F	—	P	—	
Perigonimus repens (*Wright*)...	—	Po	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.B.
Garveia nutans (*Wright*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Po	B.
Heterocordyle Conybearei (*All.*)	P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	B.
Bougainvillia ramosa (*Van Ben.*)	P	Po	M	—	P	*P*	P	—	—	—	Fo	M	—	—	—	—	—	—	B.
Tubularia indivisa, *Linn.* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Po	A.L.
Clytia Johnstoni (*Alder*) ...	P	M	M	M	M	—	M	—	—	—	M	—	—	P	F	—	P	M	A.L.
Obelia dichotoma (*Linn.*) ...	P	—	F	—	F	—	Fo	—	—	—	—	—	—	—	—	—	—	F	L.B.
Campanularia Hincksii, *Alder* .	P	—	P	P	—	—	M	*P*	P	F	—	P	—	P	—	—	P	P	B.
,, verticillata (*Linn.*)	F	—	Fo	—	—	P	—	—	—	—	—	—	—	—	—	—	P	Fo	A.L.
,, flexuosa (*Hincks*).	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Mo	—	L.B.
Lovenella clausa (*Lovén*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	F	B.
Opercularella lacerta (*Johnston*)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	F	B.
Lafoëa dumosa (*Fleming*) ...	F	P	M	M	M	P	M	P	—	Fo	P	—	M	F	F	P	Fo	M	A.L.
,, fruticosa, *Sars* ...	Fo	—	F	Fo	—	—	—	—	—	—	P	—	—	—	—	—	—	—	A.B.
Calycella syringa (*Linn.*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*P*	F.	A.L.
,, fastigiata (*Alder*) ...	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	B.
Cuspidella costata, *Hincks* ...	P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	B.
Trichydra pudica, *Wright* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	P	—	—	—	B.
Coppinia arcta (*Dalyell*) ...	F	M	M	—	M	—	—	—	—	—	—	—	—	—	—	—	—	—	A.B.
Halecium halecinum (*Linn.*) ...	F	—	F	P	—	P	P	*P*	M	Fo	M	F	M	P	F	Fo	F	—	A.L.
,, Beanii, *Johnston* ...	F	—	F	P	F	—	P	—	P	Fo	M	—	—	F	F	—	Fo	Fo	L.
,, labrosum, *Alder* ...	—	—	—	—	—	—	Po	—	—	—	—	—	—	—	—	—	—	—	L.

	Fine sand.								Coarse gravel with sand or mud.					Fine gravel.		Shell gravel.		Stones.	
	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	
Sertularella Gayi, *Lamouroux* .	P	P	M	M	P	M	P	*P*	F	Fo	P	M	F	F	F	Fo	—	—	B.
,, polyzonias (*Linn.*)	P	P	P	P	P	—	F	—	—	—	P	P	—	F	—	—	—	—	A.L.
Diphasia rosacea (*Linn.*) ...	Fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	—	Po	B.
,, attenuata, *Hincks* ...	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	—	B.
,, tamarisca (*Linn.*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	Fo	—	L.B.
Sertularia abietina, *Linn.* ...	—	M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Mo	M	A.L.
,, argentea, *Ellis and Solander*	Fo	—	F	Fo	—	—	F	—	—	—	—	—	—	Fo	—	Fo	F	P	A.L.
Hydrallmania falcata (*Linn.*)...	F	F	F	F	F	F	F	F	F	Fo	—	—	F	F	F	Fo	F	M	A.B.
Thuiaria articulata (*Pallas*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Po	P	L.
Antennularia antennina (*Linn.*)	M	Fo	M	P	*P*	M	P	P	—	Fo	M	M	*P*	F	F	—	F	F	L.
,, ramosa, *Lamarck*	P	—	P	—	—	M	F	—	F	Fo	P	F	—	F	F	Fo	Fo	F	B.
Aglaophenia myriophyllum (*Linn.*)	Fo	—	M	M	*P*	F	P	P	—	—	M	F	*P*	—	F	—	—	Fo	L.B.
Aglaophenia tubulifera, *Hincks*	—	—	—	—	—	—	—	—	—	Fo	—	—	—	—	—	Fo	—	—	B.
Plumularia pinnata (*Linn.*) ...	—	Po	*P*	Po	—	P	M	—	M	—	*P*	F	P	Fo	—	—	F	F	L.B.
,, setacea (*Ellis*) ...	—	—	—	Po	—	—	Fo	—	*P*	—	Fo	—	—	—	—	—	—	F	L.
,, Catharina, *Johnston*	F	P	P	Po	F	P	Mo	—	M	Fo	M	—	P	Fo	F	Fo	—	—	B.
,, frutescens (*Ellis and Solander*)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Po	—	—	L.
ACTINOZOA.																			
Alcyonium digitatum, *Linn.* ...	F	M	F	F	F	M	F	F	F	Fo	F	—	P	F	f	Po	F(M)	M	B.
Sarcodictyon catenata, *Forbes* ..	—	—	—	Fo	—	—	Mo	—	—	Fo	—	—	F	P	F	M	M	M	L.
Gorgonia verrucosa, *Pallas* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	L.
Caryophyllia Smithii (*Stokes*)...	—	—	—	—	—	—	P	—	M	P	P	—	P	M	F	Mo	F	M	L.
Epizoanthus incrustatus (*Düb. and Kor.*)	—	M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	—	B.
Sagartia parasitica (*Couch*) ...	F	F	F	P	F	—	F	—	—	—	—	—	—	—	—	—	—	—	L.
Adamsia palliata (*Bohadsch*) ...	—	—	F	P	*P*	P	F	—	*P*	Fo	Fo	—	F	F	—	—	F	—	L.
Paraphellia expansa *Haddon* ...	—	—	—	—	—	—	Fo	—	F	—	F	—	—	—	—	—	—	—	L. (?)
Chondractinia digitata (*Müller*)	—	F	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	B.
Corynactis viridis, *Allman* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Po	L.
ECHINODERMATA.																			
Cucumaria pentactes (*Linn.*) ...	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	A.L.
,, lactea (*Forbes and Goodsir*)	—	—	F	—	—	—	Fo	—	—	—	—	—	—	—	—	Fo	Fo	Fo	B.
Thyone fusus (*O.F.M.*) ...	—	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	L.B.
Holothuria nigra (*Gray*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Po	—	—	L.
Astropecten irregularis (*Penn.*)	M	M	M	F	F	Fo	Fo	—	f	—	Fo	—	—	f	Fo	Fo	—	—	B.
Luidia Sarsi, *Düb. and Kor.* ...	—	Fo	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	L.B.
Porania pulvillus (*O.F.M.*) ...	—	—	—	Fo	—	—	—	—	—	Fo	—	—	—	M	—	—	—	—	B.
Palmipes placenta (*Pennant*) ...	Fo	—	F	—	M	—	P	*P*	—	—	F	—	—	—	—	—	—	—	L.
Solaster papposus (*Linn.*) ...	Fo	—	Fo	Po	M	—	F	—	F	fo	f	—	F	f	—	fo	F	F	A.B.
Henricia sanguinolenta (*O.F.M.*)	—	—	Fo	P	—	—	F	F	—	—	—	—	—	Fo	—	—	—	—	A.B.
Asterias glacialis, *Linn.* ...	F	P	P	M	P	P	P	F	M	Fo	P	F	—	M	—	—	Fo	—	L.
,, rubens, *Linn.* ...	F	P	P	M	M	P	P	F	M	Fo	P	—	F	PM	—	—	P	F	B.
Ophiura ciliaris (*Linn.*) ...	F	P	F	F	F	F	F	M	M	F	—	M	F	F	—	—	Fo	—	L.B.
,, albida, *Forbes* ...	—	—	—	fo	—	F	F	F	M	—	M	—	P	F	—	—	F	Fo	A.L.
,, affinis, *Lütken* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	—	L.B.
Amphiura elegans (*Leach*) ...	—	—	—	—	—	P	—	—	—	—	—	—	—	—	—	M	F	—	A.L.
,, filiformis (*O.F.M.*) ...	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	L.B.
Ophiactis Balli (*Thompson*) ...	—	—	—	Fo	—	—	P	—	M	Fo	P	F	M	P	—	F	F	M	B.
Ophiocoma nigra (*O.F.M.*) ...	—	—	—	—	—	—	—	P	F	F	Po	f	—	Fo	—	fo	F	Mo	A.B.
Ophiothrix fragilis (*O.F.M.*) ...	f	f	f	f	—	f	P	P	M	M	M	M	M	M	—	fo	F	F	L.B.
Echinus acutus, *Lamk.* ...	—	fo	—	Fo	—	—	Fo	—	F	Fo	F	—	—	P	—	—	F	—	L B.
,, miliaris, *Leske* ...	—	f	P	F	—	*P*	M	—	P	F	M	—	P	P	—	M	M	M	L.B.
,, esculentus, *Linn.* ...	—	—	—	F	—	—	P	P	F	Fo	P	F	F	P	—	Po	F	f	L.B.
Echinocyamus pusillus (*O.F.M.*)	—	F	—	—	—	—	Po	—	—	—	—	—	*P*	Fo	—	P	F	F	L.B.
Spatangus purpureus (*O.F.M.*)	—	—	—	—	—	—	Fo	P	—	Fo	—	—	—	F	—	P	M	Po	L.B.
Echinocardium cordatum (*Pen.*)	—	F	—	—	—	—	—	—	—	—	—	—	—	—	Fo	—	—	—	L.B.
,, pennatifidum, *Nor.*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	—	

	Fine sand.								Coarse gravel with sand or mud.					Fine gravel.		Shell gravel.		Stones.	
NEMERTINA.	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	
Carinella superba (*Köll.*) ...	*P*	—	—	—	—	—	F	—	*P*	—	—	—	—	P	—	—	—	P	L.
C. annulata (*Mont.*) *C. McIntoshii*	—	—	—	*P*	—	*P*	—	—	—	—	—	—	—	—	—	*P*	—	—	L.
Amphiporus pulcher (*Johnston*)	—	—	—	*P*	—	—	—	—	—	—	—	—	*P*	—	—	—	—	—	A.L.
Drepanophorus rubrostriatus, *Hubrecht*	—	—	—	—	—	—	—	—	—	Fo	—	—	—	F	—	—	—	—	L.
Tetrastemma flavidum (*Ehren.*) *McI.*	*P*	—	—	—	—	—	—	—	—	—	—	—	—	*P*	—	—	—	—	L.
Tetrastemma dorsale, *Abild.* ...	*P*	*P*	—	—	—	*P*	—	—	—	—	—	—	—	—	—	—	—	—	
,, candidum (*O.F.M.*)	—	—	—	—	—	—	—	—	—	—	—	—	—	*P*	—	*P*	—	—	A.L.
Eupolia curta, *Hubrecht* ...	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	F	F	—	L.
Lineus bilineatus (*Renier*) *McI.*	F	—	—	*P*	—	*P*	F	—	—	—	—	—	—	*P*	—	—	—	—	L.
,, marinus (*Mont.*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*P*	B.
Micrura purpurea (*Dalyell*) ...	—	—	—	—	—	—	F	—	*P*	—	—	—	*P*	*P*	—	*P*	—	*P*	L.
,, fasciolata (*Ehrenb.*) ...	—	—	—	*P*	—	—	—	—	*P*	—	—	—	*P*	*P*	—	*P*	*P*	*P*	L.
Cerebratulus fuscus, *McIntosh* ...	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	A.L.
TURBELLARIA.																			
Eurylepta cornuta (*O.F.M.*) ...	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	
GEPHYREA.																			
Phascolion strombi (*Mont.*) ...	—	—	—	—	—	—	F	*P*	—	—	*P*	—	—	*P*	—	—	—	F	
POLYCHAETA.																			
Polygordius sp.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	F	M	—	
Euphrosyne foliosa, *Aud. & Edw.*	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	—	—	—	—	L.
Aphrodite aculeata, *Linn.* ...	—	—	Fo	Fo	M	—	—	—	—	—	—	—	—	—	—	—	—	—	L.B.
Hermione hystrix, *Sav.* ...	—	—	—	—	—	—	—	—	F	Fo	—	—	—	—	—	—	—	—	L.
Lepidonotus squamatus (*Linn.*)	—	Fo	Fo	—	—	—	F	—	M	Fo	P	—	F	Fo	—	—	*P*	Fo	B.
Eunoe nodosa (*Sars.*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	A.B.
Lagisca propinqua (*Mlmgn.*) ...	P	P	P	Fo	—	F	P	—	M	Fo	Fo	—	M	—	—	—	Fo	—	L.B.
,, rarispina (*Mlmgn.*) ...	*P*	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	A.B.
Harmothoë imbricata (*Linn.*) ...	—	—	Fo	—	—	—	F	—	—	—	—	—	—	—	—	Fo	—	—	A.B.
Evarne impar (*Johnston*) ...	P	—	—	—	—	—	F	—	—	—	—	—	—	Fo	—	—	—	Fo	A.B.
Polynoe scolopendrina, *Sav.* ...	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	L.
Halosydna gelatinosa (*Mlmgn.*)	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	L.
Hermadion assimile (*McInt.*) ...	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	B.
Acholoe astericola, *Clpd.* ...	P	P	P?	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.
Hyalinoecia tubicola (*O.F.M.*)	—	—	Fo	P	—	—	Fo	*P*	M	Fo	P	—	P	—	—	—	—	—	L.B.
Lumbriconereis (large) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	*P*	—	Fo	—	—	
,, (small) ...	—	—	—	—	—	—	—	—	—	—	—	—	F	P	—	—	—	—	
Nereis fucata (*Sav.*)	With Eupagurus Bernhardus in Buccinum shells.																		B.
,, procera (*Ehl.*) ...	Fo	P	M	Fo	—	P	M	—	—	—	F	—	—	—	—	—	Fo	—	L.
Typosyllis alternosetosa (*S. Jos.*)	—	—	—	—	—	P	—	—	—	—	—	—	—	—	—	—	—	—	B.
Ehlersia cornuta (*Rthke.*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	—	—	A.L.
Eulalia viridis, *Sav.*... ...	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	A.L.
Amblyosyllis spectabilis (*John.*)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	—	
Polydora caeca (*Oerstd.*) ...	—	—	—	—	—	P	—	—	—	—	—	—	—	—	—	—	—	—	A.L.
Nephthys Hombergii (*A. & E.*)	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A.L.
Glycera convoluta (*Kef.*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	F	sp?	—	L.
Chaetopterus variopedatus, *Clpd.*	Fo	—	F	Fo	—	P	P	F	M	Po	M	F	M	M	fo	—	Fo	Fo	L.B.
Pectinaria auricoma, *Dan.* ...	—	—	—	—	—	—	F	F	—	Fo	—	F	—	—	—	—	P	F	L.B.
Polymnia nebulosa (*Mont.*) ...	—	—	—	—	—	—	Fo	—	F	—	—	—	F	Fo	—	—	—	—	L.B.
Nicolea venustula (*v. Mrzllr.*)	f	—	*P*	—	—	F	Fo	—	—	Fo	—	—	—	—	—	—	—	—	A.L.
Thelepus sp.	P	P	M	M	—	M	M	P	M	Fo	M	*P*	—	Fo	—	—	—	—	A.L.
Amphitrite gracilis (*v. Mrzllr.*)	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	Fo	—	A.B.
Polycirrus aurantiacus (*Gr.*) ...	—	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	L.
Terebellid tubes	—	—	—	—	—	—	F	—	*P*	*P*	F	—	—	M	P	M	M	—	
Sabella (pavonina ?)	P	F	P	P	*P*	P	*P*	—	P	Fo	P	—	—	—	—	—	—	—	A.B.
Sabellaria spinulosa (*Leuck*) ...	—	—	—	—	—	P	*P*	—	—	—	P	—	—	—	—	—	*P*	*P*	B.
Filograna implexa, *Berkley* ...	—	—	—	—	—	—	P	—	*P*	—	—	—	M	P	—	—	—	—	L.B.
Dasychone bombyx (*Dal.*) ...	P	P	M	P	—	P	M	—	M	Fo	—	P	P	—	—	Fo	—	—	L.B.
Protula tubularia (*Mont.*) ...	—	—	—	—	—	—	F	*P*	—	Fo	—	—	—	Fo	—	F	F	—	L.
Serpula vermicularis, *Linn.* ...	—	—	P	Fo	—	F	P	—	P	Fo	—	—	P	P	—	—	Fo	F	L.B.
Hydroides norvegica (*Gunn*) ...	F	P	P	—	F	P	P	—	P	Fo	P	—	P	P	F	F	P	P	L.B.
Potamoceros triqueter (*Linn.*)...	—	Fo	—	—	—	P	F	—	P	—	*P*	—	—	—	—	—	—	—	L.B.
Spirorbis sp.	—	P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	P	P	

	Fine sand.								Coarse gravel with sand or mud.					Fine gravel.		Shell gravel.		Stones.	
CRUSTACEA.	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	
Homarus vulgaris, *M.-Edw.* ...	Fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	B.
Pandalus brevirostris, *Rthke.* ...	—	—	M	M	—	—	F	—	F	—	—	—	—	—	—	—	—	—	B.A.
Eupagurus Bernhardus, *Linn*...	P	M	M	P	P	P	F	—	P	Fo	F	F	—	F	—	—	F	F	B.A.
,, Prideauxii (*Leach*) ..	—	—	P	P	*P*	P	F	*P*	*P*	Fo	—	—	F	Fo	—	—	Fo	—	L.B.
,, cuanensis (*Thompson*)	—	—	—	—	—	—	F	—	—	—	P	—	P	Fo	—	Fo	Fo	—	L.
Anapagurus laevis (*Thompson*)	—	M	Fo	Fo	M	*P*	F	*P*	M	—	Po	—	—	—	—	—	Fo	F	L.
Porcellana longicornis (*Linn.*)...	P	P	M	M	M	M	F	*P*	M	F	M	—	P	P	—	P	M	M	L.
Galathea dispersa, *Bate* ...	P	M	M	M	M	M	M	*P*	M	Fo	M	—	M	P	F	Fo	F	M	L.
Stenorhynchus longirostris, *Fab.*	F	F	M	M	M	P	P	*P*	P	Fo	P	—	*P*	P	F	—	Fo	Fo	L.
Inachus dorsettensis (*Pennant*)	Fo	F	M	M	M	P	P	*P*	M	—	P	—	P	P	F	—	Fo	Fo	L.
Maia squinado, *Latreille* ...	Fo	—	Fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.
Hyas coarctatus, *Leach* ...	Fo	—	—	Fo	—	P	—	—	—	—	—	—	—	—	—	—	F	M	A.B.
Eurynome aspera (*Pennant*) ...	F	Fo	F	Fo	—	F	F	F	M	—	F	F	F	Fo	—	—	Fo	P	L.
Cancer pagurus, *Linn.* ...	—	—	Fo	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	B.L.
Pilumnus hirtellus, *Leach* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	L.
Portunus depurator (*Linn*) ...	—	—	Mo	M	—	P	—	F	—	—	—	—	P	Po	—	—	—	—	L.B.
,, pusillus, *Leach* ...	—	—	—	*Po*	—	F	Fo	F	P	Fo	M	—	—	—	—	Fo	F	Fo	L.
Corystes cassivelaunus (*Penn.*)	Mo	Fo	Mo	—	F	—	—	—	—	—	—	—	—	—	—	—	Fo	—	L.
Atelecyclus heterodon, *Leach*...	Fo	—	—	Fo	—	P	Fo	—	m	—	F	—	M	—	Fo	—	Fo	Fo	L.B.
Ebalia tumefacta (*Montagu*) ...	—	Fo	—	—	—	—	—	F	M	Fo	P	—	—	Fo	—	F	F	F	L.B.
,, tuberosa (*Pennant*) ...	—	—	—	—	—	F	Fo	F	M	Fo	P	—	P	F	—	—	F	F	L.B.
,, Cranchii, *Leach* ...	—	—	—	—	—	—	—	—	—	—	P	—	—	—	—	—	F	F	L.B.
Gonoplax angulata (*Fabr*) ...	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	L.
Balanus crenatus, *Bruguière* ...	—	—	—	—	—	—	P	—	—	F	*P*	—	—	P	—	*P*	*P*	—	A.L.
Scalpellum vulgare, *Leach* ...	P	P	M	M	—	P	P	—	M	Fo	P	*P*	—	P	F	—	F	—	L.B.
Pyrgoma anglicum (*Gray*) ...	—	—	—	—	—	—	—	—	M	—	P	—	—	—	—	P	P	P	L.
Phthisica marina, *Slabber* ...	—	—	—	—	—	—	—	—	—	—	*P*	—	—	—	*P*	—	—	—	L.B.
Ampelisca spinipes, *Boeck* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*P*	*P*	B.
Melita obtusata (*Mont.*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	F	B.
Gammaropsis erythrophthalmium *Lilljeborg*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*P*	P	L.B.
Erichthonius abditus, *Templeton*	—	—	—	—	—	—	—	—	—	—	*P*	*P*	—	—	—	—	—	—	L.B.
MOLLUSCA. *Living.*																			
Pholas parva, *Pennant* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	L.
Pholadidea papyracea (*Turton*)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	M	L.
Saxicava rugosa, *var.* arctica, (*Linn.*)	Fo	—	—	P	—	—	P	—	P	—	M	—	*P*	—	—	—	P	F	L.B.
Pandora obtusa, *Leach* ...	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	A.L.
Lyonsia norvegica (*Chemnitz*)...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	—	A.L.
Psammobia costulata, *Turton*...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	F	—	—	L.
Tellina crassa, *Pennant* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	F	—	—	L.
Tapes virginea (*Linn.*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	F	—	Fo	—	Fo	L.B.
Venus verrucosa, *Linn.* ...	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	L.
,, casina, *Linn*.... ...	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	L.B.
,, fasciata, *Donovan* ...	—	—	—	—	—	—	—	—	—	—	Fo	—	—	—	—	Fo	Fo	Fo	L.B.
,, ovata, *Pennant* ...	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	L.B.
Artemis exoleta (*Linn.*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	—	—	L.B.
Circe minima (*Montagu*) ...	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	L.B.
Astarte sulcata (*Da Costa*) ...	—	—	—	—	—	—	—	—	—	Mo	—	—	F	Fo	—	—	Fo	—	A.L.
Cardium echinatum, *Linn* ...	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	A.L.
,, norvegicum, *Spengler*	—	—	—	F	—	—	Fo	—	F	Fo	—	—	—	P	—	Fo	—	—	L.B.
Montacuta substriata (*Montagu*)	—	—	—	—	—	—	—	—	—	—	—	—	—	P	—	P	P	—	L B.
Kellia suborbicularis (*Montagu*)	—	—	—	—	—	—	Fo	—	—	Fo	P	—	—	Fo	—	—	—	Fo	L.B.
Modiola modiolus (*Linn.*) ...	—	—	—	f	—	—	p	—	p	—	p	p	—	p	—	—	p	f	
Nucula nucleus (*Linn.*) ...	—	—	—	—	—	—	Fo	—	—	—	—	—	F	—	—	—	—	—	L.B.
,, nitida, *Sowerby* ...	—	M	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	A.L.
Arca tetragona, *Poli.* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	f	f	L.B.
Pectunculus glycimeris (*Linn.*)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	f	—	M	fo	L.B.
Lima Loscombii, *Sowerby* ...	—	—	—	—	—	—	Fo	—	F	—	Fo	—	—	P	—	Mo	Fo	—	A.L.

	Fine sand.								Coarse gravel with sand or mud.					Fine gravel.		Shell gravel.		Stones.	
	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv.	xv.	xvi.	xvii.	xviii.	
Pecten tigrinus, *Müller* ...	—	—	—	—	—	F	Fo	—	—	—	Fo	—	F	—	—	Fo	Fo	Fo	B.
,, maximus (*Linn.*) ...	—	—	—	Fo	—	—	P	P	M	Fo	P	F	P	P	—	F	—	Fo	L.
,, opercularis (*Linn.*) ...	Fm	Fm	MFm	Mm	F	F	P	Fm	M	Fo	Fm	f	F	MF	p	f	Fo	Fo	L.
Anomia ephippium, *Linn.* ...	—	—	P	—	—	—	P	—	M	Fo	P	m	P	P	—	—	P	—	A.L.
,, patelliformis, *Linn.* ...	—	P	—	—	—	—	P	—	M	Fo	—	—	P	P	P	—	P	—	L.B.
Dentalium entalis, *Linn.* ...	M	—	M	—	—	P	P	—	—	—	Fo	—	—	—	—	—	Fo	—	A.L.
Pileopsis hungaricus (*Linn.*) ...	—	—	—	—	—	—	—	—	F	Fo	*P*	—	—	P	—	—	Fo	—	L.B.
Emarginula reticulata, *Sowerby*	—	—	—	—	—	—	P	—	—	Fo	M	—	—	P	—	F	Po	M	L.B.
,, rosea, *Bell* ...	—	—	—	—	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	L.
Trochus zizyphinus, *Linn.* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	fo	—	—	fo	f	L.B.
,, granulatus, *Born* ...	—	—	—	—	—	—	—	—	F	—	Fo	—	F	—	—	—	Fo	—	L.
Turritella communis, *Risso* ...	—	—	—	Fo	—	—	—	—	M	—	—	—	—	—	—	—	—	—	L.B.
Aporrhais pes-pelecani (*Linn.*)	—	—	—	—	—	—	—	F	—	Fo	—	—	—	—	—	Fo	—	—	L.B.
Eulima polita (*Linn.*) ...	—	—	—	—	—	—	—	—	—	—	Fo	—	F	—	—	—	—	—	L.B.
Natica nitida (*Donovan*) ...	—	—	—	—	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	L.B.
Lamellaria perspicua (*Linn.*) ...	—	—	—	—	—	—	F	—	—	—	F	—	—	—	—	—	Fo	—	L.B.
Nassa incrassata (*Müller*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	Fo	L.B.
Buccinum undatum, *Linn.* ...	—	—	M	M	—	*P*	P	—	P	Fo	P	F	f	Fo	—	—	P	Fo	B.
Fusus islandicus, *Chemnitz* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Mo	—	A B.
Cypraea europaea, *Montagu* ...	—	—	F	F	—	—	Fo	—	—	—	—	—	F	F	—	—	Fo	—	L.
Ovula patula (*Pennant*) ...	—	F	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	Fo	L.
Chiton asellus, *Chemnitz* ...	Fo	—	—	—	—	P	P	—	P	Fo	—	—	—	M	*P*	F	P	M	A.L.
,, discrepans, *Brown* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	L.
Proneomenia aglaopheniae, *Mar. & Kowalevsky*	—	—	P	—	—	—	F	F	—	—	P	F	—	—	—	—	—	—	L.
Dondersia banyulensis, *Pruvot* .	—	—	P	P	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	L.
Scaphander lignarius, *Linn.* ...	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	L.B.
Oscanius membranaceus (*Mont.*)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Tritonia Hombergii, *Cuvier* ...	—	fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*P*	—	L.
,, plebeia, *Johnston* ...	*P*	—	—	—	—	—	—	—	—	—	—	—	—	*P*	—	—	—	—	L.
Dendronotus arborescens (*O.F.M.*)	*P*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*P*	—	A.B.
Doto fragilis (*Forbes*) ...	*P*	—	—	—	—	*P*	*P*	—	M	—	P	P	P	P	—	—	—	—	L.
,, pinnatifida (*Montagu*) ...	*P*	—	—	—	—	*P*	*P*	—	—	—	—	—	—	—	—	—	—	—	
,, coronata (*Gmelin*) ...	—	*Po*	*P*	—	—	*P*	*P*	—	—	—	—	—	—	—	—	—	*P*	*P*	L.B.
Hero formosa, *Lovén* ...	—	Fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	B.
Cratena viridis (*Forbes*) ...	*P*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	B.(?)
Galvina tricolor (*Forbes*) ...	—	*Po*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	B.
Coryphella rufibranchialis (*Jon.*)	—	—	P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.B.
,, Landsburgii (*Alder & Hancock*)	*P*	—	—	—	—	—	—	—	—	—	—	—	—	*P*	—	—	—	*P*	L.
Archidoris tuberculata (*Cuvier*)	—	—	*P*	—	—	*P*	—	—	—	—	—	—	—	—	—	—	—	—	L.B.
,, maculata, *Garstang* .	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	
Lamellidoris oblonga, *Alder & Hancock*	P	—	P	P	—	—	P	—	—	—	—	—	—	—	—	—	—	—	
Triopa claviger (*O. F. M.*) ...	—	—	—	—	—	*P*	—	—	—	—	—	—	—	—	—	—	—	—	B.
Aegirus punctilucens, *D'Orbigny*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	—	—	B.(?)
Polycera quadrilineata (*O.F.M.*)	—	—	—	—	—	*P*	—	—	—	—	—	—	—	—	—	—	—	*P*	L.
MOLLUSCA. *Shells.*																			
Lyonsia norvegica (*Chemnitz*) ...	—	—	—	—	—	—	F	—	—	—	F	—	F	—	—	—	—	—	
Solen ensis, *Linn.*	—	—	—	F	—	—	—	—	—	—	F	—	—	F	—	—	F	—	
Solecurtus candidus (*Renieri*)...	—	—	—	F	—	—	F	—	—	—	—	—	—	—	—	—	Fo	—	
Psammobia ferroensis (*Chemnitz*)	—	—	—	—	—	F	F	—	—	—	—	—	—	Fo	—	—	—	—	
Tellina crassa, *Pennant* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	*P*	Fo	—	
,, donacina, *Linn.* ...	—	—	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	
Lutraria elliptica, *Lamarck* ...	—	—	—	—	—	—	F	*P*	P	F	—	*P*	—	M	—	*P*	M	Fo	
Tapes virginea (*Linn.*) ...	—	—	—	M	—	M	M	—	M	F	M	—	*P*	M	P	M	P	Fo	
Venus verrucosa, *Linn.* ...	—	—	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	
,, striatula, *Donovan* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	*P*	—	—	—	—	
,, fasciata, *Donovan* ..	—	—	—	—	—	—	—	—	—	—	—	—	—	*P*	—	—	*P*	Fo	

	Fine sand.								Coarse gravel with sand or mud.					Fine gravel.		Shell gravel.		Stones.	
	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii.	xiv	xv.	xvi.	xvii.	xviii.	
Venus ovata, *Pennant* ...	—	—	—	—	—	—	—	—	M	F	—	—	P	—	—	—	M	—	
Artemis exoleta (*Linn.*) ...	—	—	—	P	—	—	F	—	—	—	M	—	—	*P*	—	M	Fo	—	
Cyprina islandica (*Linn.*) ...	—	P	—	P	—	P	F	—	F	—	—	*P*	—	*P*	—	—	—	—	
Astarte sulcata (*Da Costa*) ...	—	—	—	—	—	—	—	—	—	Mo	—	—	—	*P*	—	*P*	Fo	—	
Cardium echinatum, *Linn.* ...	M	M	—	—	—	M	M	P	—	F	F	*P*	*P*	F	—	—	—	—	
,, norvegicum, *Spengler.*	—	—	—	P	—	—	M	P	M	F	*P*	p	*P*	M	—	M	P	Fo	
Nucula nucleus (*Linn.*) ...	—	—	—	—	—	P	—	—	—	—	—	—	P	P	—	—	—	—	
,, nitida, *Sowerby* ...	—	M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Pectunculus glycimeris, *Linn*...	—	—	—	—	—	—	f	—	—	—	—	—	f	*P*	p	p	M	Fo	
Pinna pectinata, *Linn.* ...	—	—	—	F	—	F	F	—	F	F	—	—	—	Fo	—	—	—	—	L.
Lima Loscombii, *Sowerby* ...	—	—	—	—	—	—	—	—	—	F	Mo	—	—	M	P	*P*	—	Fo	
Pecten tigrinus, *Müller* ...	—	—	—	—	—	—	*P*	—	F	F	—	—	—	F	—	—	—	Fo	
,, maximus (*Linn.*) ...	—	—	—	M	—	P	M	—	M	P	M	F	M	M	P	P	F	—	
,, opercularis (*Linn.*) ...	—	F	—	M	F	M	M	P	M	M	M	M	M	M	P	P	M	P	
Ostrea edulis, *Linn.*... ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	F	—	
Dentalium entalis, *Linn.* ...	—	P	P	F	—	P	*P*	P	—	P	*P*	—	—	F	—	*P*	—	—	
Trochus granulatus, *Born* ...	—	—	—	—	—	—	—	—	*P*	—	F	—	—	—	—	—	F	—	
Turritella communis, *Risso* ...	—	—	—	—	—	—	F	—	M	—	F	—	—	F	—	—	—	—	
Aporrhais pes-pelecani (*Linn.*)	—	Fo	—	—	—	—	F	—	F	F	—	—	F	—	—	P	Fo	—	
Scalaria Turtonis (*Turton*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	—	—	—	—	
Natica nitida (*Donovan*) ...	—	P	—	—	—	—	—	—	P	—	—	—	—	—	—	—	Fo	—	
Murex erinaceus, *Linn.* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	
Nassa incrassata (*Müller*) ...	—	—	—	—	—	—	—	—	P	—	—	—	—	—	—	—	—	—	
Buccinum undatum, *Linn.* ...	P	P	P	P	—	—	—	—	—	—	—	F	—	Fo	—	—	—	—	
Fusus islandicus, *Chemnitz* ...	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	P	Fo	
POLYZOA.																			
Aetea recta, *Hincks*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	F	Fo	B.
Scrupocellaria scruposa (*Linn.*)	F	—	M	P	—	P	M	M	M	Fo	M	—	P	F	—	—	F	F	L.B.
Bicellaria ciliata (*Linn.*) ...	F	—	—	—	—	P	M	P	P	—	P	—	—	—	—	—	—	F	B.
Bugula turbinata, *Alder* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	F	?
,, avicularia (*Linn.*) ...	—	—	Fo	—	—	P	F	P	—	Fo	—	—	—	F	—	—	F	—	A.L.
,, flabellata (*Thompson*)...	—	—	F	Fo	—	—	—	P	—	Fo	—	—	—	—	—	—	—	—	L.
Cellaria sinuosa (*Hassall*) ...	M	F	M	M	F	M	M	M	—	Fo	F	—	F	—	—	—	—	Fo	?
,, fistulosa (*Linn.*) ...	M	F	M	M	F	M	M	M	F	Fo	F	f	F	F	—	—	—	Fo	L.
,, Johnstoni, *Busk* ...	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.
Membranipora Dumerilii (*Aud.*)	P	—	Fo	F	—	—	F	—	—	F	—	—	—	—	—	F	F	P	B.
,, catenularia (*Jam.*)	—	—	—	F	—	—	F	—	—	—	—	—	—	P	—	—	Fo	P	L.B.
,, Flemingii (*Busk*)	—	*P*	—	F	—	—	F	—	—	—	—	—	—	—	—	—	—	P	A.L.
Micropora coriacea (*Esper*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	Fo	B.
Cribrilina radiata (*Moll.*) ...	—	—	—	P	—	—	—	—	—	—	—	—	—	P	—	F	P	P	L.
,, figularis (*Johnston*) ...	—	—	—	P	—	—	F	—	—	—	—	—	—	P	—	F	F	P	L.
Microporella ciliata (*Pallas*) ...	—	—	Fo	P	—	—	P	—	P	F	F	—	—	P	—	*P*	P	P	A.L.
,, Malusii (*Audouin*)	—	—	—	P	—	—	F	—	—	—	—	—	—	P	—	*P*	P	P	A.L.
,, violacea (*Johnston*)	—	—	—	—	—	—	P	—	—	—	—	—	—	P	—	F	Fo	P	L.
Chorizopora Brongniartii (*Aud.*)	—	—	—	P	—	—	P	—	P	F	F	—	—	M	—	—	P	P	L.
Schizoporella linearis (*Hassall*)	Fo	—	—	P	—	—	P	—	—	F	F	*P*	—	P	—	F	P	P	L.B.
,, auriculata (*Hasl.*)	—	—	Fo	P	F	—	P	—	P	F	F	*P*	—	P	—	F	P	P	A.L.
Schizotheca fissa (*Busk*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	—	F	F	—	L.
Hippothoa divaricata, *Lamrx.*	F	—	—	P	—	—	P	—	—	—	P	—	—	P	—	P	P	P	A.L.
Lepralia foliacea (*Ellis & Sol.*)	Fo	—	—	Fo	—	—	—	—	—	—	Fo	—	—	Fo	—	—	—	—	L.
,, pertusa (*Esper*) ...	—	—	—	P	—	—	F	—	—	F	—	—	—	—	—	Fo	—	Fo	A.L.
Porella concinna (*Busk*) ...	Fo	—	—	P	—	—	F	—	M	F	P	*P*	—	P	—	Fo	P	P	A.L.
Smittia trispinosa (*Johnston*) ...	—	—	—	P	—	—	F	—	—	F	—	—	—	P	—	Fo	P	P	A.L.
,, cheilostomata (*Manzoni*)	—	—	—	P	—	—	—	—	—	F	—	—	—	Fo	—	Fo	P	F	?
Phylactella collaris (*Norman*).	—	—	—	F	—	—	—	—	—	—	F	—		—	—	—	—	—	?
Mucronella ventricosa (*Hassall*)	Fo	—	Fo	P	—	—	P	P	P	F	P	—	Many incrusting polyzoa, as in XIV.	P	F	Fo	P	P	A.L.
,, Peachii (*Johnston*).	—	—	—	P	—	—	P	—	P	F	F	—		P	—	Fo	P	P	A.L.
,, variolosa (*Johnston*)	—	—	—	P	—	—	—	—	—	—	—	—		P	—	Fo	P	P	L.
,, coccinea	—	—	—	P	—	—	—	—	—	—	—	—		—	—	—	—	Fo	A.L.
Palmicellaria Skenei, *Ellis & Sol.*	—	—	—	—	—	—	—	—	—	—	—	—		Fo	—	—	—	—	A.B.
Rhynchopora bispinosa (*Johnston*)	—	—	—	—	—	—	—	—	—	F	F	F		—	—	F	F	F	L. (?)
Cellepora avicularis (*Hincks*) ...	P	P	M	M	P	—	M	M	—	—	P	*P*		P	F	—	F	F	A.L.
,, ramulosa, *Linn.* ...	—	P	M	M	P	M	M	M	—	Fo	P	—		—	—	Fo	—	—	A.L.

	Fine sand.								Coarse gravel with sand or mud.					Fine gravel.		Shell gravel.		Stones.	
	i.	ii.	iii.	iv.	v.	vi.	vii.	viii.	ix.	x.	xi.	xii.	xiii	xiv.	xv.	xvi.	xvii.	xviii.	
Crisia eburnea (*Linn.*) ...	—	—	—	—	—	—	F	—	—	—	—	—	Many incrusting polyzoa, as in XIV.	P	—	—	F	F	A.L.
,, ramosa, *Harmer* ...	—	—	—	—	—	—	—	—	—	—	—	—		—	—	Fo	—	—	
Stomatopora major (*Johnston*)...	—	—	—	P	—	—	—	—	P	—	—	—		P	—	F	P	—	B. (?)
,, Johnstoni (*Heller*)	—	—	—	F	—	—	—	—	—	—	—	—		—	—	F	F	—	L. (?)
,, granulata (*M. Edw.*)	—	—	—	F	—	—	—	—	—	—	—	—		F	—	F	F	F	B. (?)
Idmonea serpens (*Linn.*) ...	—	—	M	M	—	—	—	M	P	—	P	*P*		—	—	Fo	F	F	L.B.
Diastopora suborbicularis, *Hnks.*	—	—	—	F	—	—	F	—	—	—	Fo	—		P	—	F	P	P	A.L.
,, sarniensis (*Norman*)	—	—	—	F	—	—	F	—	P	F	Fo	—		P	—	F	Fo	P	?
,, obelia (*Johnston*) ...	—	—	—	—	—	—	F	—	—	—	—	—	—	F	—	—	—	—	A.L.
,, patina (*Lamarck*) ...	Fo	—	—	—	—	—	Fo	—	P	—	—	—	—	F	—	—	Fo	P	A.L.
Lichenopora hispida (*Fleming*)	Fo	—	—	P	—	—	P	P	P	F	F	—	—	P	F	F	P	P	A.B.
Alcyonidium gelatinosum (*Lin.*)	—	—	F	—	—	—	Fo	P	—	—	—	—	—	—	—	—	—	—	A.B.
,, parasiticum (*Flem.*)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	B.
,, albidum, *Alder* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A.B.
Cylindroecium dilatatum (*Hnks.*)	—	—	*P*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	B.
Pedicellina cernua (*Pallas*) ...	*P*	—	*P*	—	P	—	Fo	*P*	—	Fo	*P*	—	—	—	—	—	—	Fo	A.L.
TUNICATA.																			
Molgula oculata, *Forbes* ...	—	—	—	—	—	—	—	—	—	—	Fo	—	—	—	—	F	—	—	L.B.
,, simplex, *Alder & Han.*..	—	—	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	B.
Forbesella tesselata (*Forbes*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	F	—	—	—	?
Styelopsis grossularia, *Van Ben.*	—	—	—	—	—	—	—	—	—	—	—	—	P	P	—	—	P	—	B.
Polycarpa varians, *Heller* ...	fo	—	—	—	—	—	M	—	M	Po	Fo	—	f	M	—	—	—	—	L.B.
Corella larvaeformis, *Hancock*...	—	—	—	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	B.
Ascidiella venosa (*O.F.M.*) ...	—	—	—	Fo	—	—	—	—	—	—	F	—	—	—	—	—	—	—	L.B.
,, scabra (*O.F.M.*) ...	P	F	M	M	f	M	F	*P*	F	—	F	F	F	F	—	Fo	Fo	—	L.B.
Ascidia depressa, *Alder* ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	F	Fo	?
,, mentula (*O.F.M.*) ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Fo	—	L.B.
Ciona intestinalis (*Linn.*) ...	—	F	—	—	—	—	F	—	—	—	—	—	—	Fo	—	—	P	Fo	L.B.
CEPHALOCHORDA.																			
Amphioxus lanceolatus, *Yarrell*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	F	F	F	—	L.
FISHES.																			
Pleuronectes platessa, *Linn.* ...	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A.B.
,, limanda, *Linn.* ...	—	—	M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A.B.
,, microcephalus, *Don.*	—	—	M	Fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	A.B.
Solea lutea (*Risso*)	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.
,, variegata (*Donovan*) ...	—	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.
Arnoglossus laterna (*Walb*) ...	M	—	M	Fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.
Gadus minutus, *Linn.* ...	Fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.
Merluccius vulgaris (*Linn.*) ...	Fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.
Capros aper (*Linn.*)... ...	P	—	P	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.
Zeus faber, *Linn.*	Mo	—	P	Fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.
Trigla pini, *Bloch*	F	F	M	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	L.
,, gurnardus, *Linn.* ...	M	F	M	Fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.B.
,, lineata, *Gmel.* ...	—	—	Fo	Mo	F	—	—	—	—	—	—	—	—	—	—	—	—	—	L.
,, hirundo, *Linn.* ...	Fo	—	—	Fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.
Lophius piscatorius, *Linn.* ...	—	—	F	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	L.B.
Callionymus lyra, *Linn.* ...	P	—	M	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.
Gobius Jeffreysi, *Günther* ...	M	—	M	M	—	—	—	—	—	—	—	—	—	—	—	—	—	—	B.
Crystallogobius Nilssoni, *D. & K.*	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Lepadogaster bimaculatus (*Don.*)	—	—	—	—	—	—	F	—	F	F	—	F	F	—	—	—	Fo	—	L.
Scyllium canicula (*Linn.*) ...	fo	—	fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.
Raia clavata, *Linn.*... ...	Fo	Fo	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	L.B.
,, blanda, *Holt*	—	—	—	—	F	—	—	—	—	—	—	—	—	—	—	—	—	—	
,, sp. (*young*)	—	—	f	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
Rhina squatina (*Linn.*) ...	—	—	—	fo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	L.

Table VII.

Showing the number and percentage of animals of each group living at a depth of about 30 fathoms between the Eddystone and Start Point, which are found in the different geographical regions.

	A. L. Arctic to Lusitanian	A. B. Arctic and Boreal	B. Boreal	L. B. Lusitanian and Boreal	L. Lusitanian	Remarks
Foraminifera	1	—	—	—	—	Foraminifera from bottom-deposits not included.
Hydrozoa	11 25 %	4 9 %	17 39 %	6 14 %	6 14 %	
Anthozoa	—	—	3 30 %	—	7 70 %	
Echinodermata	3 12 %	3 12 %	5 19 %	12 46 %	3 12 %	
Nemertina	3 25 %	—	1 8 %	—	8 67 %	Nemertina of northern seas not well known.
Polychaete	6 16 %	6 16 %	5 13 %	11 30 %	9 24 %	
Crustacea	1 3 %	3 10 %	3 10 %	11 35 %	13 42 %	
Mollusca	9 14 %	2 3 %	7 10 %	27 41 %	20 31 %	
Polyzoa	19 40 %	4 9 %	8 17 %	4 9 %	12 26 %	
Tunicata	—	—	3 33 %	6 67 %	—	Tunicata of northern seas not well known.
Fishes	—	3 14 %	1 4 %	3 14 %	15 68 %	The number of fishes captured is not large, as the results are mostly those of dredgings.
Total	53 18 %	25 8 %	53 18 %	80 26 %	93 30 %	

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EXPLANATION OF CHARTS

Illustrating the Report "On the Fauna and Bottom-deposits near the Thirty-fathom line from the Eddystone Grounds to Start Point."

Conventional signs have been adopted to indicate the texture of the bottom-deposits.

Each species is indicated by a letter, and the kind of type shows the relative abundance of the species. A thick capital placed on any ground indicates that the species is very abundant on the ground; a hollow capital that it is moderately plentiful; a thin capital that it is generally present but only in small numbers; and a small letter that only one or two occasional stray specimens have been taken on the ground.

Chart I.
Alcyonium digitatum.
Caryophyllia Smithii.
Sarcodictyon catenata.
Epizoanthus incrustatus.
Chondractinia digitata.

Chart II.
Halecium halecinum.
Sertularella Gayi.
Aglaophenia myriophyllum.
Sertularia abietina.

Chart III.
Eudendrium ramosum.
„ rameum.
Bougainvillia ramosa.
Hydrallmania falcata.

Chart IV.
Antennularia antennina.
Antennularia ramosa.
Thuiaria articulata.
Plumularia Catharina.

Chart V.
Echinus esculentus.
„ acutus.
„ miliaris.
Spatangus purpureus.
Echinocardium cordatum.

Chart VI.
Asterias glacialis.
„ rubens.
Holothuria nigra.
Solaster papposus.
Amphiura elegans.
„ filiformis.

Chart VII.
Palmipes placenta.
Luidia Sarsii.
Porania pulvillus.
Henricia sanguinolenta.

Chart VIII.
Astropecten irregularis.
Ophiura ciliaris.
Ophiothrix fragilis.
Ophiocoma nigra.

Chart IX.
Ophiactis Balli.
Ophiura albida.
„ affinis.
Proneomenia aglaopheniae.
Dondersia banyulensis.

Chart X.
Chaetopterus variopedatus.
Polygordius sp.
Hyalinoecia tubicola.
Aphrodite aculeata.

Chart XI.
Stenorhynchus longirostris.
Inachus dorsettensis.
Hyas coarctatus.
Ebalia tumefacta.
„ tuberosa.
„ Cranchii.

CHART XII

Pandalus brevirostris.
Eupagurus Bernhardus.
„ Prideauxii.
Sagartia parasitica.

CHART XIII.

Atelecyclus heterodon.
Corystes cassivelaunus.
Gonoplax angulata.
Portunus depurator.
„ pusillus.

CHART XIV.

Pecten opercularis.
„ maximus.
Cardium norvegicum.
Cardium echinatum (shells).
„ „ (living).

CHART XV.

Pectunculus glycimeris.
Fusus islandicus.
Buccinum undatum.
Dentalium entalis.
Turritella communis.
Lima Loscombii.

CHART XVI.

Cellaria fistulosa and sinuosa.
Ascidiella scabra.
Polycarpa varians.
Amphioxus lanceolatus.
Lepadogaster bimaculatus.

A = *Alcyonium digitatum*. C = *Caryophyllia Smithii*. S = *Sarcodictyon catenata*. E = *Epizoanthus incrustatus*. D = *Chondractinia digitata*.

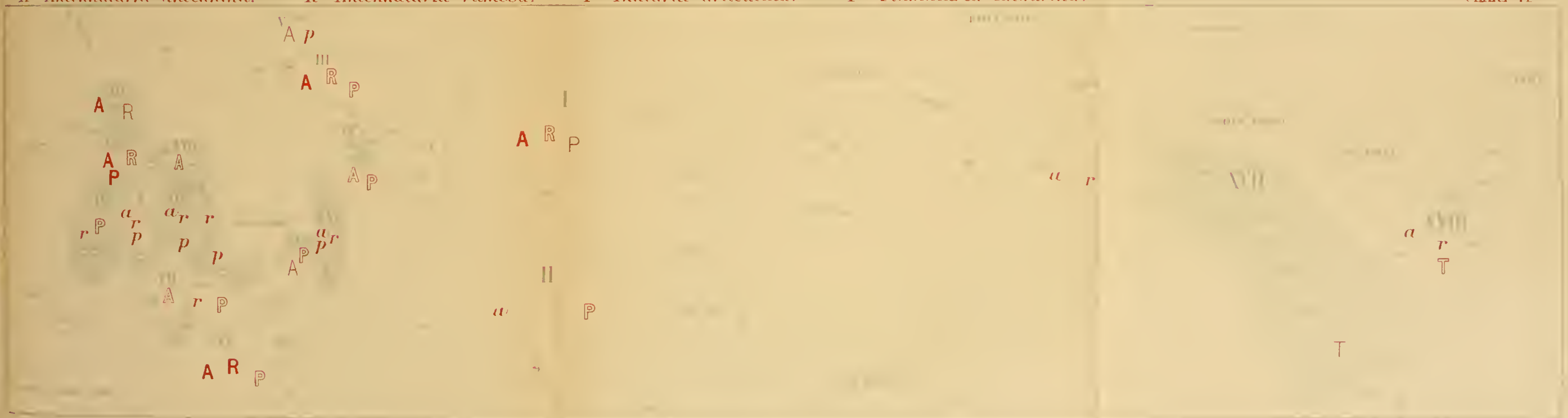
CHART I

H = *Halecium halecinum*. S = *Sertularella Gayi*. M = *Aglaophenia myriophyllum*. A = *Sertularia abietina*.

CHART II

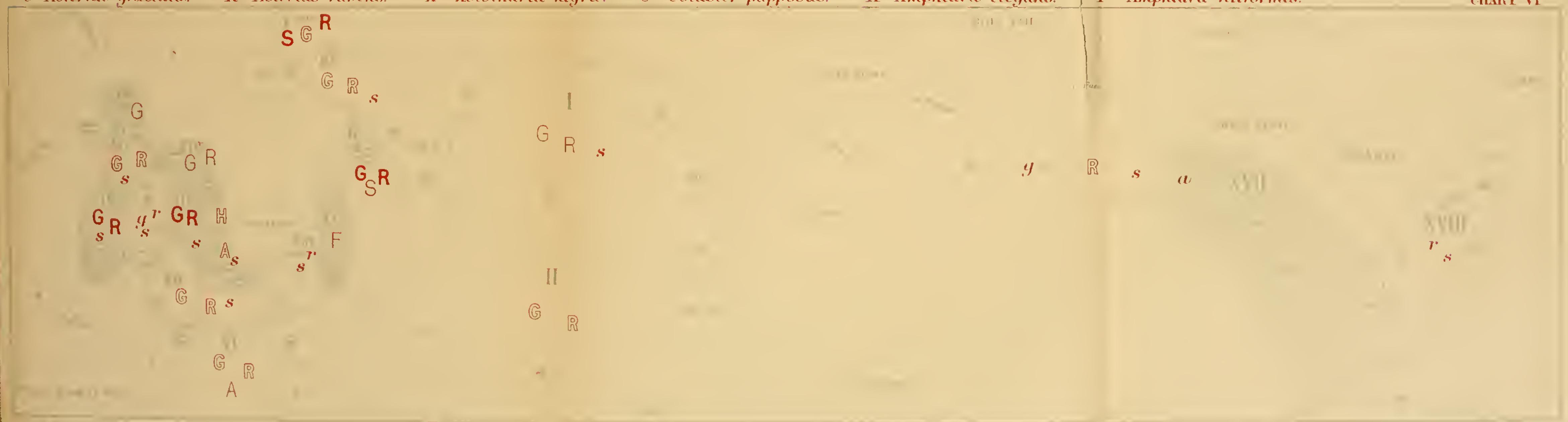
O = *Eudendrium ramosum.* E = *Eudendrium rameum.* B = *Bougainvillia ramosa.* H = *Hydrallmania falcata.* CHART III

A = *Antennularia antennina.* R = *Antennularia ramosa.* T = *Thuiaria articulata.* P *Plumularia Catharina.* CHART IV



E – Echinus esculentus. *A – Echinus acutus.* *M – Echinus miliaris.* *S – Spatangus purpureus.* *C – Echinocardium cordatum.* CHART V

G = Asterias glacialis. *R = Asterias rubens.* *H = Holothuria nigra.* *S = Solaster papposus.* *A = Amphiura elegans.* *F = Amphiura filiformis.* CHART VI



P = Palmipes placenta. L = Luidia Sarsii. O = Porania pulvillus. H = Henricia sanguinolenta.

CHART VII

A = Astropecten irregularis. C = Ophiura ciliaris. F = Ophiothrix fragilis. N = Ophiocoma nigra.

CHART VIII

B – *Ophiactis Balli.* A – *Ophiura albida.* F = *Ophiura affinis.* P – *Proneomenia aglaopheniae.* D = *Dondersia banyulensis.*

CHART IX

C – *Chaetopterus variopedatus.* P – *Polygordius sp.* H – *Hyalinoecia tubicola.* A = *Aphrodite aculeata.*

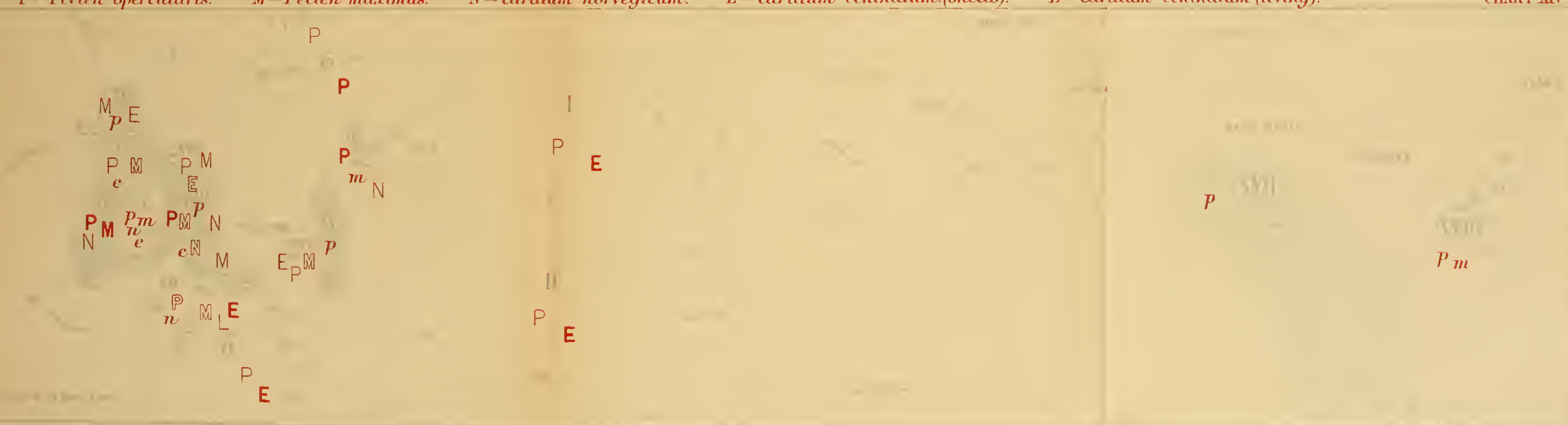
CHART X

S = *Stenorhynchus longirostris*. I = *Inachus dorsettensis*. H = *Hyas coarctatus*. M = *Ebalia tumefacta*. B = *Ebalia tuberosa*. C = *Ebalia Cranchii*. CHART XI

H = *Pandalus brevirostris*. B = *Eupagurus Bernhardus*. P = *Eupagurus Prideauxii*. S = *Sagartia parasitica*. CHART XII

A = Atelecyclus heterodon. C = Corystes cassivelaunus. G = Gonoplax angulata. D = Portunus depurator. P = Portunus pusillus. CHART XIII

P = Pecten opercularis. M = Pecten maximus. N = Cardium norvegicum. E = Cardium echinatum (shells). L = Cardium echinatum (living). CHART XIV



P = Pectunculus glycimeris. F = Fusus Islandicus. B = Buccinum undatum. D = Dentalium entalis. T = Turritella communis. L = Lima Loscombii. CHART XV

C = Cellaria fistulosa & sinuosa. S = Ascidiella scabra. P = Polycarpa varians. A = Amphioxus lanceolatus. L = Lepadogaster bimaculatus. CHART XVI

INDEX.

PLYMOUTH:
WILLIAM BRENDON AND SON, PRINTERS.

OBJECTS

OF THE

Marine Biological Association of the United Kingdom.

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

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

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

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

The Association has received some £30,000, of which £14,000 has been granted by the Treasury. The annual revenue which can be at present counted on is about £1,820, of which £1,000 a year is granted by the Treasury, the remainder being principally made up in subscriptions.

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

The purpose of the Association is to aid at the same time both science and industry. It is national in character and constitution, and its affairs are conducted by a representative Council, by an Honorary Secretary and an Honorary Treasurer, without any charge upon its funds, so that the whole of the subscriptions and donations received are devoted absolutely to the support of the Laboratory and the prosecution of researches by aid of its appliances. The reader is referred to page 4 of the Cover for information as to membership of the Association.

CONTENTS OF NEW SERIES Vol. V., No. 4.

NOTICE.

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

TERMS OF MEMBERSHIP.

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Life Members . . .	Composition Fee.	15	15	0
Founders . . .	. . .	100	0	0
Governors . . .	. . .	500	0	0

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

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