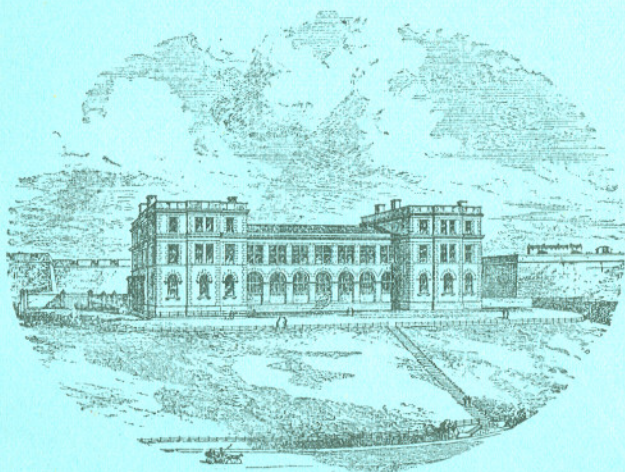


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## Report on the Present State of Knowledge with regard to the Habits and Migrations of the Mackerel (*Scomber scomber*).

By

E. J. Allen, B.Sc.,

Director of the Plymouth Laboratory.

*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. ( $\frac{3}{4}$  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  $9\frac{1}{2}$  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  $6\frac{1}{2}$  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. (Cunning- ham.)	Length of fish.	Age in Months. (Atwood.)
January .....	<i>Spawning</i> (?)	—	—	—	—	—	—	—
February .....	<i>Spawning</i> (?) 20-24 cm.	12	—	—	—	—	—	—
March .....	<i>Spawning.</i> End of Month: 5-5.8 cm. in quantity at Nice; 15 cm., Mar- seille.	2	—	—	—	—	—	—
April .....	<i>Spawning.</i> 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	<i>Spawning.</i>	—	31-33 cm.	24	<i>Spawning.</i>	—



June.....	12-15 cm. 10 cm.	6 4	<i>Spawning.</i> 21-23 cm.	12	<i>Spawning.</i> 22-23 cm.	12	<i>Spawning till 10th.</i>	—
July .....	15-20 cm. 10-13 cm.	—	<i>Spawning.</i>	—	<i>Spawning.</i> 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 speci- men.)	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.	MEDITER- RANEAN.	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.		
	MAR- SEILLE.	CETTE.	PORTUGAL.	WEST OF FRANCE.	SOUTH OF ENGLAND. Princi- pally 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 HAT- TERAS TO CAPES OF DELA- WARE.	NEW ENGLAND COAST.	GULF OF ST. LAW- RENCE.
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
July .....	5	2	plentiful	2	spawning 3	2	2	—	spawning 3 ?	5	2	—	present	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.			
	EAST COAST. Average, 1893-1895.	SOUTH COAST. Average, 1893-1895.	WEST COAST. Average, 1893-1895.	NORTH.	WEST.	SOUTH.	
	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.
	<i>Cwts.</i>	<i>Cwts.</i>	<i>Cwts.</i>	<i>Cwts.</i>	<i>Cwts.</i>	<i>Cwts.</i>	<i>Cwts.</i>	<i>Cwts.</i>	<i>Cwts.</i>
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.
	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>
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.
	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>	<i>Kilos.</i>
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.

much better condition than those taken in spring, owing to the more

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

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 Orchadensis*), 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. Earle, 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  $17\frac{1}{2}$  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.

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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  $1\frac{1}{2}$  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. deustsch. 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

*rella 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 zocœcia are torn by the operation, or if the lamella be too thin to include any zocœcia, 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 zocœcia, and by the two curious vesicular cavities which occur, one on either side of the distal end of the zocœcium. Excellent figures of

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 Deep.

## Note on New or Rare British Marine Polyzoa.

By

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

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### 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 chaetopteri*, 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 *Chaetopterus*.

On one of the last days of my stay at Plymouth in April last, a few *Chaetopterus* 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 zoecia are torn by the operation, or if the lamella be too thin to include any zoecia, 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 zoecia, and by the two curious vesicular cavities which occur, one on either side of the distal end of the zoecium. 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 *Chaetopterus* 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 zoecia, 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*.

Actinulae 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 Gymnoblasic Hydroids.

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

By

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and Naturalist in charge of Fishery Investigation at the Plymouth Laboratory.

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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. (*Videnskabselskabet's 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

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  $19\frac{3}{4}$  by  $11\frac{1}{2}$  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 whittings, the lesser weever, and the sandeel. Brill of 14½ and 20½ ins. were feeding on whittings. Flounders (12 to 18 ins.) had *Donax trunculus*, sandeels, *Macra 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, whittings, *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 ... calm.
	Aug. 7..	4 ...	—	—	16 ...	60 ...	51 ...	—	—	—	—	—	55 ...	{ NE sea ... W.
														smooth ...
	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.

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).  $2\frac{1}{2}$ -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	.526 ...	14 ...	— ...	— ...	40	5.3	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	.527 ...	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.

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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 Farøe 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  $7\frac{1}{4}$  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.

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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 "brednings," or broads, connected with each other by somewhat narrow channels of various lengths. The westernmost (Nisum) broad communicates with the sea (since the beginning of the present century) by means of an inconsiderable opening in the barrier ridge of Hasboøre, 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 Hasboøre 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  $9\frac{3}{4}$  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 reckon 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.

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**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,  $6\frac{1}{4}$  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.

*Muraena 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.

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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. Entwicklungsgesch.  
Gegenbaur.  
Proceedings of the Royal Society of London, previous to Vol. xlv.  
1888.  
Royal Society of Edinburgh. Transactions previous to 1888. Pro-  
ceedings 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. Beobacht. 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 Entwicklungsgeschichte 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 Sibiriens 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 Entwicklungsgeschichte 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 Farøe 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.

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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.

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### 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 Entwicklungsmechanik*.

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. Entwickl. mech. iii. p. 301.

BROWNE, E. T.—*On British Hydroids and Meduse.* 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 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. GERMAN.

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 CHAMBER-  
LAIN, 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. S. J. HICKSON, F.R.S.
Prof. F. JEFFREY BELL, F.Z.S.	J. J. LISTER, Esq.
G. C. BOURNE, Esq., F.L.S.	JOHN MURRAY, Esq., F.R.S.
Sir JOHN EVANS, K.C.B., Treas. R.S.	P. L. SCLATER, Esq., F.R.S., Sec. Z.S.
G. HERBERT FOWLER, Esq.	D. H. SCOTT, Esq., F.R.S.
S. F. HARMER, Esq.	Prof. CHARLES STEWART, F.R.S.
Prof. W. A. HERDMAN, 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.	Prof. BURDON SANDERSON, F.R.S. (Oxford University).
J. P. THOMASSON, Esq.	Prof. MICHAEL FOSTER, F.R.S. (Cambridge University).
THE PRIME WARDEN OF THE FISHMONGERS' COMPANY.	Sir WILLIAM FLOWER, K.C.B., F.R.S. (Brit. Assoc. for Advmt. of Science).
E. L. BECKWITH, Esq. (Fishmongers' Company).	

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 <i>Journal</i> .....	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

Examined and found correct,

EDWIN WATERHOUSE,

F. E. BEDDARD,

STEPHEN E. SPRING RICE,

W. F. R. WELDON,

} Auditors.

£2455 1 7

Expenditure.	£	s.	d.	£	s.	d.
By Balance from last year, being Overdraft at Bank, less Cash in hand .....				201	10	3
„ 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 <i>Journal</i> .....				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
„ Balance forward, being Cash in hand, less Overdraft at Bank .....				198	11	4

£2455 1 7

Investment held, £500 Forth Bridge Railway 4 % Guaranteed Stock.

# 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.



# CONTENTS OF NEW SERIES, Vol. V., No. 1.

	PAGE
1. REPORT ON THE PRESENT STATE OF KNOWLEDGE WITH REGARD TO THE HABITS AND MIGRATIONS OF THE MACKEREL ( <i>Scomber scomber</i> ). By E. J. ALLEN, B.Sc.	1
2. PRELIMINARY NOTES ON THE REPRODUCTION OF TELEOSTEAN FISHES IN THE SOUTH-WESTERN DISTRICT. By E. W. L. HOLT	41
3. NOTES ON NEW OR RARE BRITISH MARINE POLYZOA. By S. F. HARMER, M.A., B.Sc.	51
4. ON <i>Tubularia crocea</i> IN PLYMOUTH SOUND. By EDWARD T. BROWNE.	54
5. HJORT'S HYDROGRAPHIC-BIOLOGICAL STUDIES OF THE NORWEGIAN FISHERIES: A REVIEW. By WALTER GARSTANG, M.A.	56
6. AN ACCOUNT OF THE SCIENTIFIC WORK OF THE NORTHUMBERLAND SEA FISHERIES COMMITTEE. By ALEXANDER MEEK, M.Sc.	72
7. <i>Gadus Esmarkii</i> , NILSSON, THE NORWAY POULT, AN ADDITION TO THE FISH FAUNA OF THE ENGLISH SOUTH-WESTERN DISTRICT. By MATTHIAS DUNN and E. W. L. HOLT	79
8. REMARKS ON DR. PETERSEN'S REPORT OF THE DANISH BIOLOGICAL STATION FOR 1895. By E. W. L. HOLT	82
9. NOTES AND MEMORANDA	89
10. DIRECTOR'S REPORT	92
11. INSPECTION OF THE LABORATORY	98
12. REPORT OF THE COUNCIL, 1896-97	100

## NOTICE.

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

## TERMS OF MEMBERSHIP.

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

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

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