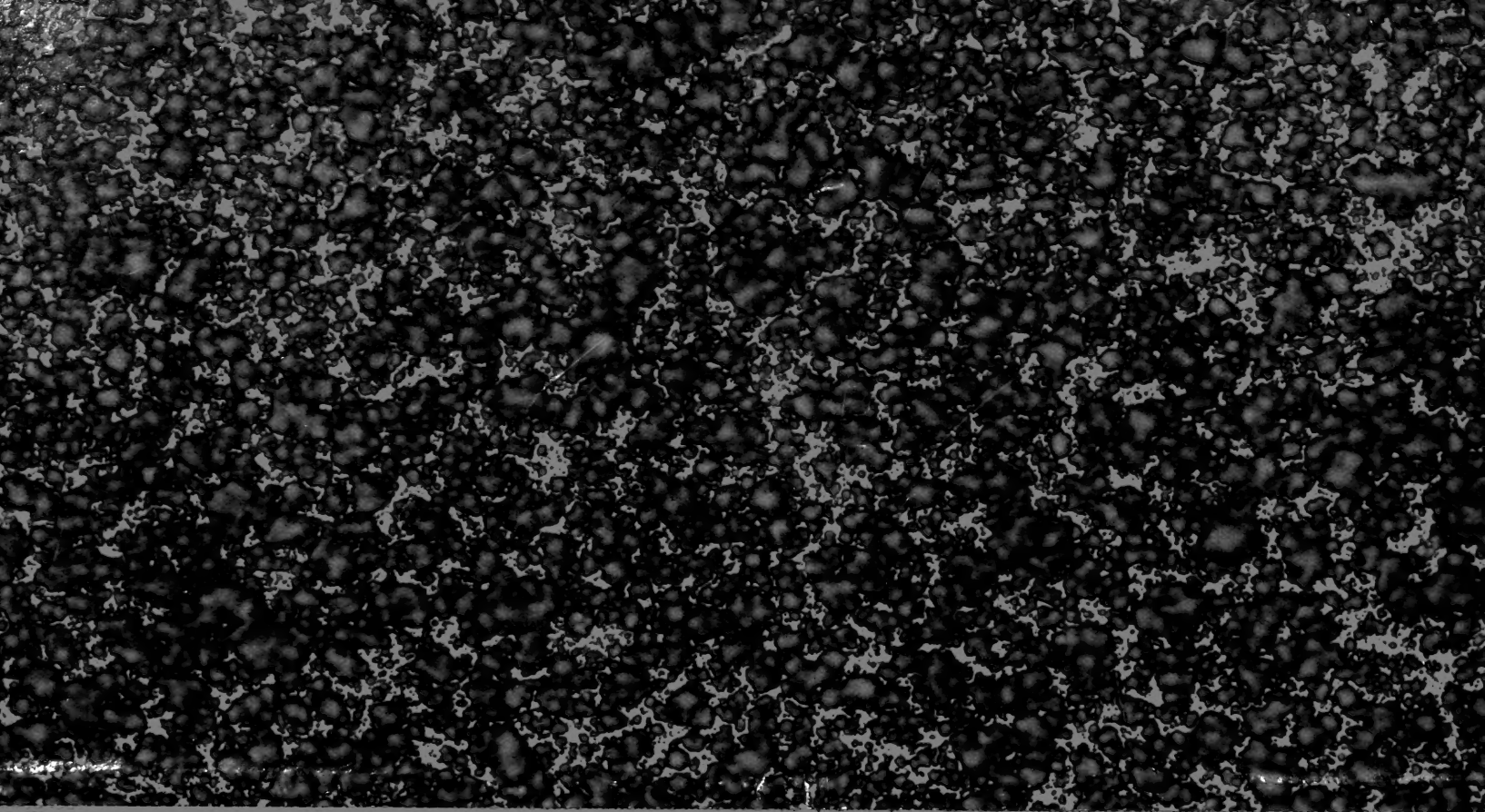

REPORT FOR 1893

ON THE

LANCASHIRE SEA-FISHERIES LABORATORY

AT

UNIVERSITY COLLEGE, LIVERPOOL.

DRAWN UP BY

Professor W. A. HERDMAN, D.Sc., F.R.S.

WITH APPENDIX

UPON THE METHODS OF

OYSTER AND MUSSEL CULTURE

IN USE ON THE

WEST COAST OF FRANCE.

WITH FOUR PLATES.

LIVERPOOL:

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Report on the Investigations carried on in 1893 in connection with the Lancashire Sea-Fisheries Laboratory at University College, Liverpool.

By Professor W. A. Herdman, D.Sc., F.R.S.;
assisted by Mr. P. F. J. Corbin.

The last Report besides treating of the work carried on in the Fisheries laboratory down to the end of 1892, gave an account of the establishment and fittings of the laboratory, and a certain amount of preliminary information in regard to the physical and biological features of our district of the Irish Sea, and the need of scientific investigations therein in regard to Fishery matters. There is therefore no need to give again any such general introduction, and the present report will deal merely with the work carried out in the laboratory and at sea during 1893 and the discussion of any results arising from it. Some of this work is merely a continuation of that undertaken last year, such as the investigation of the foods of our various edible fishes and of some inedible ones which frequent the same grounds and so may enter into competition with marketable species; while on the other hand some new questions have been opened up, such as the limits of size of the various species in this district at sexual maturity, the relative amount of vitality in individuals both large and small caught by various nets, the position and physical conditions of the spawning grounds, and the further extension of the food investigations to very young individuals of the edible fishes.

A few notes on faunistic investigations of the feeding grounds, on parasites, and on abnormalities of fish are also given; and a preliminary statement is made as to the

bearing of the statistics as to the distribution of fish collected by Mr. Dawson on board the steamer. A fuller discussion of these results can only take place after the accumulation of further statistics extending over a couple of years. The report ends with a note on Lobster hatching; and an Appendix on the methods of Oyster and Mussel culture adopted in France, illustrated by three plates.

The Food of Young Fishes.

One of the objects we have set before us has been to determine what the fish feed upon in our district at all stages of their lives, and so we have taken any opportunities that offered of examining, small individuals. When this investigation has been extended, as we hope to extend it during next spring and summer, to still younger stages including larval and young post-larval forms it may have the practical value of enabling us to succeed in finding suitable organisms, such as certain Diatoms and Copepoda, upon which young fish hatched artificially may be reared through the earlier and more critical stages of their life-history.

As a matter of fact we have already made during this last summer at the aquarium of the Port Erin Biological Station some experiments in breeding Copepoda in tanks, and I see no reason to doubt that we could cultivate at least some species in large quantities if required. In one of our aquaria we have had now for six months enormous swarms of *Idya furcata*, and in another we have quantities of *Harpacticus fulvus* which are reproducing freely. The Harpacticidæ seem on the whole to be the easiest to cultivate, and it is consequently important to notice that in the young Plaice we have examined, by far the most important constituent of the food seems to be the Har-

pacticidæ, especially the species *Jonesiella hyænæ*. It is curious that this animal which must be very abundant in the sand at the bottom in some parts of our district, and which is clearly from our investigations of so much importance as a food matter for the young fishes was not known at all even to naturalists until we captured some specimens in the bottom tow-net in April 1889, when dredging from the steamer "Hyæna" in Port Erin Bay.

In the following list we give the locality, date, number of specimens examined, limits of size in inches, and finally the contents of the stomachs. The numerals before the food matters indicate the number of stomachs containing the respective substances. The Map of the district (see Plate) shows the positions of the stations and other localities mentioned.

Young Plaice (*Pleuronectes platessa*).

R. Dee.	Feb. 15	39 fish.	$1\frac{3}{4}-2\frac{3}{4}$ inch.	5 *Crangon*, 3 *Gammarus* 3 Copepoda, 1 Ostracoda 1 Bivalve shells, 4 An. tiss., 22 Empty.
Burbo Bank.	Feb. 17	28 ,,	$2-2\frac{7}{8}$,,	28 Empty.
Morecambe.	Feb. 23	10 ,,	$1\frac{7}{8}-2\frac{3}{4}$,,	1 Crustacea, 1 Annelida, 8 Empty.
North Banks.	Feb. 24	31 ,,	$1\frac{7}{8}-2\frac{3}{4}$,,	4 Crustacea, 1 Ostracoda 2 Annelida, 1 Bivalve shells, 7 An. tiss., 16 Empty.
Formby Ch.	Mar. 6	10 ,,	$2-2\frac{7}{8}$,,	10 Empty.
Blackpool.	Apl. 21	3 ,,	$1\frac{3}{4}-2\frac{7}{8}$,,	3 An. tiss.
Morecambe.	May 17	5 ,,	$2-2\frac{3}{4}$,,	5 Copepoda, 3 Cumacea.
Station 4	June 6	5 ,,	$1\frac{1}{4}-1\frac{3}{4}$,,	3 *Cardium*, 2 *Corophium*, 3 Copepoda.
do.	do.	3 ,,	$2\frac{3}{4}-2\frac{7}{8}$,,	2 *Corophium*, 1 Empty.
Morecambe.	June 7	14 ,,	$1\frac{7}{8}-2\frac{7}{8}$,,	3 *Gammarus*, 1 *Carcinus* 2 *Pseudocuma*, 6 Copepoda, 2 Annelida, 2 Empty.

Young Plaice (*Pleuronectes platessa*).

Rock Ch.	June 13	9 fish.	$2\frac{1}{4}$--$2\frac{3}{8}$ inch.	1 *Cardium*, 8 Annelida.
Station 1.	June 21	31 ,,	$1\frac{3}{8}-1\frac{3}{4}$,,	26 *Pseudocuma*, 11 *Crangon*, 14 Copepoda, 4 Amphipoda, 1 An. tiss.
do.	do.	10 ,,	$1\frac{7}{8}-2\frac{1}{8}$,,	1 *Cardium*, 4 *Crangon*, 4 *Pseudocuma*. 2 Copepoda, 1 Schizopoda, 3 Amphipoda, An. tiss.
Morecambe.	June 22	15 ,,	$1\frac{1}{4}-1\frac{3}{4}$,,	5 *Pseudocuma*, 2 *Crangon*, 4 *Cardium*, 3 *Gammarus*, 1 Ostracoda, 11 Copepoda, 1 *Mysis*.
do.	do.	18 ,,	$1\frac{7}{8}-2\frac{3}{4}$,,	12 *Crangon*, 2 *Pseudocuma*, 1 *Cardium*, 4 Copepoda, 4 Amphipoda An. tiss.
Morecambe.	June 23	81 ,,	$\frac{7}{8}-1\frac{7}{8}$,,	81 Copepoda, 2 *Crangon*
Morecambe.	June 28	57 ,,	$1\frac{3}{8}-1\frac{3}{4}$,,	14 *Cardium*, 6 *Tellina*, 1 *Mytilus*, 8 *Pseudocuma*, 2 *Crangon*, 35 Copepoda, An. tiss.
do.	do.	2 ,,	$2\frac{3}{4}$,,	1 *Tellina*, 1 *Gammarus*.
Morecambe.	July 5	1 ,,	$2\frac{3}{4}$,,	An. tiss.
Morecambe.	July 21	12 ,,	$1\frac{1}{2}-1\frac{3}{4}$,,	2 *Crangon*, 1 *Pseudocuma*, 12 Copepoda, 1 Amphipoda.
do.	do.	11 ,,	$1\frac{7}{8}-2\frac{3}{8}$,,	3 *Cardium*, 2 *Crangon*, 6 Copepoda.
Lytham.	July 25	41 ,,	$1\frac{3}{4}-3$,,	9 *Tellina*, 8 *Cardium*, 2 *Corophium*, 3 *Crangon* 4 Copepoda, 2 Annelida, 2 *Mysis*, 2 An. tiss., 10 Empty.
Rock Channel.	July 25	1 ,,	$2\frac{3}{4}$	Annelida.
Morecambe.	July 26	23 ,,	$1\frac{3}{8}-1\frac{3}{4}$,,	9 Cumacea, 21 Copepoda 2 Spines of echini, 11 Small bivalves, An. tiss.
do.	do.	23 ,,	$1\frac{7}{8}-3$,.	9 *Cardium*, 1 *Tellina*, 1 *Mactra*, 7 Copepoda, 2 Small bivalves, 1 Annelida, 4 Cumacea, 1 Amphipoda, 1 spines of echini, 1 An. tiss., 2 Empty.

Young Plaice (*Pleuronectes platessa*).

Morecambe.	July 27	1 fish.	$2\frac{3}{4}$ inch.	*Cardium*.
Southport.	July 28	85 ,,	$1\frac{3}{8}-1\frac{3}{4}$,,	13 Copepoda, 2 Cumacea, 2 Crustacea, 4 Mactra, 3 *Tellina*, 1 *Mytilus*, 3 Bivalves, 2 Annelida, 1 Zoeas of Crab, 46 An. tiss., 7 Empty.
Morecambe.	Aug. 2	10 ,,	$1\frac{5}{8}-1\frac{3}{4}$,,	9 Copepoda, 1 Cumacea, 4 Amphipoda, 1 Zoeas of Crab.
do.	do.	12 ,,	$1\frac{7}{8}-2$,,	11 Copepoda, 3 Cumacea, 2 *Talitrus*.
Ribble, Gut Bar.	Aug. 9	73 ,,	$1\frac{3}{4}-2\frac{3}{4}$,,	6 Bivalves, 5 Annelida, 3 Copepoda, 5 Amphipoda, 4 Cumacea, 26 An. tiss., 33 Empty.
Morecambe.	Aug. 10	8 ,,	$1\frac{3}{8}-1\frac{3}{4}$,,	6 Copepoda, 3 *Pseudocuma*, 1 Amphipoda.
do.	do.	35 ,,	$1\frac{7}{8}-2\frac{7}{8}$,,	10 *Cardium*, 12 *Tellina*, 1 *Mactra*, 3 *Crangon*, 12 Copepoda, 3 Amphipoda, 1 *Mysis*, 2 Annelida, 1 Empty.
River Dee.	Aug. 19	11 ,,	$1\frac{3}{4}-2\frac{7}{8}$,,	4 Copepoda, 1 *Crangon*, 6 Bivalves, 2 Empty.
Morecambe.	Aug. 24	2 ,,	$2\frac{3}{4}$,,	2 *Cardium*.
Blackpool.	Aug. 29	42 ,,	$1\frac{7}{8}-2\frac{7}{8}$,,	6 *Tellina*, 12 Amphipoda, 5 Cumacea, 3 Annelids, 5 Copepoda, 12 An. tiss.
Morecambe.	Aug. 31	16 ,,	$1\frac{3}{4}-2\frac{5}{8}$,,	2 *Cardium*, 5 Copepoda, 1 Annelida, 7 An. tiss. 1 Empty.
Morecambe.	Sept. 3	22 ,,	$1\frac{5}{8}-2\frac{7}{8}$,,	9 Copepoda, 13 *Pseudocuma*, 4 Amphipoda.
Morecambe.	Sept. 23	3 ,,	$1\frac{7}{8}-2\frac{7}{8}$,,	3 *Cardium*.
Morecambe.	Oct. 6	9 ,,	$2\frac{1}{8}-2\frac{3}{4}$,,	1 *Crangon*, 1 *Pseudocuma*, 2 Copepoda, 7 Sponge.
Deposit Buoy (Horse Ch.)	Oct. 10	6 ,,	$2\frac{1}{2}-2\frac{3}{4}$,,	1 *Diastylis*, 1 *Mytilus*, 4 Empty.
Horse Ch.	Oct. 13	4 ,,	$2\frac{3}{8}-2\frac{7}{8}$,,	4 Empty.

Young Plaice (*Pleuronectes platessa*).

Morecambe	Oct. 14	7 fish.	2 – 2¾ inch.	7 Empty.
Rock Ch.	Oct. 28	11 ,,	2 – 2⅞ ,,	1 *Crangon*, 5 *Atylus*, 5 Empty.
R. Mersey.	Nov. 4	3 ,,	1½ – 2¾ ,,	1 *Pseudocuma*, 1 Amphipoda. 2 Empty.
R. Mersey.	Nov. 9	7 ,,	2 – 2⅞ ,,	3 *Crangon*, 1 Copepoda, 5 Amphiphoda.
Heysham Lake.	Nov. 9	3 ,,	1¾ – 2⅞ ,,	1 *Pseudocuma*, 2 *Cardium*, 1 Empty.
Morecambe.	Nov. 14	6 ,,	2 – 2½ ,,	1 Copepoda, 1 *Gammarus*, 1 An. tiss., 3 Empty.
Rock Ch.	Nov. 16	5 ,,	2 – 2⅞ ,,	3 Crustacea, 2 Empty.
Morecambe.	Nov. 17	8 ,,	2 – 2¾ ,,	1 Copepoda, 1 Amphipoda, 7 An. tiss.
Garston.	Dec. 8	20 ,,	1¾ – 2⅞ ,,	1 *Crangon*, 1 Sponges, 7 An. tiss., 11 Empty.

These lists show that of the 893 young Plaice,

547 had Crustacea.
134 ,, Mollusca.
30 ,, Annelida.
128 ,, Animal tissues (indistinguishable).
182 were empty.

Of the 547 (from ⅞ to 2⅞ inch in size) with Crustacea
296 had Copepoda.

In a total of 348 fish from ⅞ to 1¾ inch in size,
205 had Copepoda.

In a total of 545 fish from 1⅞ to 2⅞ inch in size,
91 had Copepoda.

These Copepoda have been kindly examined for us by Mr. I. C. Thompson, F.L.S., and he reports that they are chiefly Harpacticidæ, the majority being *Jonesiella hyænæ*. Other Copepoda present in numbers were *Longipedia coronata* and *Canuella perplexa*.

Young Dabs (*Pleuronectes limanda*).

W. of Burbo Bk.	Feb. 17	41 fish.	$1\frac{1}{2}-2\frac{7}{8}$ inch.	4 *Scrobicularia*, 1 Copepoda, 36 Empty.
Ribble, Gut Ch.	Feb. 23	11 fish.	$1\frac{7}{8}-2\frac{7}{8}$ inch.	1 *Mytilus*, 1 Copepoda, 1 *Campanularia*, 8 Empty.
Ribble, Gut Ch.	Aug. 10	123 fish.	$2-3\frac{3}{4}$ inch.	15 *Scrobicularia*, 4 *Mactra*, 5 *Donax*, 3 *Pectinaria*, 10 Amphipoda, 1 Annelida, 85 Empty.

Of these 175 young Dabs, 29 had Mollusca,
12 had Crustacea,
4 had Annelida.

The great majority, 129, had their stomachs empty, but they were from a neighbourhood (Ribble, Gut Channel) where we usually find that the adult fish have little or nothing in their stomachs.

Examination of Food in Stomachs.

During the past twelve months 4326 stomachs of marine animals have been examined in order to determine the food contents. Of these 4078 will be accounted for in the lists which follow, the remainder are of various species none of which are numerous enough to make them worth recording. Of the 4078 recorded, 3656 are fish proper while of the remainder 154 are shrimps and 85 shanks (*Pandalus annulicornis*).

In addition to the fish of various sizes recorded in the following table, over 1000 young plaice and dabs have been examined, and these are reported upon separately. The plaice, of which we have a considerable number recorded, nearly 900, show clearly that at sizes of about an inch in length they live mainly on Copepoda, small Cumacea and some Crustacean larval forms, while afterwards they take to a more mixed diet consisting largely of Mollusca and worms. The change of diet, as far as can

be made out from our material, takes place at a size of about $1\frac{3}{4}$ inch.

In the following lists are given the locality, the date, the number of fish examined, the limits of size in inches, and the contents of the stomachs.

Plaice (*Pleuronectes platessa*).

Morecambe.	Jan. 13	3 fish.	$3-5\frac{1}{4}$ inch.	1 Annelida, 2 Empty.
Morecambe.	Jan. 25	5 ,,	$5-6\frac{3}{4}$,,	1 Annelida, 1 Amphipoda, 4 Empty.
Crosby.	Feb. 7	8 ,,	$5\frac{1}{4}-7\frac{1}{2}$,,	8 Empty.
Crosby.	Feb. 13	50 ,,	$5\frac{1}{2}-11\frac{3}{4}$,,	1 Annelida, 49 Empty.
Ribble.	Feb. 13	1 ,,	$4\frac{1}{2}$,,	*Pectinaria.*
R. Dee.	Feb. 15	8 ,,	$3-7$,,	1 Bivalves, 1 Young Fish, 7 Empty.
Burbo Bk.	Feb. 17	6 ,,	$3-3\frac{5}{8}$,,	6 Empty.
Morecambe.	Feb. 23	6 ,,	$4\frac{1}{4}-6\frac{1}{4}$,,	1 *Tellina*, 1 Crustacea, 1 Annelida, 3 Empty.
North Banks.	Feb. 24	23 ,,	$3-6\frac{3}{4}$,,	*Pectinaria*, 1 *Nereis*, Bivalves, 2 An. tiss., Empty.
Formby Ch.	Mar. 6	9 ,,	$3\frac{3}{8}-5\frac{3}{4}$,,	*Scrobicularia*, 7 Empty
Maughold Hd. N.W. by W.	Mar. 13	20 ,,	$5-13$,,	8 *Ammodytes*, 1 *Echinocyamus*, 1 *Ophioglypha* 1 *Carinella*, 1 *Nereis*, 2 *Solen*, 1 *Pectinaria*, 9 Annelida, 3 Empty.
The Hole.	Mar. 13	2 ,,	$19-20$,,	2 Empty.
The Hole.	Mar. 21	37 ,,	$9\frac{1}{2}-19$,,	32 *Scrobicularia*, 1 *Philine*, 5 Empty.
N. of Morecambe. Bay Ship.	Mar. 28	14 ,,	$10-18$,,	13 *Scrobicularia*, 1 Empty.
Blackpool.	April 21	6 ,,	$3-5\frac{1}{2}$,,	5 Annelid tubes, 1 Bivalves.
Blackcombe. N.E. $\frac{3}{4}$ E.	May 9	105 ,,	$7-13\frac{1}{4}$,,	100 *Corbula*, 3 *Scrobicularia*, 1 *Mactra*, 2 Empty.

Plaice (*Pleuronectes platessa*).

West of Gynn 4 miles.	May 11	12 fish.	7 – 10½ inch.	2 *Pectinaria*, 1 *Solen*, 9 *Mactra*, 3 Annelida.
Morecambe.	May 17	21 ,,	3 – 5¾ ,,	3 *Corophium*, 16 Copepoda, 13 *Pseudocuma*, 1 Annelida, 1 An. tiss.
Off Bahama Ship.	May 22	1 ,,	10½ ,,	*Polynoe* and *Terebella*.
Zebra Buoy.	May 23	83 ,,	5¾ – 12½ ,,	67 *Mactra*, 13 *Scrobicularia*, 5 Annelida, 2 Empty.
Station 4.	June 6	12 ,,	3¼ – 5 ,,	5 *Corophuim*, 1 *Tellina*, 1 *Cardium*, 4 Annelida, 2 An. tiss., 1 Empty.
Morecambe.	June 7	9 ,,	3 – 7 ,,	8 Annelida, 1 Bivalves, 1 Schizopoda.
Rock Ch.	June 13	30 ,,	3 – 6 ,,	5 *Crangon*, 3 *Tellina*, 12 Annelida, 1 Copepoda, 1 *Mysis*, 8 An. tiss., 2 Empty.
Crosby Ch.	June 21	2 ,,	7⅛ – 7½ ,,	2 *Tellina*, 1 *Cardium*.
Morecambe.	June 22	14 ,,	3 – 3½ ,,	3 *Atylus*, 7 *Crangon*, 3 Annelida, 2 Empty.
Morecambe.	June 28	18 ,,	3 – 4½ ,,	5 *Tellina*, 3 *Cardium*, 4 *Crangon*, 3 Annelida, 1 Amphipoda, 3 An. tiss.
Horse Ch.	July 1	115 ,,	6¾ – 16½ ,,	114 *Mactra*, 1 *Tellina*, 1 *Carcinus*, 1 *Nereis*.
Morecambe.	July 5	16 ,,	3 – 4¾ ,,	6 *Crangon*, 1 Amphipoda, 1 Vegetable tiss., 6 An. tiss., 4 Empty.
Horse Ch.	July 7	6 ,,	8¼ – 9¼ ,,	2 *Tellina*, 1 *Nereis*, 4 Empty.
Morecambe.	July 21	13 ,,	3¾ – 6½ ,,	16 Annelida, 2 *Mysis*.
Rock Ch.	July 25	22 ,,	3 – 6¼ ,,	9 *Crangon*, 1 *Portunus*, 2 *Cardium*, 8 Annelida, 1 An. tiss., 2 Empty.
Morecambe.	July 27	11 ,,	3⅛ – 7 ,,	6 *Cardium*, 3 *Crangon*, 1 Annelida, 1 Bivalves.
Morecambe.	Aug. 2	3 ,,	4⅜ – 5¼ ,,	1 Annelida, 2 Empty.
Bank off Bahama Ship.	Aug. 7	4 ,,	8¾ – 12 ,,	4 *Mactra*.

Plaice (*Pleuronectes platessa*).

Ribble.	Aug. 9	35 fish.	$3\frac{1}{4}-5\frac{1}{2}$ inch.	1 *Tellina*, 7 *Scrobicularia*, 1 Annelida, 1 An. tiss., 26 Sand.
Morecambe.	Aug. 10	22 ,,	3 - 5 ,,	5 *Tellina*, 4 *Cardium*, 1 *Arenicola*, 1 *Nereis*, 9 Annelida, 1 Crustacea, 1 An. tiss., 1 Empty.
Morecambe.	Aug. 12	8 ,,	$3\frac{3}{8}-4\frac{7}{8}$,,	2 *Eurydice*, 2 Crustacea, 4 Empty.
Horse Ch.	Aug. 18	170 ,,	$7\frac{1}{2}-13\frac{1}{4}$,,	129 *Scrobicularia*, 28 *Tellina*, 27 *Pectinaria*, 59 *Nereis*, 1 *Mactra*, 1 *Carcinus*.
R. Dee.	Aug. 19	42 ,,	$3\frac{1}{8}-7\frac{1}{2}$,,	5 *Mytilus*, 1 *Nereis*, 11 Bivalves shells, 11 Annelida, 14 Empty.
Morecambe.	Aug. 24	9 ,,	$3-6\frac{1}{2}$,,	1 *Cardium*, 4 Annelida, 4 Empty.
Formby Ch.	Aug. 30	32 ,,	$4-6\frac{1}{2}$,,	32 *Mactra*.
Morecambe.	Aug. 30	17 ,,	3 - 7 ,,	8 *Cardium*, 1 Annelida. 1 Crustacea, 1 An. tiss.. 6 Empty.
Blackpool.	Sep. 3	50 ,,	$3\frac{1}{2}-7\frac{1}{4}$,,	49 Worm tubes, 1 *Pectinaria*, 1 *Mactra*.
Morecambe.	Sep. 3	33 ,,	$3-4\frac{3}{8}$,,	9 *Pseudocuma*, 1 Copepoda, 30 Annelida, 1 Young Fish 3 Bivalve shells, 4 Amphipoda, 1 *Cardium*.
Morecambe.	Sep. 5	20 ,,	$3\frac{3}{8}-7$,,	3 *Tellina*, 1 *Arenicola*, 1 *Portunus*, 1 *Cardium*, 3 Annelida, 12 Empty.
Morecambe.	Sep. 10	5 ,,	$4\frac{3}{8}-5\frac{1}{4}$,,	2 Annelida, 1 An. tiss., 2 Empty.
Morecambe.	Sep. 23	6 ,,	$3\frac{1}{4}-7\frac{1}{2}$,,	2 *Cardium*, 4 Annelida, 1 Empty.
Morecambe.	Oct. 6	16 ,,	$3-5\frac{1}{2}$,,	3 sponges, 12 An. tiss., 1 Empty.
Deposit Buoy. Horse Ch.	Oct. 10	87 ,,	$3\frac{1}{2}-10\frac{1}{2}$,,	84 *Mactra*, 2 *Ophioglypha*, 1 *Pectinaria*, 2 *Donax*, 1 *Nereis*, 3 Empty.

Plaice (*Pleuronectes platessa*).

Horse Ch.	Oct. 13	2 fish.	$3\frac{1}{4}-3\frac{3}{8}$ inch.	2 Empty.
Morecambe.	Oct. 14	10 ,,	$3-5\frac{3}{4}$,,	7 Sponges, 3 Empty.
Rock Ch.	Oct. 28	19 ,,	$3\frac{1}{8}-6\frac{1}{4}$,,	5 *Atylus*, 2 Annelida, 13 Empty.
R. Mersey.	Nov. 4	13 ,,	$3-6$,,	11 Sponges, 2 Annelida, 2 Empty.
R. Mersey.	Nov. 9	73 ,,	$3-7\frac{1}{8}$,,	19 *Scrobicularia*, 1 *Diastylis*, 1 *Mactra*, 1 Annelida, 52 Empty.
Heysham Lake.	Nov. 9	5 ,,	$3\frac{1}{4}-9$,,	2 *Tellina*, 2 *Scrobicularia* 5 Empty.
Morecambe.	Nov. 10	9 ,,	$4\frac{1}{4}-9$,,	9 Empty.
Rock Ch.	Nov. 16	5 ,,	$3-5\frac{1}{2}$,,	1 Annelida, 4 Empty.
Morecambe.	Nov. 17	7 ,,	$3\frac{1}{4}-6\frac{1}{4}$,,	7 Empty.
Morecambe.	Nov. 21	12 ,,	$3\frac{7}{8}-6\frac{1}{4}$,,	1 *Phyllodoce*, 11 Empty.
Morecambe.	Nov. 23	5 ,,	$3\frac{1}{4}-5$,,	2 Annelida, 3 Empty.
Garston.	Dec. 8	28 ,,	$3-8\frac{1}{4}$,,	6 Sponge remains, 9 An. tiss., 14 Empty.

Dab (*Pleuronectes limanda*).

Blackpool. closed ground.	Jan. 16	9 ,,	$2\frac{1}{4}-4$,,	3 An. tiss., 6 Empty.
Morecambe.	Jan. 25	18 ,,	$3\frac{1}{4}-6\frac{3}{4}$,,	1 *Atylus*, 1 *Idotea*, 2 Annelida, 14 Empty.
Crosby Ch.	Feb. 7	8 ,,	$4\frac{1}{4}-8$,,	8 Empty.
Crosby Ch.	Feb. 15	4 ,,	$6\frac{1}{2}-10\frac{1}{4}$,,	1 An. tiss., 3 Empty.
Burbo Bk.	Feb. 17	12 ,,	$3\frac{3}{8}-5\frac{1}{8}$,,	1 *Philine*, 1 Annelida, 2 Crustacea, 2 An. tiss., 7 Empty.
Ribble, Gut Bar.	Feb 18	6 ,,	$4\frac{1}{2}-6$,,	1 *Crangon*, 1 *Clupea*, 2 Annelida, 3 Empty.
Morecambe.	Feb. 24	4 ,,	$3\frac{1}{2}-6\frac{3}{4}$,,	1 Annelida, 1 An. tiss., 2 Empty.
Formby Ch.	Mar. 7	18 ,,	$1\frac{3}{4}-5\frac{1}{4}$,,	4 *Scrobicularia*, 2 *Terebella*, 3 An. tiss., 9 Empty.

Dab (*Pleuronectes limanda*).

Maughold Hd. E.S.E., 5 miles.	Mar. 13	23 ,,	$4\frac{3}{4}-9$,,	2 *Philine*, 1 *Pagurus*, 1 *Ophioglypha*, 1 *Stenorhynchus*, 15 *Solen* (foot) 1 *Ammodytes*, 1 Zoophytes, 2 Empty.
The Hole.	Mar. 13	49 ,,	$4\frac{3}{4}-10\frac{1}{4}$,,	2 *Solen* (foot) 47 Empty.
The Hole.	Mar. 21	240 ,,	$4\frac{1}{2}-11\frac{3}{4}$,,	70 *Scrobicularia*, 1 *Ophioglypha*, 1 *Portunus* 1 *Nephrops*, 1 Fish remains 69 Weeds, 89 Empty.
N. of Morecambe. Bay Ship.	Mar. 28	81 ,,	$4\frac{1}{2}-12\frac{1}{2}$,,	22 *Scrobicularia*, 1 *Virgularia*, 1 *Pandalus*, 3 *Pagurus*, 3 *Solen*, 2 *Sabella*, 1 *Buccinum*, 2 *Nephrops*, 1 *Portunus*, 3 Annelida, 5 Weed, 38 Empty.
Blackpool. N.E. $\frac{3}{4}$ E.	May 10	85 ,,	5–10 ,,	41 *Corbula*, 20 *Scrobicularia*, 7 *Pagurus*, 8 *Solen*, 4 *Cardium*, 1 *Amphiura*, 13 *Ophioglypha*, 1 *Pandalus*, 1 *Phyllodoce*, 1 *Corystes*, 3 Empty.
West of Gynn, 4 miles.	May 11	11 ,,	$8-10\frac{3}{4}$,,	8 *Ophioglypha*, 5 *Pagurus*, 1 *Philine*, 1 *Pectinaria*, 1 *Scrobicularia*.
The Hole.	May 19	20 ,,	$6\frac{1}{2}-12$,,	3 *Pagurus*, 1 *Solen*, 12 Annelida, 1 Fish remains 3 Empty.
Off Bahama Ship.	May 22	40 ,,	$4\frac{1}{2}$—11 ,,	1 *Terebella*, 7 *Ophioglypha*, 8 *Solen*, 2 *Pagurus*, 11 Annelida, 5 Bivalve shells, 2 Schizopoda, 2 Amphipoda, 6 Empty.
Zebra Buoy.	May 23	4 ,,	$6\frac{3}{4}-8\frac{1}{4}$,,	1 *Ophioglypha*, 1 *Actinia*, 1 *Mactra*, 1 Annelida.
Morecambe.	June 22	3 ,,	$2\frac{3}{4}-5\frac{1}{4}$,,	2 *Crangon*, 1 An. tiss.
Garston.	July 20	2 ,,	$3\frac{1}{2}-4\frac{1}{8}$,,	1 An. tiss., 1 Empty.
Rock Ch.	July 25	5 ,,	$3-5\frac{3}{8}$,,	4 *Crangon*, 1 *Carcinus*, 1 Bivalve shells.
Blackpool. closed ground.	Aug. 1	4 ,,	$1\frac{7}{8}-4$,,	3 Annelida, 1 Worm tubes.

Dab (*Pleuronectes limanda*).

Off Bahama Ship.	Aug. 7	43 ,,	5–11 ,,	7 *Solen*, 3 *Pagurus*, 1 *Pecten*, 2 *Cardium*, 8 Annelida, 4 *Scrobicularia*, 1 *Philine*, 1 *Portunus*, 2 *Ophioglypha*, 14 Empty.
Deposit Buoy.	Oct. 18	7 ,,	$5\frac{3}{4}$–$9\frac{1}{2}$,,	1 *Pagurus*, 1 *Mactra*, 1 *Portunus*, 3 Small Bivalves, 1 Vegetables, 1 Empty.
Gut Ch., Ribble.	Aug. 9	5 ,,	$4\frac{3}{8}$–$7\frac{1}{2}$,,	5 Empty.
Morecambe.	Nov. 17	7 ,,	3–$5\frac{1}{4}$,,	2 *Atylus*, 5 Empty.
Morecambe.	Nov. 29	5 ,,	$3\frac{3}{8}$–$4\frac{1}{4}$,,	1 Bivalves, 1 Crustacea, 3 Empty.

These statistics show the Dab to be a very omnivorous feeder.

Flounder (*Pleuronectes flesus*).

Morecambe.	Jan. 13	14 ,,	$4\frac{5}{8}$–7 ,,	1 Annelida, 13 Empty
Morecambe.	Jan. 19	13 ,,	$6\frac{1}{4}$–$8\frac{1}{4}$,,	1 Crustacean remains, 1 *Campanularia*, 11 Empty.
Crosby Ch.	Feb. 7	1 ,,	11 ,,	Empty.
Morecambe.	Feb. 23	3 ,,	5–$7\frac{1}{4}$,,	1 *Pectinaria*, 2 Empty.
The Hole.	Mar. 16	16 ,,	8–$14\frac{1}{2}$,,	16 Empty.
The Hole.	Mar. 21	23 ,,	$8\frac{1}{2}$–$13\frac{1}{2}$,,	8 *Scrobicularia*, 15 Empty.
N. of Morecambe Bay Ship.	Mar. 28	28 ,,	8–$11\frac{1}{2}$,,	6 *Scrobicularia*, 1 Worms, 21 Empty.
Morecambe.	July 21	1 ,,	6 ,,	Empty.

Sole (*Solea vulgaris*).

N. of Morecambe Bay Ship.	May 9	14 ,,	$9\frac{1}{2}$–17 ,,	1 *Crangon*, 13 Empty.
West of Gynn.	May 11	3 ,,	$11\frac{1}{4}$–$12\frac{1}{2}$,,	2 Annelida, 1 Empty.
The Hole.	May 19	11 ,,	$11\frac{1}{2}$–$18\frac{1}{2}$,,	3 *Donax*, 8 Empty.
Off Bahama Ship.	May 22	16 ,,	11–$17\frac{1}{2}$,,	16 Empty.

Cod (*Gadus morrhua*).

Morecambe.	Jan. 13	10 fish.	$3\frac{1}{2}-5\frac{1}{4}$ inch.	3 *Crangon*, 3 *Gammarus*, 1 *Mysis*, 1 Annelida, 1 Bivalves, 1 Empty.
Morecambe.	Jan. 19	1 ,,	$7\frac{1}{4}$,,	*Crangon*, *Gammarus*.
Egremont.	Jan. 20	3 ,,	$7\frac{1}{4}-7\frac{3}{4}$,,	2 *Carcinus*, 1 *Crangon*, 1 Bivalves.
Morecambe.	Jan. 25	8 ,,	$2\frac{3}{4}-5\frac{1}{2}$,,	3 *Crangon*, 4 *Gammarus*, 1 Empty.
Crosby Ch.	Feb. 7	6 ,,	$6\frac{1}{2}-8\frac{1}{4}$,,	4 *Crangon*, 2 *Mysis*.
Ribble, Gut Bar.	Feb. 13	1 ,,	$4\frac{1}{2}$,,	*Pectinaria*, *Gammarus*.
Crosby Ch.	Feb. 15	16 ,,	$7\frac{1}{2}-18$,,	5 *Crangon*, 5 *Arenicola*, 3 *Gadus*. 1 *Gammarus*, 1 *Portunus*, 1 *Pagurus*, 2 Bivalves, 1 Empty.
Burbo Bk.	Feb. 17	1 ,,	$5\frac{1}{2}$,,	*Crangon*.
Morecambe.	Feb. 23	5 ,,	$3\frac{1}{2}-7$,,	2 *Crangon*, 1 *Idotea*, 2 *Clupea*, 1 *Gobius*, 1 *Carcinus*.
North Bks.	Feb. 24	4 ,,	$4\frac{3}{4}-7\frac{3}{4}$,,	3 *Crangon*, 3 *Atylus*, 1 *Idotea*.
Off Bahama Ship.	Mar. 13	1 ,,	$4\frac{1}{2}$,,	*Pagurus*.
The Hole.	Mar. 21	1 ,,	20 ,,	*Gadus*, *Gonoplax*.
Morecambe.	July 27	5 ,,	$2\frac{1}{8}-3\frac{3}{4}$,,	4 *Crangon*, 1 *Atylus*.
Morecambe.	Nov. 21	7 ,,	$3\frac{1}{4}-5\frac{3}{8}$,,	3 *Crangon*.
Morecambe.	Nov. 28	2 ,,	$3\frac{3}{4}$,,	2 *Crangon*.
Rock Ch.	Dec. 14	52 ,,	$4\frac{1}{8}-9$,,	20 *Crangon*, 3 *Pandalus*, 4 *Gammarus*, 2 *Atylus*, 5 *Mysis*, 4 *Eunice*, 4 Fish remains, 5 Mollusca, 1 Weed, 9 Empty.

Most of these Cod are from 3 to 9 inches in length, and these feed chiefly upon Crustacea, such as *Crangon* (the Shrimp), *Mysis*, and Amphipoda (sand hoppers). As they get larger they take to eating fish, such as smaller Cod, Whiting, Sprats, Gobies, &c., and large Crustacea such as the true crabs and large hermit crabs. The locality apparently has no marked effect upon the diet.

Whiting (*Gadus merlangus*),

Crosby Ch.	Feb. 7	4 fish.	$4\frac{3}{4}-5\frac{1}{2}$ inch.	4 *Mysis*, 1 Fish.
Ribble, Gut Bar.	Feb. 13	10 ,,	$4\frac{1}{4}-6$,,	1 *Arenicola*, 1 *Crangon*, 2 *Clupea*, 1 Amphipoda, 2 Annelida, 4 Empty.
Burbo Bank.	Feb. 17	14 ,,	$5\frac{1}{4}-8$,,	1 *Nereis*, 1 *Pectinaria*, 3 *Mysis*, 1 *Atylus*, 5 Annelida, 1 Bivalves, 2 Empty.
Morecambe.	Feb. 23	8 ,,	$3\frac{1}{2}-7\frac{1}{2}$,,	2 *Clupea*, 2 *Gadus*, 1 *Crangon*, 1 *Pandalus*, 1 *Nereis*, 1 Amphipoda, 4 Empty.
Rock Ch.	Mar. 7	30 ,,	$3\frac{3}{4}-7\frac{1}{2}$,,	10 *Crangon*, 2 *Clupea*, 2 Annelida, 2 Amphipoda, 1 An. tiss., 14 Empty.
The Hole.	Mar. 14	2 ,,	10 – 12 ,,	1 *Pandalus*, 1 Empty.
Southport.	Mar. 20	5 ,,	$4\frac{1}{2}-5\frac{1}{2}$,,	2 Fish remains, 1 *Pectinaria*, 2 Empty.
N. of Morecambe Bay Ship.	Mar. 28	1 ,,	14 ,,	Empty.
Rock. Ch.	May 4	9 ,,	$4\frac{1}{2}-6\frac{5}{8}$,,	5 *Crangon*, 4 Empty.
Rock Ch.	July 25	6 ,,	$5\frac{1}{4}-6\frac{1}{4}$,,	2 *Crangon*, 4 Empty.
Morecambe.	July 27	9 ,,	$2\frac{1}{2}-4\frac{3}{8}$,,	3 *Crangon*, 1 *Mysis*, 2 Fish remains, 3 Empty.
Morecambe.	Aug. 2	4 ,,	$3\frac{1}{4}-4\frac{3}{8}$,,	1 *Carcinus*, 3 Empty.
Off Bahama Ship.	Aug. 7	1 ,,	7 ,,	Empty.
Morecambe.	Aug. 24	18 ,,	$3-4\frac{1}{2}$,,	10 *Crangon*, 10 *Clupea*, 2 *Arenicola*, 2 Empty.
Morecambe.	Aug. 31	3 ,,	$2\frac{3}{4}-6$,,	1 *Crangon*, 1 Fish, 1 Emp.
Morecambe.	Sept. 5	4 ,,	$3\frac{1}{2}-4$,,	2 *Crangon*, 2 Empty.
Morecambe	Sept. 13	17 ,,	$2\frac{3}{4}-4\frac{1}{2}$,,	5 *Crangon*, 3 *Clupea*, 1 *Gammarus*, 1 *Pagurus*, 7 Empty.
Morecambe.	Nov. 21	7 ,,	$4-6\frac{3}{4}$,,	2 *Crangon*, 1 *Mysis*, 1 *Corophium*, 4 *Clupea*.
Rock. Ch.	Dec. 14	44 ,,	$3\frac{1}{2}-3\frac{7}{8}$,,	19 *Crangon*, 12 *Mysis*, 4 *Atylus*, 5 *Gammarus*, 3 *Clupea*, 3 *Nereis*, 3 Amphipoda, 1 Mollusca.

These Whiting, mostly from 4 to 8 inches in length, like the Cod, in this district live largely upon the commoner Crustacea, *e.g.*, *Crangon vulgaris* and *Mysis* and Amphipoda, and in a good many cases remains of fish, chiefly the Sprat, and some worms, have been found in the stomach. All these food matters being common and widely distributed, locality apparently makes no noticeable difference in the diet.

Red Gurnard (*Trigla cuculus*).

Off Bahama Ship.	Mar. 13	1 ,,	13 ,,	Empty.
The Hole.	Mar. 28	4 ,,	$12\frac{1}{2}-15\frac{1}{2}$,,	1 *Ammodytes*, 1 *Pagurus*, 1 Fish remains, 1 Empty.
N. of Morecambe. Bay Ship.	May 9	4 ,,	$12-17\frac{1}{2}$,,	2 *Pagurus*, 2 *Ammodytes*.
Off Bahama Ship.	May 22	41 ,,	$9\frac{3}{4}-16\frac{1}{2}$,,	8 *Callionymus*, 9 *Portunus*. 3 *Hyas*, 2 *Mysis*, 5 *Pagurus*, 5 *Crangon*, 3 *Pandalus*, 1 *Nephrops*, 1 *Ammodytes*, 3 *Hippolyte*, 1 *Stenorhynchus*, 4 Fish remains, 4 Amphipoda, 7 Empty.
The Hole.	Aug. 7	10 ,,	7–23 ,,	1 *Aphrodite*, 6 *Crangon*, 1 Fish remains, 2 Empty.

The food of these Red gurnards is chiefly Crustacea, especially crabs and hermit crabs, and some fish.

Haddock (*Gadus aeglefinus*).

The Hole.	Mar. 21	30 ,,	9–27 ,,	21 *Scrobicularia*, 3 *Gonoplax*, 1 *Aphrodite*, 1 *Spatangus*, 1 *Nephrops*, 1 *Pectinaria*, 1 Schizopoda, 2 Amphipoda, 2 Annelida, 4 Empty.
N. of Morecambe. Bay Ship.	Mar. 28	7 ,,	$7\frac{3}{4}-17$,,	2 *Solen*, 3 *Scrobicularia*, 1 *Pectinaria*, 1 Amphipoda, 1 Empty.

The diet of the Haddock seems very varied, but no conclusions can be drawn from such a small number.

Sprat (*Clupea spratta*).

Morecambe.	Jan. 13	6 fish.	$3\frac{1}{2}-4$ inch.	2 *Mysis*, 2 Amphipoda, 2 Empty.
Morecambe.	Jan. 24	5 ,,	$2\frac{1}{4}-2\frac{3}{4}$,,	1 Copepoda, 4 Empty.
Ribble, Gut Bar.	Feb. 13	4 ,,	$3-4\frac{1}{4}$,,	4 Empty.
Morecambe.	Sept. 13	3 ,,	$3\frac{1}{4}-3\frac{3}{4}$,,	1 *Corophium*, 2 Amphipoda.
Morecambe.	Oct. 6	2 ,,	$2\frac{5}{8}-3\frac{1}{8}$,,	1 *Corophium*, 2 Spines of echini.
Morecambe.	Oct. 21	3 ,,	$3\frac{1}{4}-5\frac{1}{2}$,,	1 *Mysis vulgaris*, 1 Bivalve, 1 Empty.
Rock Ch.	Oct. 28	17 ,,	$2\frac{3}{4}-4\frac{1}{8}$,,	1 *Pandalus*, 1 *Campanularia*, 2 Copepoda, 9 Amphipoda, 2 Cumacea, 1 Empty.
Morecambe.	Nov. 14	4 ,,	$3-4\frac{1}{4}$,,	4 Empty.
Morecambe.	Nov. 21	3 ,,	$3\frac{1}{8}-4\frac{5}{8}$,,	1 Copepoda, 2 Empty.
Morecambe.	Nov. 24	3 ,,	$3-4\frac{3}{8}$,,	1 *Crangon*, 2 Empty.

The sprat between $2\frac{1}{4}-5\frac{1}{5}$ inches in length appears to feed almost entirely on the smaller kinds of Crustacea such as Copepoda and Amphipoda.

Thornback Skate (*Raia clavata*).

N. of Morecambe. Bay Ship.	Mar. 28	2 fish.	$6\frac{1}{4}-7$ inch.	2 Empty.
W. of Gynn.	May 11	11 ,,	10–26 ,,	2 *Pagurus*, 7 *Philine aperta*, 4 *Corystes*, 2 *Portunus*, 1 *Carcinus*, 1 *Crangon*, 1 *Pleuronectes*, 1 *Mactra*.
Off Bahama Ship.	Aug. 7	14 ,,	13–26 ,,	10 *Pagurus*, 4 *Solen*, 1 *Portunus*, 1 *Pectinaria*, 5 Bivalve shell.
Isle of Man E.S.E. (14 miles).	Dec. 21	16 ,,	10–14 ,,	1 *Portunus*, 2 *Pagurus*, 1 Fish, 15 Mollusca, 1 Empty.

This Skate has a very varied diet.

Shrimp and Shank.

Some Shrimps (154) have been examined, and their food consisted of small *Cardium edule*, various algæ, amphipods, vegetable tissue, Copepoda, *Tellina balthica*, annelid remains (setae and occasionally half digested portions of a Nereis or a worm closely allied to it being found), *Crangon vulgaris* (the shrimp itself), starfishes and echini (the pedicellariæ and spines), *Pectinaria belgica* a tubicolous annelid very common in the sand below low water mark, Nauplius larvæ, Diatoms of various species, *Eunice*, small fish, and a few Ostracods.

The Shank (*Pandalus annulicornis*) of which 85 were examined, feeds to a large extent on *Sabellaria alveolata*—a worm which builds up masses of rock by cementing together sand grains—as the stomach contains usually numerous setae, occasionally the remains of the worm itself, amphipods, young *Mytilus edulis*, vegetable matter, spines of echini, stalks of Campanularians, and remains of Crustacea which were unidentifiable being merely small portions of legs and other appendages.

The Maturity of Fishes.

It is desirable that the average size at which each species of food fish arrives at maturity, or produces spawn for the first time, should be determined for various parts of our coast. It does not do in this matter to take the figures ascertained for other places, such as the south coast or the North Sea, for what little we do know of spawning sizes tends to show that on different coasts the same kind of fish arrives at maturity at different sizes, if not ages. Consequently during last spawning season we made a beginning in the examination of fish and the collection of statistics in regard to size at maturity. Besides small numbers of half-a-dozen other edible fish, the following

seven have been specially examined, Sole, Plaice, Dab, Flounder, Haddock, Grey Gurnard and Red Gurnard. Our object was to keep a record of the smallest mature males and females we met with and of the largest immature males and females. In regard to those in the latter category it may be remarked that great caution must be exercised, as in the case of an individual fish that is a late spawner the reproductive organs at the normal breeding season may show little or no signs of the distension which is usual in fish that are approaching maturity.

Sole (*Solea vulgaris*)—smallest ripe female $11\frac{1}{4}$ inches, largest immature fish (male) $9\frac{1}{2}$ inches. The number we have examined has, on account of the difficulty of obtaining the fish in this district, been too small to lead to any conclusion, but the results such as they are agree tolerably with those given by Holt for the North Sea—10 inches for the mature male and 12 inches for the female.

Plaice (*Pleuronectes platessa*)—smallest ripe female 13 inches, male $10\frac{1}{2}$ inches; largest immature female 19 inches, male 13 inches. We have as yet examined only 73 fish, ranging in size from 6 to 20 inches, trawled on the spawning grounds. The smallest ripe male was only $10\frac{1}{2}$ inches, but that was probably an exceptional case. Holt gives the spawning period in the North Sea as from the middle of January to the end of March, and rarely going as late as May. We did not obtain spawning fish here till the middle of March, and they went on till the middle of May.

Dab (*Pleuronectes limanda*)—smallest ripe female $5\frac{1}{4}$ inch, male $4\frac{1}{2}$ inch; largest immature female $11\frac{3}{4}$ inch, male $6\frac{3}{4}$. The largest female fish was $12\frac{1}{2}$ inches, the largest male 9 inches. 511 fish have been examined. The smallest ripe male we have found is only $4\frac{1}{2}$ inches long, but this is undoubtedly an exceptional case, the average at maturity

being from 6 to 7 inches, and the ordinary minimum reproductive size $5\frac{1}{2}$ to 6. The smallest ripe female is $5\frac{1}{4}$ inches, and the average size at maturity from $6\frac{1}{2}$ to 8 inches, the ordinary minimum size at spawning being 6 to $6\frac{1}{2}$.

Flounder (*Pleuronectes flesus*)—smallest ripe female 8 inches, male 7 inches; largest immature female $12\frac{1}{2}$ inches, male $10\frac{1}{2}$ inches. Only 75 have been examined. The females arrive at maturity on the average at about $10\frac{1}{2}$ inches, and the males at about 9 inches. They were spawning from the middle of March to the middle of May when they seemed to have finished spawning and to be returning to the rivers from which they came. One of the first facts we discovered in the trawlings on the offshore spawning beds last season was that, contrary to the opinions of the fishermen, the Flounder leaves the rivers and estuaries up which it is usually found and comes for the purpose of spawning to these offshore grounds about 20 miles from the mouth of the nearest river.

Haddock (*Gadus æglefinus*)—only 35 examined. Smallest ripe male $9\frac{1}{2}$ inches; smallest ripe female $12\frac{1}{2}$ inches; largest immature female 17 inches, male 13 inches.

Grey gurnard (*Trigla gurnardus*)—smallest ripe female $9\frac{3}{4}$ inches, male $8\frac{1}{2}$ inches, largest immature female $11\frac{1}{2}$ inches, male also $11\frac{1}{2}$ inches. 25 fish were examined.

Red gurnard (*Trigla cuculus*)—smallest ripe female 13 inches, male $9\frac{1}{2}$ inches; largest immature female $13\frac{1}{2}$ inches, male $12\frac{1}{4}$ inches. 65 fish were examined.

During the coming spawning season we shall devote considerable attention to the maturity question, and besides accumulating more statistics of the above nature we shall endeavour to make some observations on the rate of growth of the fishes, and the ages at which they arrive at sexual maturity.

Although the ideal minimum size at which fish ought

to be caught is the "biological" one of the smallest size which will ensure that the animal has had the chance of reproducing its species once, still, if that is at present impracticable, any limit set by the law would be of some value, as the protection of the immature stages will—other things being equal—lead to a greater number being present of the lowest unprotected size, and, *if the rate of capture remains the same*, in each size above that, so that there will be an increased number of spawners, and the average size of the species will become greater. If a fish spawns, for example, at 12 inches, and it is not possible to extend protection to that size, it is better to protect it up to 8 inches, say, than not to protect it at all. And if, as the result of this partial protection, the numbers and the average size of the fish are increased it may be possible in the future gradually to raise the minimum catchable size until the "biological" limit is reached.

Spawning Grounds.

In last year's report it was recommended that a systematic search should be made with the new steamer for any spawning grounds that exist in the district. One of the places visited, on March 11 and 13, was a sandbank of considerable size situated off the Bahama lightship, about 5 miles E.S.E. of Maughold Head, Isle of Man, and having a depth of 8—10 fathoms over it (see map). Several hauls of the trawl were taken over this bank and a tow-net was also kept going at the surface to see if there were any floating fish eggs, but no indication was found of any spawning fish or eggs being present.

The next place tried (on March 13) was the spot known to fishermen as "The Hole," a tongue of deep water running up from the south of the Isle of Man and being a continuation of the deep belt of water which leads in

from the ocean up St. George's Channel and along the west side of the Isle of Man (see map). This proved to be an important spawning ground for Plaice, Dabs, Flounders, Cod, Haddock and Whiting, as not only were fish distended with ripe ova brought up in the trawl but large numbers of transparent pelagic fish ova and embryos in various stages of development were obtained in the surface tow-nets.

This was the first piece of actual evidence obtained as to the spawning place of the food fishes of this district. Subsequent trawlings and tow-nettings during the summer showed that this is probably the great spawning ground for this part of the Irish sea, and it is noteworthy that *it is not a bank*, but is actually a depression on the average 8 fathoms deeper than the neighbouring sea. This locality has a remarkably rich fauna. The small bivalve mollusc *Scrobicularia alba*, which is a favourite food of various edible fishes, is very abundant, along with many rarer things, such as the beautiful Nudibranchs *Tritonia hombergi*, *Eolis tricolor*, and *Dendronotus arborescens*, the crab *Gonoplax angulatus* and the Pennatulid *Virgularia mirabilis* which is constantly browsed on by fishes of the Cod tribe. The bottom here is a soft bluish black mud with which we find great numbers of the long spiral mollusc *Turritella terebra*, and the egg masses of this and other molluscs when brought up from the bottom on long lines or in nets have frequently been mistaken by fishermen for the spawn of food fishes. It is well-known now that our ordinary food fishes, except the Herring, produce pelagic eggs which are not deposited at the bottom, but which rise to near the surface of the sea where they undergo their development while floating freely.

Although it is obvious that there must be determining factors which attract fish from great distances to certain

special spots for spawning, it is difficult to say what—besides distance from land, a fair depth of water, and abundance of food both on bottom and surface—these factors are in the present case. In co-operation with Mr. Dawson, it is proposed during the coming spawning season to make some expeditions to this ground, when no doubt further information both as to the kinds, numbers, and sizes of the spawning fish, and also as to their surrounding conditions, will be obtained.

We have also while dredging from Port Erin come upon a spawning ground on the other side of the Isle of Man. It is 5 miles west of Dalby, the depth is 30 fathoms and the bottom is what the trawlers call "reamy," *i.e.*, a mixture of sand and mud. Here in the latter half of June we found Sole, Turbot and Brill all spawning.

Vitality Experiments.

In connection with the enormous destruction of immature food fishes by shrimp nets discussed in the last report, and the disputed question as to whether it is much use returning the more or less exhausted fish to the sea, it was suggested (p. 27) that investigations should be carried on from the "John Fell" on the same lines as those started by the Scottish Fishery Board on their steamer "Garland." This has been done during the past year, and we have now statistics showing the results of a number of experiments made on fish taken both with the shrimp trawl and and also with the fish trawl.

The mode of procedure has been as follows:—The fish are taken from the net, measured, and the species noted, and are then put into a fixed tub (about 3 × 2 feet) through which is kept running by means of the hose a constant stream of sea-water. They are left in the tub from half-an-hour to an hour, or even two hours, and then the

length of time and the resulting effects upon the fish are noted. The proportion of the fish, chiefly Plaice, Dabs, and Soles, which have recovered is surprisingly large, as will be seen from the particulars given below. The conditions were sometimes very different in one experiment from those in another and yet the results were in nearly all cases favourable. The duration of the haul varied from 30 to 165 minutes, in some cases the fish were allowed to lie on deck in the sun for 10 minutes before being placed in the tub, while the time they remained in the tub varied from 30 to 180 minutes. In a few exceptional cases where there is a very large mortality this can generally be assigned to some special cause, such as the fish being taken along with a heavy weight of starfish, or with a large quantity of rubbish such as may be got in the net at the bottom of the Horse Channel or outside the Liverpool Bar.

We have picked out from the statistics taken on board the steamer by Mr. Dawson the following series of cases which relate to the three edible fish with which the greatest number of experiments have been made—viz., Plaice, Dab, and Sole. Each of these series, and especially the Plaice, contains sufficient examples to allow us to draw definite conclusions. The other fish experimented with are not yet numerous enough to make it worth while recording them.

Plaice.

						inch.	
Shrimp	net down	55	min.	7	Plaice from	$2\frac{1}{2}-7\frac{1}{4}$.	7 hrs. in tub ; all alive.
Shrimp	,,	65	,,	16	,,	$2-8\frac{1}{2}$.	in 1 hr. ; all alive.
Shrimp	,,	65	,,	130	,,	and Dabs from 3 inch,	25 min. on deck, 100 lived.
Shrimp	,,	60	,,	39	,,	$2-6\frac{1}{2}$ inch ;	1 hr. ; all alive.
Shrimp	,,	60	,,	100	,,	3–5.	(on deck 30 min.) ; 50 alive
Fish	,,	90	,,	3	,,	$7-10\frac{1}{2}$.	(deadly); alive after $\frac{1}{2}$ hr.
Fish	,,	105	,,	8	,,	$6\frac{3}{4}-8\frac{1}{2}$.	after 75 min., 1 dead.

Fish	,,	60	,,	10	,,	7–8	after 60 min.,		4 dead.
Shrimp	,,	75	,,	5	,,	$1\frac{1}{2}$–5	,,	70 ,,	all alive.
Fish	,,	75	,,	5	,,	$3\frac{1}{2}$–6	,,	180 ,,	all alive.
Shrimp	,,	45	,,	7	,,	$2\frac{1}{4}$–4	,,	70 ,,	all alive.
Fish	,,	90	,,	3	,,	$8\frac{1}{2}$	,,	90 ,,	all alive.
Shrimp	,,	70	,,	12	,,	$2\frac{1}{2}$–6	,,	60 ,,	2 dead.
Fish	,,	75	,,	4	,,	6–$8\frac{1}{2}$	,,	150 ,,	all alive.
Fish	,,	60	,,	14	,,	6–9	,,	120 ,,	1 dead.
Shrimp	,,	60	,,	3	,,	4	,,	60 ,,	all alive.
Fish	,,	75	,,	2	,,	9–$9\frac{1}{2}$	,,	35 ,,	,,
Fish	,,	90	,,	3	,,	6–7	,,	105 ,,	,,
Fish	,,	105	,,	8	,,	$7\frac{1}{2}$–$9\frac{1}{2}$	,,	105 ,,	,,
Fish	,,	125	,,	9	,,	3–$5\frac{1}{2}$	,,	75 ,,	,,
Fish	,,	75	,,	11	,,	5–$6\frac{1}{2}$	,,	125 ,,	,,
Shrimp	,,	60	,,	9	,,	2–5	,,	110 ,,	,,
Shrimp	,,	30	,,	20	,,	2	,,	75 ,,	all alive.
Shrimp	,,	45	,,	8	,,	2–5	,,	65 ,,	2 dead.
Shrimp	,,	40	,,	22	,,	2–5	,,	105 ,,	all alive.

Thus out of 393 plaice, caught some with shrimp and some with fish net, 318, or 81 per cent., have recovered after being on an average about an hour in the tub. It does not appear that the one net is any more fatal than the other. It must be remembered however that these experimental hauls were of short duration and that under ordinary circumstances the fish trawl is down for about six hours.* Probably the greatest mortality is caused when the net is down for a considerable time and accumulates a great weight of fish, or of starfishes, or gets choked with mud and rubbish, or when in rough weather the net full of fish is bumped heavily on the side of the boat in being got on board. It is astonishing however how even a crushed looking plaice may sometimes recover when put in the tub.

* However in our district the greatest destruction of young food fishes is certainly caused by the shrimpers and other smaller boats fishing in inshore waters which in many places are the fish nurseries.

Dabs.

Fish	net down	80 min.	6 Dabs (3 deadly), $6\frac{1}{4}-8$ inch., after 60 min., 1 dead.							
Shrimp	,,	65 ,,	7 Dabs, from 4—6 inch, 60 min., all alive.							
Shrimp	,,	60 ,,	11	,,	$2-8$	,,	60	,,	,,	
Fish	,,	110 ,,	2	,,	$6\frac{3}{4}-7\frac{1}{4}$	,,	70	,,	,,	
Fish	,,	90 ,,	5	,,	$7-8$	,,	60	,,	,,	
Fish	,,	165 ,,	5	,,	$6\frac{1}{2}-11$	,,	90	,,	,,	
Fish	,,	90 ,,	8	,,	$7\frac{1}{2}-9\frac{1}{2}$	,,	45	,,	all dead. (crushed by starfish.)	
Fish	,,	105 ,,	8	,,	$7-9\frac{1}{2}$	,,	75	,,	2 dead.	
Fish	,,	75 ,,	6	,,	$5-8$	,,	180	,,	1 dead.	
Fish	,,	75 ,,	1	,,	5	,,	90	,,	lively.	
Shrimp	,,	45 ,,	4	,,	$2\frac{1}{2}-5$	,,	70	,,	lively.	
Fish	,,	90 ,,	6	,,	$6-9\frac{1}{2}$	,,	90	,,	3 dead.	
Shrimp	,,	70 ,,	6	,,	$4-5\frac{1}{2}$	,,	60	,,	very lively.	
Fish	,,	105 ,,	3	,,	$5-7\frac{1}{2}$	,,	60	,,	,,	
Fish	,,	75 ,,	2	,, (deadly)	$6\frac{1}{4}-7$		150	,,	,,	
Fish	,,	60 ,,	4	,,	$6-8$	,,	120	,,	2 dead.	
Shrimp	,,	60 ,,	4	,,	$4\frac{1}{2}$	,,	60	,,	2 ,,	
Fish	,,	90 ,,	4	,,	$4-7$	,,	105	,,	3 ,,	
Fish	,,	105 ,,	11	,,	5	,,	105	,,	5 ,,	
Fish	,,	65 ,,	4	,,	$5-6$	,,	75	,,	1 ,,	
Fish	,,	75 ,,	4	,,	$4\frac{1}{2}-7$	,,	125	,,	very lively.	
Shrimp	,,	60 ,,	7	,,	$1\frac{1}{2}-6$	,,	110	,,	,,	

These experiments seem to show that the dab is not so hardy as the plaice, and that when caught with the fish trawl the dabs are less liable to live, if returned to the sea, than if caught in the shrimp trawl.

In 16 hauls with the fish trawl, out of 79 fish 20 were dead; in 9 hauls some of the fish died.

In 6 hauls with the shrimp trawl out of 39 fish 2 only were dead; in 1 haul only did some fish die.

Sole.

						inch.				
Fish	net down	90 min.	1 Sole			9	after 30 min., very lively.			
Shrimp		105 ,,	2	,,		$8\frac{1}{2}$	,,	40	,,	,,
Shrimp	,,	75 ,,	5	,,	from	$3\frac{1}{2}-10$	,,	70	,,	,,
Fish	,,	75 ,,	8	,,	,,	$5\frac{1}{4}-8$	,,	180	,,	,,
Fish	,,	75 ,,	6	,,	,,	$7-9\frac{1}{4}$	,,	90	,,	,,

Shrimp	,,	45	,,	4	,,	,,	$4\frac{1}{2}-10$	after	70	min.,	,,
Shrimp	,,	70	,,	7	,,	,,	4 – 9	,,	60	,,	,,
Fish	,,	75	,,	4	,,	,,	$8\frac{1}{4}-9\frac{1}{2}$	,,	150	,,	,,
Shrimp	,,	60	,,	6	,,		3	,,	60	,,	3 dead.
Fish	,,	90	,,	2	,,		10	,,	105	,,	very lively.
Fish	,,	125	,,	2	,,	,,	8 – 9	,,	75	,,	,,
Fish	,,	75	,,	2	,,	,,	$5\frac{1}{2}-8\frac{1}{2}$	,,	125	,,	,,
Shrimp	,,	60	,,	1	,,		$5\frac{1}{2}$	,,	60	,,	,,
Fish	,,	110	,,	1	,,		$9\frac{1}{2}$	,,	70	,,	,,
Fish	,,	95	,,	1	,,		$10\frac{3}{4}$	,,	60	,,	,,
Fish	,,	120	,,	1	,,		$10\frac{1}{4}$	,,	60	,,	,,
Fish	,,	90	,,	2	,,	,,	$13\frac{1}{2}-14$	,,	60	,,	,,
Fish	,,	165	,,	2	,,	,,	$11\frac{1}{2}-15$	,,	60	,,	,,
Fish	,,	165	,,	4	,,	,,	$11\frac{1}{2}-13$	,,	60	,,	,,

Thus, out of 61 soles tried only 3, or 5 per cent., died, so this goes to show that the young sole if returned to the sea has an excellent chance of living. The kind of net used appears to have little or no influence upon the result.

We shall now give a few examples of our vitality experiments, from the statistics, in which other fish are dealt with.

I. At 11.45 a.m. put in tank 6 Soles, $2\frac{1}{4}-6\frac{1}{2}$ inches, 7 Plaice, $2\frac{1}{2}-7\frac{1}{4}$ inches, 8 Dabs, $3-4\frac{1}{2}$ inches, 5 Skates, 7 – 8 inches, all lively. At 7 p.m. all lively, circulation stopped and at 9 a.m. 1 Sole, 4 Plaice, 4 Skate, 1 Dab were still alive.

II. 2 Red Gurnards, 6 Dabs, 2 Lemon Soles, 1 Skate and 3 Dabs, all deadly; after being in tank 1 hour all recovered except 1 Dab.

III. 16 Plaice, 7 Dabs, 2 Rays, (11 Plaice lively, 3 deadly, 2 just alive; Dabs 4 just alive). Fish in basket 10 minutes, then in tub 1 hour, when all recovered and very lively.

IV. 130 Plaice and Dabs left in basket in sun for 25 minutes then put in tub for an hour when 100 had recovered and were quite lively.

V 39 Plaice, 11 Dabs, 2 Whiting, 1 Sole put in tub; after 1 hour only 3 Plaice and 1 Whiting were dead.

VI. 100 Plaice, 3 – 5 inches, left on damp deck ½ hour then put in tank when 50 were still alive.

VII. 1 Sole, 2 Dabs, 2 Lemon Soles (all lively) put in tank for 1 hour and 10 minutes when all were still alive.

These results show pretty clearly that if the immature fish taken by shrimpers and other small boats were sorted out and thrown overboard within a reasonable time after capture a very large proportion of them would recover and have a fair chance of growing up. Mr. Dawson tell us that the fishermen themselves are beginning to realise the necessity of sorting out the fish and shrimps as soon as possible after hauling. If they can be got to do so *systematically* and *efficiently* it will undoubtedly prevent a great deal of the present needless destruction of young fish and will perhaps obviate the necessity of restrictive legislation in regard to shrimping which might otherwise be required in the interests of our very important fluke and sole fisheries. It can scarcely be too emphatically pointed out that the remedy for the present unsatisfactory state of affairs lies largely with the fishermen themselves. The enormous destruction has been abundantly demonstrated, these vitality experiments teach us that under ordinary conditions the young fish will live if returned promptly to the sea, consequently it is very important that this should be made widely known to the fishermen, and it would be well worth while to go to some trouble and expense in persuading or compelling them to adopt such methods as will lead to the young fish being separated out and returned to the sea with the least possible damage and delay.

THE DISTRIBUTION OF IMMATURE AND OTHER FISH.

The statistics, in regard to size, number, &c., of fish, taken by Mr. Dawson on the s.s. "John Fell" have been carefully analysed by us, with the results given in the following pages. We are of opinion, however, that the observations have not yet been continued for a sufficient length of time to enable us to come to definite conclusions in regard to the migrations of fishes during the year in our district.

An area at Blackpool, about 10 miles long, was closed two years and a half ago against trawling because it was known to be a "nursery" for young food fishes, and in order to see what the effect would be on the numbers of young fish. On comparison with other grounds it seems to us now there are far more immature fish (chiefly Plaice and Dabs) on it than elsewhere. The following list gives the average number of fish taken in each month with the shrimp trawl on the Blackpool closed ground.

1892.	August	270	1893.	May	101
	September	712		June	122
	October	1658		July	385
	November	1984		August	437
	December	2471		September	14892
1893.	January	134	(Of these 11000 were Dabs.)		
	February	1199		October	.....
	March	636		November	2536
	April	302		December	13055

These seem to show that during the months from September to December the young fish congregate in large numbers, so that one haul may take thousands, on this ground; while for some reason from January or February to August (which period covers the spawning season) the numbers are comparatively few, say on an average 500 or 600 per haul. The smallest numbers are in May and June. The number of fish taken on this ground seems steadily increasing since it has been closed. The largest

haul taken in 1892 (November) was 3929, in September, 1893, 14892 were taken in one haul, and now in December the largest haul is 20,889.

We give next a comparison between these takes on the Blackpool ground and the corresponding takes in Morecambe Bay, in the estuary of the Mersey, and in the Ribble estuary, which shows the greater numbers present on the Blackpool ground, especially in autumn and winter. As in the preceding list, each entry is the average of a number of hauls. The column Morecambe Bay includes Grange Channel, Heysham Lake, River Keer, and River Lune. The column River Mersey includes the Rock Channel and the Horse Channel. The column Ribble includes the Gut Channel. In the Morecambe district there seems to be fewest fish in the winter and spring months, December to May; and in the Mersey fewest in April and May. In the Ribble, as at Blackpool, the greatest hauls are taken late in the year, in September, October and November.

1892.	Blackpool.	Morecambe B.	R. Mersey.	Ribble.
Aug.	270	719	—	—
Sept.	712	577	—	823
Oct.	1658	828	1176	942
Nov.	1984	524	814	1527
Dec.	2471	275	471	122
Jan.	134	124	—	82
Feb.	1199	119	608	207
March	636	61	665	313
April	302	92	247	—
May	101	238	171	—
June	122	514	1409	153
July	85	1084	—	43
Aug.	437	1160	2538	—
Sept.	14892	555	1513	—
Oct.	—	921	733	604
Nov.	2536	449	729	—
Dec.	13055	216	592	—
	40,794	8,559	11,686	4,816

Mr. Dawson tells us that the ground known as the "Deposit Ground" lying between the Queen's and Horse Channels, outside Burbo Bank, is also a place where young flat-fish congregate in large numbers, as many as 10,000 having been obtained at a single haul of the shrimp trawl. During the time the fish are on this ground there is a great deal of trawling for shrimps with the usual destruction of immature flat-fish.

We have drawn up from the statistics a series of tables showing the takes of fish for each month in the year in each of 4 areas into which we have divided the ground trawled over, but we are of opinion that we require information extending over several successive years before we can come to reliable conclusions in regard to the movements of the fish, and consequently we shall not publish these tables now but retain them and add to them with the view of having them incorporated, when more extensive, in a future report. We have also "taken out" particular fish—Plaice, Dab, Whiting—from the statistics and have drawn up tables of their distribution, as shown by the trawlings, in various parts of the district for each month. These tables also we retain for further additions, but we may at present draw the following tentative conclusions:—

Plaice—Taking the three localities (*a*) Horse and Rock Channels, (*b*) the Mersey estuary, and (*c*) Burbo and North Banks, we find that the biggest hauls in all three were in September and October, the average for the 3 or 4 winter months (November to February) was about 100 fish in each case, and the average for the 3 or 4 summer months (June to September) was about 700 in each. Very large hauls of young plaice (2 to 6 inches) are taken with the shrimp net in August in the Horse Channel and the Dee estuary.

Dab—In the Horse Channel the largest hauls were in

the height of summer, from June to August, while in the Mersey the best hauls were in November and December.

Whiting—Both in the Horse Channel and in the Mersey district the whiting seems most abundant in summer, the largest hauls being taken in July and August. After that the numbers fall off and remain comparatively small during the winter, then rise somewhat in February, and fall again in March, April and May, after which they rise to the maximum in July.

Parasites and Abnormalities in Fish.

All the fish which pass through our hands are carefully examined in order to detect the presence of parasites or abnormalities. A collection is being formed of the Copepoda (generally known as "Fish-lice") obtained from the bodies of the fish. These Copepoda have been examined for us by Mr. I. C. Thompson, F.L.S., who reports that he has identified the following:—

> Parasites—From the Cod—*Caligus rapax* and *C. curtus*. From the Hake—*Anchorella appendiculata*. From Flounder and from *Arnoglossus megastoma*—*Lepeoptheirus pectoralis*. From the Sprat *Lerneonema spratta*.

Various abnormalities have been also found, including a blind cod and a number of "reversed" flat-fish—specimens of Dabs and Flounders in which the young animal has evidently settled down upon its right in place of upon its left side, the result being that the side which is usually blind has both eyes upon it and the side which is usually pigmented is white. A condition not uncommonly met with amongst flat-fish, especially in the plaice, is the partial or entire pigmentation of the lower, usually colourless, side. In these cases the upper side is in its usual pigmented condition.

We have found two specimens of Dabs in which there are similar irregularities in the lateral line. This organ in place of being one continuous row of scales is divided into two nearly parallel tracts, the one dorsal and anterior and the other ventral and posterior. The posterior part of the semi-circular curve near the anterior end of the lateral line is absent.

Faunistic Investigations.

During the various trips that have been taken, on the steamer "John Fell," on various trawlers, and on the cutter stationed at New Brighton, for the purpose of collecting and making observations on fish a number of notes and collections have been made of the fauna of the ground trawled over, and this has led to the discovery of several animals new to the district. Besides this we are now able to show that there are definite areas in the district, both inside and outside of the territorial limits, which are inhabited by large numbers of some one or two particular molluscs or annelids or echinoderms. These areas with their assemblages of animals are of economic importance as constituting the chief feeding grounds of our food-fish.

Below are given the names of some of the animals which are of importance in this way with a few notes as to the localities, depth, etc. :—

Scrobicularia alba :—This small bluish-white bivalve shell well known to the fishermen as "henpens" covers a very large extent of the sea-bottom, usually in the deep water lying about midway between the Lancashire coast and the Isle of Man and extending down to the bottom end of the Horse Channel, the depth varying from 7 to 31 fathoms. It is usually found on a dark blue mud and as this extends also in places round the Isle of Man

it is highly probable that this shell may be found to be widely distributed throughout the Irish Sea. *Scrobicularia* has been found mostly in the stomachs of Plaice, Dabs, Haddock and Flounder.

Mactra stultorum and *M. elliptica*:—These two shell-fish which have been taken in large numbers off the Zebra buoy, R. Mersey, and also off the Ribble Gut Bar in comparatively shallow water—2 or 3 fathoms, constitute a not inconsiderable element in the food of Plaice and Dabs of small size (up to 12 inches) which are found in the territorial waters. Their young afford also a considerable amount of food to the very young fish stages from $1\frac{3}{4}$ in. upwards.

Tellina balthica and *Cardium edule*:—these two shell-fish are put together as they generally occur together, the *Tellina* being extremely abundant on the extensive cockle beds of this district, and both are of very great importance in furnishing food to the fry of the flat-fishes at a time when they first become ground feeders and leave off eating copepods.

Corbula gibba:—This small shell-fish, notable for having its two valves unequal, has been found to furnish food to considerable numbers of flat-fish on certain grounds where it is found, especially in a locality off Morecambe Bay, Blackcomb bearing N.E. $\frac{3}{4}$ E., at 14 fathoms, where it must be extremely abundant.

Philine aperta:—This soft mollusc is to be found in great numbers off the Ribble, Gut Bar, at the seaward side of Blackpool closed ground, and also at the bottom end of the Horse Channel on the mud, in a moderate depth of water. It has so far been taken chiefly in the stomachs of skate.

Pecten opercularis and one or two other species of the genus are to be found in large numbers on the deep

ground outside Morecambe Bay and off the Cumberland coast, and also off some parts of the Isle of Man. It is not yet known whether these are of much use as food to the fishes but so far they have not been taken in the stomachs of the large fish examined.

Aphrodite aculeata:—This characteristic worm, well known to many as the "sea mouse," is always to be taken in large numbers off the mouth of the Ribble, the Gut Bar, in about 5 fathoms. Here again we are unable to say from our own statistics whether it is used as food, but on other parts of the coast it is of frequent occurrence in the stomachs of cod.

A number of Echinodermata, viz., *Ophioglypha albida*, and *O. texturata*, *Spatangus purpureus*, *Brissopsis lyrifera* and *Echinocardium cordatum* have been taken in numbers, but as yet we have not got sufficient evidence to show that they are important articles of food for our fishes. The two species of *Ophioglypha* have been taken in immense numbers in every haul of the trawl off the Ribble Gut Bar usually in 5 fathoms, and associated with *Aphrodite aculeata*, *Philine aperta*, *Mactra stultorum* and *M. elliptica*. *Spatangus purpureus*, *Echinus esculentus* and *E. miliaris* are usually associated together with *Pecten opercularis* on the deep water ground off the northern portion of our district. *Brissopis lyrifera* has been taken in immense numbers in the deep water on the mud to the western side of the Isle of Man, and at times constitutes the main portion of the invertebrate fauna brought up in the trawl. *Echinocardium cordatum* is taken off the Blackpool closed ground in large numbers.

In regard to Crustacea, *Carcinus moenas* (shore crab), *Portunus depurator* (swimming crab), *Pagurus bernhardus* (hermit crab), are widely distributed all over the district in the shallow water; the two former do not go much beyond

the 5 fathom line, while the last is pretty generally distributed between Lancashire and the Isle of Man. *Nephrops norwegicus*, the Norway lobster, is extremely abundant off the south end of the Isle of Man and between the northern end and Cumberland, coming up in immense quantities. These Crustacea undoubtedly constitute a large part of the food of such fish as the Cod and Whiting.

A number of very interesting rarer forms have also been taken, viz :—*Cardium echinatum* and *Isocardia cor*; *Tritonia hombergi*, *Eolis tricolor* and *E. rufibranchialis* and probably *E. viridis*; *Calocaris macandreæ*, *Pasiphæa sivado*, *Munida bamffica*, and some parasitic Bopyrians; also the brittle star *Amphiura chiajii*.

These observations on the fauna of the district besides being interesting from a purely scientific point of view are of importance economically as they afford us information as to the feeding grounds of the fish, and may give some clue as to the movements or migrations of species. Probably the most important factors influencing the life, habits and prosperity of fish—and therefore of the corresponding fisheries—are their spawning grounds, their feeding grounds and their enemies.

NOTE on a LOBSTER-HATCHERY.

By Professor Herdman.

At the end of the year, I visited the Lobster hatchery established recently by the Fishery Board for Scotland at Brodick, in the Island of Arran, and of which I had heard from Dr. Fulton, the Scientific Secretary to the Board. The shore between tide marks at the spot is rocky, and the hatchery is a very simple modification of a natural creek. The sides and floor of the creek have been to some extent levelled and smoothed, and a concrete sea-wall about two feet thick has been built at each end so as to make a rectangular vivarium about 60 ft. by 20. This is roofed in with galvanized wire netting of $1\frac{1}{4}$ inch mesh set in iron frames each 9 ft. by 18 in. At each extremity of the roof two adjacent frames are hinged so as to form doors which can be raised to give access to the interior. The depth is rather greater at the lower than at the upper end on account of the natural slope of the creek, but there is on the average about 5 ft. of water in the vivarium at low tide. The lower concrete wall is penetrated at its base by a 4 inch iron escape pipe, with a wooden plug: through this pipe the place can be emptied when required.

On the floor of the vivarium are scattered some boulders and stones with growing sea-weed to afford shelter, and some large draining tiles have been found specially useful for this purpose, as the lobsters seem to like hiding in the cavities of the tiles. The lobsters live well, flourish, and reproduce in the vivarium, and they require no looking after except that a supply of food consisting of old fish—any

kind that can most readily be obtained—is thrown in to them once a day. Some of the lobsters have now been in for three years and have spawned twice in that time.

This vivarium at Brodick, however, is only used as a breeding pond, and a protection to the mother lobster and the spawn until hatching takes place. No attempt has been made to retain the young larval lobsters when set free and rear them up to the adult condition.

When I visited this vivarium the water was run off at low tide so as to let me examine the interior. It then contained a number of large lobsters, both male and female ; some of the latter had spawn which was ready to hatch out, and in fact some of it had been hatched since the previous day, others had spawn which had just recently been produced, and all seemed in a thoroughly healthy and satisfactory condition.

I have been of opinion for the last few years that Port Erin in the Isle of Man would be a most suitable place for lobster culture. In the first place, there is pure sea-water, and a rocky coast with abundance of sea-weeds ; and moreover lobsters live already in the neighbourhood, showing that the ground and other conditions are suitable, and ensuring a ready supply of the parent animals. Secondly, on the north side of the bay, between the Biological Station and Bradda Head, there are several deep creeks in the rocks which could be easily closed in to form vivaria. Thirdly, the lobsters could be easily fed and looked after by those having charge of the Biological Station, and the Sea-Fish hatchery, when that is established. Fourthly, the lobsters, whether full-grown ones for the market or in their younger stages for stocking other grounds, could readily be sent off from Port Erin, by train to Douglas and then by steamer to Liverpool, Fleetwood, etc., or direct by steamer from Port St. Mary

to Liverpool, or by the fisheries steamer from Port Erin to any required spot.

I would propose that if this suggestion is carried out and a vivarium is formed at Port Erin, the operations should not be restricted to the mere breeding of lobsters and the protection of the parents and spawn till hatching, but that an attempt be made to retain the young larvæ and rear them, either (1) through their early stages and then set them free as young lobsters in suitable localities throughout the district, or (2), if it is possible, to rear them up till they are adult.

I would set about this in the following manner:— Starting with a vivarium like that at Brodick I would stock it with breeding lobsters, or with females having spawn on the abdomen. I would examine the spawn at intervals when feeding the lobsters, and when any spawn was seen to assume the characteristic appearance which it has for a day or so before hatching I would transfer that mother lobster into a separate box or compartment of the vivarium walled in with wire gauze sufficiently fine to prevent the hatched larvæ from passing through. Here she would have to be fed for a few days, until all her spawn was hatched out, then she could be removed and put back in the vivarium, and the wire gauze box, or "nursery cage," would now contain all the young free swimming larvæ and could be lifted out of the vivarium and examined from time to time, while suitable food (possibly Copepoda, which can readily be obtained in quantity, would do) could be added, and if necessary some of the young lobsters could be taken out from time to time and distributed into other nursery cages or placed in tanks.

No doubt the greater part of the rearing work would be at first experimental until the most suitable food and the

most favourable conditions are found out, but I do not foresee any insuperable or even formidable difficulty, and if even a small percentage of the young lobsters hatched could be successfully reared it would be a very great gain, as under their natural conditions in the sea they have to run the gauntlet of so many dangers that there can be only a remote chance of one in a hundred escaping from its numerous enemies and reaching maturity. I may add as a proof of the want of many more native grown lobsters that some hundreds of thousands are imported annually from Norway and from France, and that lobster hatcheries have lately been established in Newfoundland which hatch over 500 million young lobsters annually so successfully that there is only a loss of about 11 per cent., and the promoters of these hatcheries are said to be thinking of placing their lobsters on the British markets.

APPENDIX.

REPORT

UPON THE METHODS OF

OYSTER & MUSSEL CULTURE

IN USE ON THE

WEST COAST OF FRANCE,

BY

Professor W. A. HERDMAN, D.Sc., F.R.S.

OCTOBER, 1893.

Report upon the Methods of Oyster and Mussel Culture in use on the West Coast of France.

By W. A. Herdman, D.Sc., F.R.S.

Professor of Natural History in University College, Liverpool.

[With Plates I.—III.].

Introduction.

In accordance with the wish of the Lancashire Sea-Fisheries Committee I went to France towards the end of last June and spent about three weeks in visiting the various places on the western coast between Arcachon and Brittany where oyster and mussel culture are carried on. I saw everything possible in the time of the methods employed and the results attained, collected notes and specimens, and took about 60 photographs of the more important points. From that material the following report has been drawn up.

I am indebted to Mr. C. E. Fryer, of the Board of Trade, and to several scientific friends for kindly giving me letters of introduction and for other help, and I hoped to have received similar assistance through our foreign office, but although I wrote and explained fully what my object was in wishing to study shell-fish culture and asked that facilities should be given to me by putting me in communication with the consuls or the fishery authorities at the places I proposed to visit, and although Lord Rosebery kindly gave me an introduction to the British Ambassador at Paris, to whom also I wrote explaining my objects, still I received no introductions or official help from the Government. It gives me the more pleasure then to acknowledge the friendly spirit in which I was received and the hospitable way I was treated by all the Frenchmen I came in contact with and to whom I was merely a foreign naturalist. I have since, however, obtained some information in regard to the fishing at

Le Croisic from Mr. Elford Dickie, the British Vice-Consul at St. Nazaire, to whom I tender my thanks for his courtesy and help.

I have not thought it necessary to give references to the various reports and papers on oysters and other shell-fish which have been published in the past, chiefly in France and America, as I consider it more important for the present purpose that I should give an account of what I saw myself, and state my own opinions based upon all the information I have been able to get in any way.

I shall first give a brief statement showing the order in which I visited the localities, and then a more detailed account of the fishery methods at each centre. Finally I shall draw some general conclusions as to the applicability of the French methods to our own district.

Outline of Tour.

On arriving in Bordeaux I was met by Mons. Emile Durègne, Directeur de la Station Zoologique, and Secretary of the Scientific Society of Arcachon, who very kindly offered to accompany me next morning to Arcachon and facilitate my enquiries there. I found his presence with me of the very greatest assistance as he was intimately acquainted with the ground, and knew personally the men engaged in oyster culture, and so was able to let me see the various processes in much less time than it would otherwise have taken.

At Arcachon M. Durègne placed the resources of the Zoological Station at my disposal. I was assigned a bedroom and a private laboratory, and during my short stay I lived in the institution, had the use of the station boatmen, and found it all a great convenience in obtaining, examining and packing my specimens. For this courteous treatment I take this opportunity of thanking the Scientific

Society of Arcachon, and especially their able Secretary Emile Durègne.

Besides going over samples of the oyster "parcs" both in boats and by wading, I met at Arcachon Mons. Gustave Dasté, a proprietor of parcs and exporter of oysters, who gave me a good deal of important information about his methods and the condition of the industry. I also visited M. Dasté's warehouses and establishment for the exportation of oysters at Pointe de l'Aiguillon some way to the east of Arcachon. I met also Mons. Peseux one of the oyster syndicate and a member of the oyster commission, and Mons. Dubourdieu who showed me round his parcs.

From Arcachon I returned to Bordeaux and then proceeded to Royan, at the mouth of the Gironde, where shrimping and sardine fishing is carried on, and where abundance of small wild oysters are found on the rocks at low tide. From Royan I went to La Tremblade, La Grève and Marennes which are all near the estuary of the Seudre and are in the most important district for the "fattening" and "greening" of oysters. I was at first at Tremblade and La Grève, and then crossed the Seudre to Marennes where I spent a couple of days examining the oyster "claires." I had a letter of introduction to Mons. Grenier at Bourcefranc in that neighbourhood but he was away at that time for a week. I saw however his claires on the coast a few miles off. I then went on by coach to Pointe le Chapus and saw the small and very primitive oyster parcs there, including however the basin of "dégorgement" for freeing the oyster from the mud in the intestine before being packed for transport. Here also I saw the mussel enclosures on the shore, and the ground where the girls collect "Pèlerins" (*Tapes decussata*).

I next crossed to the Island of Oléron and visited

Château d'Oléron, then St. Pierre and finally Boyardville and from there returned to the mainland at La Rochelle. I had intended going to the Island of Ré also but heard at Rochelle that it was much the same as Oléron, so, as my time was very limited, I gave it up. After examining the shore about Rochelle, and getting what information I could, I went on to the bay of Aiguillon to see the conditions under which mussel culture is there carried on. To reach the small villages on the edge of this enormous mud-swamp which has been rendered profitable in such a wonderful way by means of the "bouchot" system of mussel culture, it is necessary to go by train from Rochelle to Marans a small station on the line to Roche-sur-Yon and then find one's way across country for 10 or 12 kilomètres to the shores of the bay. I visited the village of Charron and saw the bouchots there.

I then went on to Roche-sur-Yon and from there to Les Sables d'Olonne where there is a huge oyster parc behind the harbour with built stone sides. From Sables I went to Nantes and from there to the coast near the mouth of the Loire in the neighbourhood of Le Croisic, Pornichet, and Le Poulignen where there are oyster parcs and claires, and at Le Croisic a great inland basin somewhat as at Arcachon and Sables d'Olonne. At Croisic moreover I specially wished to see and hear about the shrimp traps and take some photographs of them. This was satisfactorily managed, and I then returned home by Nantes and Paris.

I shall now discuss the chief fishery centres I saw, in order, beginning at the Southern end of the series.

Arcachon.

Arcachon is probably the most important centre for the study of oyster culture. It is one of the two places where

oyster-spat can be obtained in abundance, and it is not only able to supply young oysters to the various regions in France, such as Marennes, where the oysters are reared, fattened, flavoured, and coloured for the market, but it also exports them in large quantities to England. This artificial oyster culture at Arcachon was established in 1859 by M. Coste, a biological professor in the Collége de France.

The population of Arcachon and the neighbourhood is about 30,000, and of these 12,000 are employed constantly in the oyster parcs. About 300,000,000 oysters are produced annually, their value being upwards of 1,000,000 francs. The most notable physical feature of the neighbourhood is the vast inland sea, the "Bassin d' Arcachon" which is about 80 kilom. in circumference, contains at high tide about 15,000 hectares of area, say 30,000 acres, and is over the greater number of the channels about 5 to 10 fathoms in depth, while two thirds of the whole area dries at low tide. This "bassin" is connected with the Atlantic by a narrow entrance ("passe") at Cap Ferret through which the tide runs in and out.

In the middle of the "bassin" and due north of the town of Arcachon is a small island, Ile des Oiseaux, and on the shores of this and on various other flat shallow parts which are exposed at low tide (and which are called "crassats") are situated the oyster farms or "parcs." Some of these ("bancs reserves") belong to the state and are reserved for the purpose of producing spat—no doubt in the past a most useful provision and wise precaution against any general depletion of the private beds, but I was assured by several people at Arcachon that the state reservations were now really unnecessary. They say that there are now so many adult oysters all over the ground that abundance of spat for all is produced. Certainly during the

time of my visit (July 3rd and 4th) which was just the period when the free-swimming embryos were settling down, the water over the parcs seemed to be swarming with them, and the spat was making its appearance all over all sorts of suitable submerged objects.

The great importance of Arcachon in oyster culture is undoubtedly as a place where the adult oysters reproduce freely, and where the free-swimming larvæ or "fry" when settling down as spat can be readily collected and so be saved from destruction and made available for artificial rearing. The oyster chiefly cultivated at Arcachon is *Ostrea edulis* the ordinary rounded flat oyster of Northern Europe, but the large elongated Portuguese oyster, *Ostrea angulata*, is also abundant at Arcachon and is said to be increasing. There was some alarm recently amongst the oyster proprietors upon the ground that these two species were breeding together and producing an inferior kind of hybrid. This fear has however been dispelled, as it is well known to biologists that the reproductive arrangements in the two species are very different. A much more practical, and in fact quite likely, difficulty would ensue if the Portuguese oysters became so numerous in the "bassin," that their fry would come into competition with the fry of *Ostrea edulis* in settling down on the "collectors," and being, it is said, more hardy animals would oust the latter is the struggle for existence.

The oyster reproduces at Arcachon between May and the beginning of July and the young animal leads a free-swimming existence for nearly a week before settling down. The cultivators ("parqueurs") examine carefully the condition of the spawn in the old oyster and at what they consider to be the proper time (generally about the end of June) for catching the deposit of spat, or young oyster ssettling down after the free-swimming existence,

they place their "collectors" in position. They consider that it is of great importance that the collectors should not be put in the water unnecessarily soon as the tiles are liable to become coated with other things, slime and sediment, which will prevent the oyster spat ("naissain," as they call it) from adhering.

The collectors are crates (called "gabarets" or "ruches") of earthenware tiles coated with a lime cement (Pl. I, fig. 2). The tiles are like ordinary roofing tiles. They are about 14 inches in length 6 inches in breadth at one end and 5 at the other, and $\frac{1}{2}$ an inch in thickness The clay they are made of is coarse and of a reddish colour. Later on I saw the tiles being made further up the coast, north of the Gironde, whence they are shipped in coasting vessels.

The tiles are prepared for use as collectors by being coated with a layer of limy cement which gives them a whitewashed appearance. The cement is made of lime mixed with sea-water and a certain amount of sand so as to form a creamy paste. Different proprietors use slightly different proportions of lime and sand, and in some places hydraulic cement is also used. This process of coating, known as "chaulage," adds about from $\frac{1}{16}$ to $\frac{1}{8}$ inch in thickness to each side of the tile. It has to be done with some care so that the limy layer may be of the right nature, sufficiently strong and adhesive and yet readily detachable when the right time comes, so that the young oysters may be removed from the tiles without injury and without the necessity of breaking up the tiles as used to be the case. By the present method the oysters and cement can be scaled off and the tiles preserved for use again the following year. A dozen or more millions of these tiles are probably employed each year at Arcachon.

The prepared tiles are arranged in rows inside cases ("ruches") made of sparwork or strips of wood so that the

water may flow readily in between and around them. The cases of collectors I measured were about 6 feet in length by 2 feet in breadth and 3 feet in height; each holds 120 tiles arranged in 10 tiers or layers. The tiles in any tier are placed with their long axes at right angles to those of the tiers above and below, as is shown in Pl. I., fig. 2. This it is thought breaks up better than any other arrangement the currents of water as the tide runs through the "ruche" and so gives the young oysters a better opportunity of affixing themselves to the tiles. This is the arrangement in the "gabaret" collectors or "tuilles en ruche," which is considered after numerous experiments to be the best form at Arcachon, but various other forms of tile collectors are in use elsewhere and are better suited to special local conditions, such as depth of water and softness of bottom. The tiles are always placed with the convex surface upwards as it is very important that there should be as little opportunity as possible given for the collection of any fine sediment in which the young oysters might be smothered.

I was very fortunate in seeing some of the tiles just after the young oyster spat had been deposited, and one of the figures (Pl. I, fig. 3) represents Mons. Dubourdieu holding up such a tile, covered thickly with the little amber coloured specks, less than $\frac{1}{16}$ inch across, for me to photograph. There may be several hundred such young oysters on one side of a tile. I had the advantage of going round with Mons. Peseux and Mons. Dubourdieu on July 3rd, when they were inspecting their collectors, and they and also Mons. Dasté assured me that this was an especially good year for spat. They attributed that to the continued fine weather and especially to the high temperature of the water.

During my stay at Arcachon the water in the "bassin"

was certainly very warm. When run from the seawater taps in the Zoological Station I found it was at 74°F. with a specific gravity of 1·023, out in the middle of the "bassin" I found it at 76°F. with a specific gravity of 1·024, while over the shallow oyster parcs I found it varying from 78°F. to 80°F. with a specific gravity of 1·022 to 1·024, and in one or two corners of the parcs at low tide where the last of the ebb had been exposed to the midday sun it rose as high as nearly 90°F.

The cultivators at Arcachon are of opinion that the oysters could not be bred successfully, that there would not be a sufficient deposit of spat, in waters that are much cooler, but we have evidence to the contrary in what Captain Dannevig says in regard to the plentiful spawning of the oyster in his pond at Norway, and also in the deposits of spat on the North Coast of France and South Coast of England. The temperature in July in Dannevig's pond at Arendal was about 63°F.; while at Port Erin, Isle of Man, the temperature in the bay during the first week in July varied from 59° to 62° F., and on July 22nd was 59°F. with a specific gravity of 1·025, and shore pools near the Biological Station, fairly comparable with the oyster parcs at Arcachon, ranged in temperature on July 22nd from 59°F. to 76°F., and on July 13th from 60° to 76°F.

I am very hopeful that although the specially high temperature of the "bassin" at Arcachon—and possibly still more the calm weather during the critical period when the young animal is free-swimming and then settling down for life—may have favoured an unusually heavy deposit of spat, still no such great heat is really necessary for a normal amount of reproduction and development, and that we may have in our neighbourhood water sufficiently warm for the purpose.

As to the specific gravity:—it varies at Arcachon from

about 1·022 to 1·024, and Dr. Bashford Dean and others state as their opinion that a low specific gravity is necessary for a good deposit of spat. I asked Mons. Dasté his opinion on this point. He has had great experience as a practical ostreo-culturist and has moreover been in the habit of taking temperatures and specific gravities. He said that unusually low specific gravities (due to wet weather) during the breeding season did harm at Arcachon, while further north at the other end of the "bassin" they did good and resulted in more abundant spat because of differences in the local conditions.

Therefore it can scarcely be predicted for any particular place whether a high specific gravity of the sea water will or will not be advantageous for oyster culture. On the whole Mons. Dasté thinks that salter water is better for breeding and for the growth of the shell ("coquillage") but that less salt water—some admixture of fresh from springs or streams—is better for the growth of the animal (the soft parts in contradistinction to the shell) when one or two years old. Certainly the French wild oysters that I came across attached to rocks at low tide on the shores of the open sea, although their shells might be well grown, had the animal meagre, stringy, and saltish to the taste and wanted the fatness and flavour of those reared in "claires."

At Arcachon the young oysters are allowed to remain on the tiles at least till October or early in winter, when they are about the size of the finger-nail, say $\frac{1}{2}$ to $\frac{3}{4}$ inch in diameter (see Pl. II, fig. 1). Then the tiles are collected and taken ashore and the process of "détroquage" or separating the oysters from the tiles takes place. This is effected very rapidly by a skilled hand, the little oyster with the film of lime to which it is attached being flicked off the tile rapidly by a square-ended knife.

Many of the oysters are sold at this stage to the "éleveurs" who rear and fatten them, but many on the other hand are kept for another year or two in the parcs at Arcachon. These latter after removal from the tiles are placed in flat trays having a floor and a lid of close galvanized wire netting, of about half inch mesh, and these trays are placed between short posts in the sea on the oyster parc so that the tide can run freely through them supplying the oysters with food and oxygen. Such trays are called "ambulances" or "caisses ostreophiles" and are shown in Pl. I, figs. 4, 5. They measure about 6 feet by 4, and are 6 inches deep. They serve to keep the young oyster during the early period of its life out of the sediment, and they also protect it from its numerous natural enemies, such as the boring sponge (*Cliona*) which ruins the shell, starfishes and crabs which manage to suck or pick out the soft animal, and whelks (such as *Purpura* and *Nassa*) and other Gastropods, which can bore a hole through the shell and prey upon the oyster.

The ambulances are constantly looked after by the oyster men, and especially women, who come at low tide when the caisses are exposed, open the lid and pick over the contents, removing any enemies or impurities which may have got in, such as crabs, taking out any dead shells, and re-arranging the oysters if necessary so that all may have a fair chance of obtaining food and growing normally. The young oysters grow rapidly in the ambulances and have soon to be thinned out. The larger ones are removed to other caisses—or, if large enough, they are thrown into the open enclosures of the parc. Additional young ones may now be added, or all the space may be required for a time by those left. In this way, by thinning out, re-arranging, and adding, relays of young oysters in their first year may occupy the ambulances for

8 months although an individual oyster may only be in for one month or so. Eventually all the oysters not sold to éleveurs or exported get transferred from the ambulances to the other parts of the parc.

Mons. Dasté told me that he soaked his ambulances thoroughly in coal tar once a year to preserve them. Although they are some little expense at first they last well, and are used over and over again.

The rest of an oyster parc is marked out into certain areas like little rectangular fields having raised edges all round and a sluice at one corner so that the water may either be retained or allowed to run out (Pl. I, fig. 6). At low water the boundary banks of these are all exposed but there is usually some 6 or 8 inches or so of water retained over the area. This shallow water becomes warm towards the last of the ebb and it is swarming with living things and so no doubt supplies abundance of food to the oysters lying on the floor of the enclosure. The banks bounding these areas are formed of two parallel rows of closely set vertical bunches of the local heath, *Erica scoparia*, with the space between, a foot or more wide, filled in with masses of a tenacious clay (Pl. I, fig. 6) obtained from the Ile des Oiseaux. In some places the boundary is strengthened, or partly formed, of planks of wood and stakes.

An objection which is urged against the use of the heath is that it forms a most attractive system of "bouchots" upon which young mussels settle down and flourish. The mussels are not cultivated, nor desired, but they are present in considerable abundance over some parts of the oyster parcs, hanging in clusters from the branches of the heath. The men at Arcachon say that there is not enough lime in the water for both the oysters and the mussels, and that the latter being the stronger they get all the lime and the former suffer correspondingly. This is one way of ex-

pressing the general fact that somehow in the complex struggle for existence the mussels get on best.

There are many crabs and other enemies of the oyster in the parcs. Every here and there one can pick up empty oyster shells quite recently dead and having a neatly drilled hole in one valve which shows that the oyster had been attacked and killed by a carnivorous Gastropod. Crabs are injurious both directly by eating young oysters and also indirectly by excavating holes in the floor of the parc into which oysters slip and are then smothered by mud.

The young oysters when taken from their ambulances are put in these little fields or enclosures with the mud banks, and there they remain thickly scattered over the floor till they are required for exportation. I was informed that they usually put about 1,000,000 oysters in each enclosure, which is about at the rate of 125 to the square metre. The oysters grow very rapidly on leaving the ambulances and may be $\frac{3}{4}$ inch across in a couple of months. When one year old they are usually from 1 inch to $1\frac{1}{2}$ inches in diameter, and when two years old they are usually from $2\frac{1}{4}$ to $2\frac{1}{2}$ inches in diameter. During the time I was there (July) some of the one and two year old oysters were evidently growing very rapidly. It was easy to see the annual increments by means of the lines on the shell, and some of the shells had beautifully transparent extensions of new matter from their free edges. One *Ostrea angulata* which I was shown had evidently added an inch to the edge of its shell during the past year.

Between neighbouring oyster parcs, and surrounding the "concessions" of the various proprietors, run lanes of water about 4 metres wide. These give ready access to all parts of the parc and are traversed by the boats of the oyster men (parqueurs). These boats at Arcachon are

very remarkable. They are long and narrow but stoutly built, pointed at both ends and rather like a gondola in appearance. They are much easier to row or push along than would be thought from their appearance, and they can also be used with sails. The lanes of water around the parcs are bordered by tall saplings with their twigs left on which keep constantly waving in any slight breeze. These are called "pignons," and they are not only serviceable as a boundary, but—the oyster men declare—they also frighten away the fish and especially the large voracious ray, *Myliobatis*, which might otherwise do great damage to the preserves (see Pl. I, figs. 1, 4, and 6).

Possible depradations of another kind are guarded against by the "pontons" or large barges moored at the corners of the parcs in which the oyster police (gardes des pêches) live (see Pl. I, fig. 6).

Concessions of ground for oyster parcs at Arcachon are given by the state at about 30 francs the hectare, which comes to be about 10 shillings per acre. The practical men I met assured me that the industry was still thoroughly successful, and they thought the present year was going to be a very good one. M. Dasté informed me that he had already sent 11,000,000 of oysters this year to London. He sends out two year olds, measuring 5 to 6 centimetres across, at the rate of 12 francs per 1000, and somewhat older ones, measuring 6 to 7 cm. across, at 25 francs per 1000; these prices include packing and carriage as far as Bordeaux where they meet the steamer. On an average only 1 per cent. of those exported die on the journey. He considers from the 15th March to the 15th April the best time to send young oysters for stocking purposes to England. Before that it is liable to be too cold in England, and later it is too hot in Arcachon for the transportation to be effected safely.

Great numbers of the oysters bred and reared through their early stages at Arcachon are sent to Marennes and La Tremblade, when from one to two years old, to be fattened in a "parc d'élevage" and "greened" by feeding upon the diatom *Navicula fusiformis*, var. *ostrearia*. (See further on in this report under Marennes, p. 58; and also under General Conclusions, p. 75).

Royan.

This place is situated at the mouth of the Gironde, and is a centre of the sardine fishing. I found there a fleet of between 60 and 70 fishing boats carrying a trawl with a beam of about 20 feet. Shrimping also is carried on by means of fixed or suspended nets worked both from the long breakwater and also from the boats. The net is shaped as a shallow bag and is about 6 feet in diameter. It has either a hoop round the mouth or is attached to four light spars set in the form of a square. This framework is then suspended by a rope which passes over a pulley at the end of a long pole, on the breakwater, or a light boom, on the boat, set at such an angle that the net can be conveniently lowered into the water. Some bait is put in the centre of the net and after it has been down a short time it is hauled up rapidly and the shrimps are thus caught in the concavity of the net.

On the rocks to the north of Royan I found many small natural oysters which the people go out at low tide to collect, and to eat largely on the spot. The rocks here are a richly fossiliferous limestone (cretaceous), and the oysters seem to have rather thick, irregular, sometimes distorted shells. Most of them adhere completely by one valve, and are attached to the rocks in fair abundance from low water mark up to at least half tide. They seem to be mostly 2 or 3 years old, and are not really good to eat,

being poor and saltish in taste. Possibly these may have been grown from spat derived from embryos which have been drifted up on some occasion from Arcachon.

Marennes, &c.

The flat district on both sides of the estuary of the Seudre is the chief region for fattening up the oysters and preparing them for market, and it is in this neighbourhood that the celebrated green oysters, so well known and highly prized in some markets, are produced. But it must not be thought that all the oysters reared in these claires are green, the two kinds ("huitres vertes" and "huitres blanches") are cultivated in the same neighbourhood.

La Tremblade is on the southern side of the Seudre a few miles from the estuary, and its port is La Grève. A wide canal, up which small coasting vessels and fishing boats can sail, leads the sea-water from La Grève to Tremblade and supplies the numerous oyster "claires" in the district around. The country is very flat and the soil is clay or clay and marl. It is excavated in all directions for miles to form claires and the branch canals supplying them. The "claires" (Pl. II, fig. 4) are merely shallow artificial ponds of more or less rectangular form and about 2 feet deep on an average. The floor is simply the clayey soil and is very muddy, while the sides are turf banks pierced somewhere by a pipe leading from a branch canal or a neighbouring claire. On the north of the estuary in the neighbourhood of the little town of Marennes there are also numbers of claires supplied by a canal leading inland.

A good deal of the low-lying land is also occupied by salt marshes (marais salants), shallow excavations in which the sea-water is evaporated and from which the salt is scraped up in heaps by great wooden rakes. The pyramids

of gleaming white salt which are formed at the sides of the salt marshes are often a conspicuous feature in the landscape. They are seen in one of the figures (Pl. III, fig. 3).

In spring and early summer the éleveurs prepare their claires for use by emptying them of water and allowing the floor to be exposed for some time to the sun and weather, they then dig over the soil on the bottom and break it up thoroughly so as to let air through it. They dig the edges more deeply so as to form a slight trench all round which is said to be of some importance in catching and retaining the fine sediment, and may also be of value in equalizing the temperature. In the central part of the claire the soil is heaped up so as to form in some cases a considerable convexity, so that later on, when in use, the water is shallower in the middle.

About July or August they let a little water in by the sluices and this mixes with the clay and marl crust and makes a frothy scum in which many lowly organisms begin to grow. A little later more water is let in so as to fill up the claires and then the green water-weeds (Algæ) make their appearance and soon cover the floor with a dense green growth. This is known to the éleveurs as "moss" or "verdure" and they recognise its very great importance in connection with the nutrition of the oysters.

I collected samples of the green growth from the bottoms of several claires, and these specimens have been carefully examined for me by Mr. R. J. Harvey Gibson, the lecturer on Botany at University College, who finds that they consist of *Cladophora flavescens* and *Cladophora expansa*, along with *Spirulina tenuissima* and a *Lyngbya*, the *Cladophora* being however the chief constituent. A microscopic examination of these Algæ shows that they are teeming with other forms of life. Small Amphipods, Cladocera and other kinds of Crustacea as well as lower

animals are clinging to and entangled in the branches in abundance, some parts give attachment to little tufts of *Calothrix*, while nearly everything is covered with innumerable Diatoms or their remains, such as *Gomphonema* stalks adhering to the stems of *Cladophora*.

Probably so far as oyster culture is concerned the green Algæ thought so much of by the éleveurs are only of importance as forming points of attachment and shelter, or favourable environment, for the microscopic forms of life and especially for the Diatoms. It is known that under all conditions natural and artificial, Diatoms form a most important constituent of the food of the oysters, and it has been established by several eminent investigators that the green (or rather greenish blue) tint of the Marennes oysters is due to the presence in the "claires" of a particular kind of Diatom in enormous profusion (Pl. II, fig. 5). This special Diatom used to be known as *Amphipleura*, or *Navicula, ostrearia*, but its correct name is now *Navicula fusiformis*, var. *ostrearia*. This form is found in our own district in the estuary of the Dee, although not abundantly; but it is probable that there are many other kinds of similar Diatoms that would do equally well for rearing and fattening oysters on, and as a matter of fact the contents of an oyster's stomach show that the food has consisted of various kinds of Diatoms (in one case 87 species were found) as well as other lowly organisms.

I also collected samples of the mud, sometimes of a dark green colour or almost black and sometimes browner, from the bottom both of dry and wet claires, and on submitting these now to a detailed microscopic examination I find that the deposit is very largely composed of organic particles, such as living and dead Diatoms, spores of Algæ, and minute animals. Altogether, all the evidence I was able to collect shows, I think, that the bottom of a claire

is teeming with microscopic life, and it is probably this rich feeding *alone* which is necessary in order to bring the oysters in a very short period—a few weeks usually, sometimes 10 days or a fortnight is sufficient—to the desired condition of fatness and flavour.

It is said that the oyster can be *coloured* under favourable circumstances in 36 hours. It is only the gills and the labial palps of the animal which become green. The pigment of the Diatom (which has been called "marennin" by Prof. Ray Lankester) is really blue, but when deposited in minute granules in the yellowish coloured gills it gives rise to the greenish tint.

From the oyster's point of view the claire is a very unhealthy place. The mortality is very high, and those that survive are probably in an enfeebled, if not actually a diseased, condition. They have had far too much to eat, their food is highly nutritious, the water is very stagnant and badly aerated, and is probably unhealthily warm. However the healthy natural oyster is not what is desired by the epicure, and of course it is the business of the éleveur to produce what will fetch the highest price in the market, so he regulates the condition of the claire in such a way as to favour as much as possible the production and growth of an abundant supply of microscopic plants and animals.

The oysters are generally laid down in the claires in August, and the autumn and even early winter months are supposed to be the best times for "greening." During my visit in July most of the claires were being prepared for the reception of the oysters, but some were full. I found very considerable differences in temperature and specific gravity between some claires and others, as is to be expected when one recollects that the fresh supplies of water are admitted at very irregular intervals, so that

one claire may have been stagnating and evaporating for a week or more while the neighbouring pond may have been freshened by a canal from the estuary of the Seudre an hour or two before. In most cases the water is admitted at spring tides only.

The large canal leading towards Marennes had sp. gr. 1·016 and temperature 70°F., while several neighbouring claires had their sp. gr. about 1·027 and temperatures of 78° F., 82° F., and 85° F. respectively.

The oysters laid down in claires of the Marennes and La Tremblade neighbourhoods are obtained from Arcachon. They may be bought by the éleveurs when they are from 18 months to 2 years old, and may be fattened, greened and ready for the market by the end of the following autumn.

Pointe le Chapus.

I was disappointed in not seeing Mons. Grenier at Bourcefranc, but went on to Pt. le Chapus to see the claires, the oyster parcs on the beach and the basin of dégorgement (see Pl. II, figs. 2, 3, and 6).

The oyster enclosures on the beach, which is just at the mouth of the estuary of the Seudre on the Straits of Maumusson, are very primitive. They extend over the greater part of the muddy gravel shore as exposed at low tide, and are merely rude enclosures surrounded by low banks of stones heaped together to about one foot in height. The oysters are laid out in these parcs and are attended to at low tide by men and women. There are also at Pointe le Chapus certain enclosures of smaller size on the shore in which mussels are placed to fatten and to be protected till they are wanted. These mussel preserves are areas of about 10 yards square and one foot in depth, and the floor is of firm mud. Probably these enclosures are of considerable use in protecting the large

clusters of fine mussels from the sea, which rolls in at this point between the Islands of Oléron and Ré.

Another minor industry at Le Chapus is the "Pèlerin" gathering, which is carried on by girls (Pl. II, fig. 6). They go out on the shore at low tide attired in flannel knickerbockers and armed with a long narrow knife or spike of iron with which they scrape round the edges of the oyster parcs and in the mud between the stones. The mollusc they are in search of is *Tapes decussata*, and they seem to be able to rake it out in considerable quantities. It is a favourite article of food in the neighbourhood and I constantly met with it under the head of "coquillage" in the déjeûner menus at the hotels along this part of the coast.

The basins of dégorgement at Le Chapus are placed high up on the beach. They are shallow tanks of considerable size, regularly built and with smooth, bricked, or tiled floors so that they can be kept perfectly clean and free from mud. They can be filled at high tide or emptied, as required. Their purpose is as follows:—It is found that oysters taken fresh from the parcs or claires have a good deal of fine mud and food-matter of a decomposable nature clinging to them both externally and internally, and they also naturally have the alimentary canal filled with a collection of partially digested diatoms along with some mud and other matters. Now if such oysters are packed up in this condition and sent off on a journey there is considerable chance of some of these organic matters or the more or less impure mud going bad and causing mischief; and so the oyster-growers have discovered that it is a great advantage to place the oysters for a week or so before their journey in clean water in order that all traces of dirty mud and excrete matters may be got rid of from the intestine, etc. (See Pl. II, fig. 3.).

These basins of dégorgement are also sometimes used for the purpose of educating the oyster in view of the prospective journey and subsequent sojourn in the market or the fishmonger's shop. By emptying the basins periodically, and so accustoming the oysters gradually to stand exposure to air, they are taught to close their shells very accurately when taken out of the sea so as to be able to hold in the supply of water which lies around the gills, and upon which the animal is dependent for respiratory purposes. I am of opinion that the use of basins of dégorgement is a most important and necessary sanitary addition to successful oyster culture.

It may be added that the men at Pointe le Chapus are of the same opinion as the Arcachon parqueurs viz., that the abundant deposit of spat this year is due to the hot summer.

Ile d'Oléron.

From Pointe le Chapus I crossed to Le Château on the island of Oléron where there are enormous mud flats extending a long way into the straits of Maumusson. There are numerous oyster parcs over these mud flats and extending all along the east and north sides of the island. The parqueurs buy very small oysters from Arcachon and lay them down to grow and fatten. After 18 months or 2 years they sell them again at a considerable profit. At low tides—especially at spring tides—the parcs are very carefully worked over in order to ensure that the growing oysters are under favourable conditions and are not suffering from their enemies.

In addition to this rearing of young Arcachon (or "flat") oysters, which they say at Oleron is a most successful and profitable industry, there has been a very considerable cultivation, especially during the last year or

two, of the "Portuguese" oyster, *Ostrea angulata*. This they commence at the very beginning by placing in their parcs large quantities of plain tiles kept in place by stones. After the first summer these tiles are found to be covered with spat which has been produced from "natural," (*i.e.* not cultivated) Portuguese oysters in the neighbouring sea. The tiles are brought ashore in small flat boats and the young oysters are separated and then laid down again in the parcs, where I am told they grow very rapidly so that at the end of a year they are very much larger than those at Arcachon of the same age.

At Le Château I met Mons. Charles Laray, Courtier maritime, to whom I am indebted for some information in regard to the fisheries of the neighbourhood. M. Laray told me that there are now 10,000 people who make their living by oyster culture on this part of Oléron. The Portuguese oysters are found growing naturally over the rocks and anything else they can adhere to at several places in the neighbourhood such as the mouth of the river at Rochefort, and at Port des Barques, Fouras, &c. These are frequently gathered by the people while still small and transferred to the parcs. Flat oysters (*O. edulis*) were to be obtained in a similar manner round the coast twenty years ago, but now they say they are never seen.

Mussels used also to be cultivated at Oléron, but they have become scarce, and do not seem to have been doing well during the last couple of years. This the men attribute to the hot seasons which they say are not favourable to mussel culture. Other shell fish (*Tapes*) are scraped up on the beach and brought into the market, but only in small quantities.

The whole island of Oléron is very flat and the sea is taken for miles inland by means of canals so as to fill the claires and salt pans which one comes upon in driving

through the interior. I visited St. Pierre near the west side and then Boyardville on the north, and was much struck by the admirable way in which by this system of artificial irrigation great tracts of what would otherwise probably be waste swampy land are made good use of. Some of such claires, canals and salt pans are shown in Pl. III, fig. 3. I found the canal at Boyardville on July 7th to be 70°F. with a specific gravity of 1·023; while on the same day at 11 a.m. and in the open sea, half way between the islands of Oléron and Ré, the temperature was 72°F. and the specific gravity 1·025. On that same day the temperature of the sea at Port Erin in the Isle of Man was 60° F., at 10 a.m., and the following day at 3 p.m. it was 68°F., the highest temperature we have registered in the open sea at Port Erin this summer—the shore pools often become considerably warmer, *e.g.*, 76°F.

La Rochelle.

The shores in the neighbourhood of Rochelle are in part limestone, in some places very much broken up so as to be merely masses of separate stones, and in part a fine mud. On the rocks and stones are many small "natural" oysters which are collected by the people at low tide. Those I tasted were of poor quality and saltish in flavour.

I found the temperature of the sea near Rochelle to be 82° F., the highest temperature I met with except on the parcs at Arcachon. In the fish market at Rochelle I saw very small immature soles and plaice exposed for sale in quantities; also mussels which were small, from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in length, but very good; and also cuttlefishes and various kinds of crabs.

I had intended going next to the Island of Ré, but heard at Rochelle that it would scarcely be worth while, so I decided to visit the mussel bouchots in the Bay of Aiguillon.

Bay of Aiguillon.

This large shallow bay with flat muddy shores miles of which are exposed at low tide has become celebrated through the peculiar method of mussel cultivation there carried on. The bouchot system owes its origin to the wreck in 1035 of an Irish barque loaded with sheep upon the rocks near the village of Esnandes.* The only man rescued was the captain, named Walton, who having saved some of the sheep from the wreck crossed them with the animals of the country and produced a fine race, the marsh sheep, which is still held in high estimation. Walton also devised a kind of net the "allouret" which he stretched on poles above the level of the sea to catch the flocks of birds which fly across the surface of the bay after dark. In order to carry the net far out over the mud he had to drive in many poles, and he soon found that these became covered with mussel spat, and that the shellfish grown in this way in the open water above the mud were of superior quality. This led to the construction of the first artificial mussel plantation or set of bouchots.

Walton also invented the "pousse pied" or "acon" the characteristic boat of the boucholeurs still in constant use for traversing the soft mud—I had a trip in one last July. The "acon" is composed of a plank forming the bottom and bent up in front to make a flat prow (Pl. III, fig. 1.) The sides and stern are each formed of one piece of wood, sometimes the sides are of two planks each. The size is 9 or 10 ft. in length, from 2 ft. to 2 ft. 6 in. wide and about 1 ft. 6 in. deep. There is a shelf at the stern, a narrow thwart close to the bow, and a small wooden stool in the middle of the floor—these with a wooden paddle and a short pole complete the equipment. The boatman in using

* For this historical fact I am indebted to Quatrefages' "Souvenirs d'un Naturaliste," Paris, 1854.

the acon faces the bow, grasps the sides about the middle firmly with both hands, rests his left knee on the floor of the boat, and putting his right leg (encased in a long sea boot) over the side he plunges it into the mud and pushes the boat onward. He is able to propel it at a great rate over the soft mud, and when he gets to a channel of water where the acon floats he works with paddle or pole until he again reaches mud and is able to use his foot.

There is also a larger kind of boat in use. It is known simply as "bateau plat" and is used to transport large quantities of mussels. (See Pl. III, fig. 1.).

Originally the bouchots formed V shaped figures; but now the poles, which are trunks of small trees about 12 ft. long and 6 or 9 inches in diameter, are placed about 2 ft. apart in parallel rows at right angles to the shore and are driven for several feet into the mud. The rows are about 30 yards apart, and each has several hundred posts.

The bouchots have been increased greatly since the time of Walton, and now extend for miles along the coast, chiefly in the neighbourhood of the villages of Esnandes, Charron, and Marsilly. It was Charron that I visited. The rows of stakes or poles are placed now in at least five zones of which the outermost or furthest from land (it may be 3 miles or so from highwater mark) is called 'bouchots d' aval," the next is "bouchots batisse," the next "bouchots du bas" then "bouchots batards" and finally the row nearest the land is "bouchots d' amont" but each of these named kinds may really include several sets of bouchots. Each of these sets is composed of the above mentioned long lines of posts driven into the mud, in some cases—the bouchot d'aval—plain and in other cases interlaced with flexible branches and twigs placed a few inches apart and known as "clayonnage." There is a space at the bottom of the poles free from clayonnage

so that mud can wash through. The seaward rows of bouchots are for the young mussel spat to attach itself to and these alone have no clayonnage, while those further up the shore are for the purpose of growing and fattening the shell-fish on.

The spatting time there is in early spring and by the end of May the young mussel is the size of a lentil (say $\frac{3}{16}$ inch in length). In July it is about $\frac{3}{4}$ of an inch in length, and is then ready to be transplanted to the bouchots further up. They are thus gradually moved up the shore as the bouchots require to be thinned, and this process educates them to bear prolonged exposure to air. The bunches of young mussels are detached and are wrapped up in a piece of old net and then stuffed into the clayonnage of the bouchots d'amonts where they may remain for a year until about $1\frac{1}{2}$ inches long when they are considered ready for market. Before the netting has rotted away the mussels have managed to attach themselves by their byssus threads to the neighbouring branches or to one another.

I saw no very large mussels, the finest I saw averaged from 2 to $2\frac{1}{4}$ inches in length and were in bunches of 6 to 12, but they certainly seemed to be very abundant. The bouchots looked black with them, and the boucholeurs declared that it was an excellent summer for their industry.

The weather was unfortunately so dull that I was unable to take any satisfactory photographs at Charron. The temperature of the water I found to be 73°F. The water was exceedingly muddy, and the mud as exposed at low tide was so extremely soft that one sank into it at once and it was impossible to traverse it in any way except by means of an acon. I collected samples of mud from various parts of the shore and from the mussels themselves and these I have now carefully examined. The mud is a very yellow mud, and is extremely smooth and unctuous

to the feel. Under the microscope it seems to be composed of very finely divided particles along with the remains of many animals and microscopic plants amongst which I find Diatoms, especially *Navicula* and *Coscinodiscus*, Foraminifera, and sponge spicules.

The Sevres Niortoise and other smaller streams which flow into the bay of Aiguillon keep the water partly fresh and this is said to be highly favourable for mussel culture. The boucholeurs at Charron told me that the industry was a thorough success, and what I saw led me to the same conclusion. The mussels though not large seemed very abundant. I saw large quantities gathered from the bouchots and ready to be sent away to market. There are also a few systems of bouchots to the south of La Rochelle, at Châtelaillon, but not many; while mussels are grown on the bed system on various parts of the French coast. Many people say in France that the mussels grown on the bouchots are better than those from the beds. It may be so, but although I have tasted both I cannot be sure of it. There can be no doubt that the chief reason of the extensive cultivation by means of bouchots in the Bay of Aiguillon is simply that no other plan would succeed there. The mud is so very soft and so constantly forming that mussel beds could not be established—anything placed on the bottom is very soon smothered in mud. Consequently I am inclined to think that where mussels can be grown successfully in beds it is best to adhere to that mode of culture; while on the other hand in some of our muddy estuaries it might be worth while to try bouchots.

The Scottish Fishery Board have been trying some experiments lately with bouchots at St. Andrews, without it seems much success. For one thing, it costs more both for the first establishment and also for subsequent labour

in Scotland than in France. Then it is said that our colder seas do not favour so abundant a deposit of spat, and do not yield such abundant nourishment to the growing mussels as do those of the south. This I think has still to be proved. The spat deposited on some of our beds and other parts of the shore in our own district and on any submarine objects in any way resembling bouchots, such as pieces of wreckage, stakes, piers, stems of large seaweeds, &c., is most abundant, indicating that there is no want of the free-swimming embryos prepared to settle down upon any suitable foundation; and in regard to the nourishment of the adult it seems to me that our mussels are quite as large and well formed in every way as those I saw in France. I therefore see no reason from the biological point of view why the bouchot system of mussel culture should not be a success in our district, but it is quite possible that it might not be worth while, financially, to start it except in places where from local conditions it is impossible or difficult to grow the mussels in beds.

Les Sables d'Olonne.

Les Sables is a favourite seaside resort, and centre of oyster culture, situated close to Pointe de l'Aiguille about halfway between the mouth of the Gironde and that of the Loire. It is in an exposed situation, but behind the harbour there is a large artificial lake which reminds one of the basin at Arcachon, although it is of course much smaller (about 160 acres), and has well-built sloping walls round its edge. A considerable part of this area of shallow sea-water is devoted to oyster culture, and is divided off into parcs, which however are only for élevage, the young oysters being brought from Arcachon or Auray in Brittany. The bottom of the parcs is rather

firm muddy sand, and I found the temperature of the water to be 74° F., and the specific gravity 1·025.

The water is admitted from the sea by great sluice gates, and there seems an abundance of vegetation and food matters in the parcs. The oysters are laid down in July or so, and remain till the following March or April, when they are ready for market, but may be kept longer till required. They are all "huitres blanches" as no "greening" appears to take place in these enclosures, which by the way are not called claires here but parcs d' élevage. It is said that the growth of the oysters in this lake at Les Sables is very rapid. In the low-lying ground round the lake there are ponds dug out, very like the claires at La Tremblade and Marennes, in which the oysters may be put for a few weeks to be specially fattened up and flavoured. Salt is also made by evaporation in these or similar shallow pits.

Les Sables is a centre for the sardine fishing and has a large fleet of boats, and also factories and warehouses for the tinning of the sardines. On the actual seashore north of the town the beach is marked off into rude stone enclosures used as fishing weirs; set lines are also used on the shore and prawning is carried on. Fixed engines, as at Royan, for shrimping are in use both from the breakwater and also from small boats. In the market, in addition to the usual common fish, oysters, mussels, *Tapes decussata*, and two or three different species of crabs were exposed for sale.

Le Croisic.

This ancient little fishing town is in the south of Brittany close to the projecting point which forms the northern extremity of the estuary of the Loire. It is conveniently reached from Nantes by St. Nazaire. As in

the case of Arcachon and of Les Sables d' Olonne there is a sheltered inland sea, with a narrow entrance through which the tide runs in and out with a considerable current. The temperature of this water I found to be 66°F., and the specific gravity 1·025 to 1·026, practically that of the open sea. In this area there are oyster parcs for élevage. No production of spat takes place here, the young oysters being mostly obtained from Auray, a little to the north, when about two years old and 5 or 6 cm. in diameter. The parcs contain abundant vegetation, the same green algæ being apparently present as those I found at Marennes, and similar "green" oysters are produced in some of the parcs, although they are perhaps not so well known as those from the estuary of the Seudre.

I examined the parcs at Croisic at low tide, and photographed one set of 12 quadrangular areas, each about 30 yards by 15 yards, separated from one another by a double row of stakes supporting planks, the space between these palings—about 2 yards across—being filled in with mud and gravel. The stakes are placed about a yard apart. The parc contains about 2 feet of water and there is a sluice at one end of each enclosure. The walls between adjacent parcs are of this great thickness (2 yards) because there is no stiff clay here like that which makes such excellent enclosures at Arcachon. Ambulances with wire net lids, like those at Arcachon, are also in use here for the very small oysters. There are also great salt and oyster-rearing excavations near to at Le Poulignen, and also between Le Croisic and Le Bourg-de-Batz as shown in the accompanying sketch-plan (Pl. III, fig. 3). The more irregular areas shown in the left foreground and in the distance on each side of the watcher's house are oyster parcs, while the very regular areas in the centre are for the manufacture of salt. Mussels are also cultivated here both in beds and

in special reservoirs in which they are placed for a time before being sold—one cultivator sends 150,000 kilogrammes annually to market.

Le Croisic is also a centre for the Sardine fishery and for the capture of lobsters and "langousts" (*Palinurus vulgaris*), but it is of still greater interest because of the remarkable method there pursued with great success of catching shrimps in traps. It was chiefly to see these shrimp traps and to hear about their use that I had gone to Croisic. The trap ("casier") is a barrel-shaped structure about 3 feet long and formed of spars of wood covered with fine meshed netting and thickly tarred all over (Pl. III, fig. 2). It has a bottom plank projecting for a few inches at each end so as to form shelves upon which stones are tied to weight the apparatus. On one side there is a little wooden door, tied with string, through which the hand can be introduced to clear out the contents. At the ends are the usual funnel-shaped entrances like those of lobster pots.

Le Croisic, apart from the inland sea, is open and exposed to the Atlantic and there are no special conditions so far as I can see that are favourable to the use of the shrimp trap. The shrimpers are 60 to 70 smallish, open, one-masted boats, and each takes out 20, 25 or 30 traps. The traps are set in the open sea and are used chiefly in winter. These boats do not use the traps alone, but also fish at the same time with a small fish trawl. They go to sea and set the traps, which they leave down all night, then they go trawling and pick up the traps on the way back in the morning. I gathered from conversation with some of the men that the traps are sometimes rather uncertain in their results, on some nights catching great numbers of shrimps and on others very few. One man told me that he did not feel sure that the traps were better than a shrimp trawl would be for catching shrimps, but that the

use of the traps saved time and labour as it allowed them to use the fish trawl at the same time. Another fisherman, however, assured me that he preferred the traps to a shrimp trawl, that they gave much better results. They say that it is not very much use setting the traps in summer as they only catch very small shrimps then. The best time of the year they say is in January and February. None of the boats were using the traps at the time I was there (middle of July). The value of the shrimps caught varies from 30,000 to 60,000 francs annually.

Another object of fishery interest I saw at Croisic was the "vivier" which they are in the habit of making out of their old fishing boats. They make certain slits in the sides between the planks, put on a deck of sparwork, and several partitions in the interior so as to divide it up into about four compartments through which the water flows readily, and in these aquaria they keep their stock of lobsters and "langousts." The "viviers" float deep in the water, and are to be seen moored in various parts of the entrance to the harbour and inland sea.

General Conclusions.

There is no doubt that there are great and flourishing shellfish industries along the west coast of France; and one thing that struck me very forcibly was the admirable manner in which the people seem to make the best of unfavourable conditions and to take advantage of every opportunity given to them by nature. Few places on any coast, I fancy, could look more desolate, hopeless and forbidding than the vast mud swamps of the Bay of Aiguillon, and yet by means of the bouchot system many square miles of this useless ground have been brought

under cultivation, and an industry established which supports several prosperous villages.

It seemed to me, moreover, that the fishing populations knew more about the products of their coasts and made more use of them, took a more lively interest in the welfare and habits of the animals—not only those which are the direct objects of the fisheries, but also others which have an indirect influence through being the natural food or enemies of the former—and devoted themselves with a more constant industry, and even a loving care, to the cultivation of their shores than is generally found to be the case amongst corresponding classes in this country. The neat little enclosures along the beach, carefully tended at low tides, remind one constantly of market gardening, and enforce the truth of the idea long familiar to the biologist and now beginning to be generally recognised that the fisherman should be the farmer not the mere hunter of his fish and that aqui-culture must be carried on as industriously and scientifically as agriculture.

Another noteworthy point in regard to French fish-culture is the great extent to which the women seem to help and work along with the men. At Arcachon and several other places there seem to be as many women as men employed in the parcs, and they struck me as taking an intelligent interest and pride in their work.

In addition to these personal qualities in the fisher folk the success of the shellfish industries in France is, I think, largely due to the encouragement and wise assistance of Government, especially in the regulation of general oyster dredging and the reservation of certain grounds for supplying seed.

I do not see that the French shores are in any important respects better fitted for shellfish cultivation than ours are; the variety in geological formation is on the whole much

the same, the fauna both macroscopic and microscopic is not appreciably richer, and although the temperature of the water is certainly higher in the south, probably on the average about 10°F. higher, still I do not think that that is essential, and it may even be considered doubtful whether it is much advantage. The opinions of the practical men I met in France differed on this point. Mons. Dasté at Arcachon was convinced that considerable heat was absolutely necessary for the successful breeding of oysters, and that the greater the heat the better the deposit of spat. It is not unnatural for the successful breeder of oysters to be influenced—perhaps unconsciously—by the desire to keep that branch of the industry as much as possible in his own hands, and to think that the conditions found in his district are essential, and that all that should be attempted elsewhere is to rear the oysters he has produced. In opposition to that opinion we have the facts that Capt. Dannevig has had oyster spat produced in abundance in his pond at Arendal in Norway, and that both on the north coast of France and the south coast of England oysters reproduce and spat is deposited.

Lately Prof.H. de Lacaze-Duthiers has proved that even under artificial conditions in the aquarium of the Zoological Station at Roscoff on the North Coast of Brittany, he can bring seed oysters to a high state of development and commercial value, and that the oysters will reproduce in the aquarium, spat be deposited, and the young oysters be readily reared up until they are fit for the market—the entire life-history having been passed through in confinement. I consider that this is an important observation as there can be no doubt that under natural or semi-natural conditions a very large proportion of the free-swimming embryos are carried away by tides or currents and either destroyed or lost to the cultivator.

M. Dasté and others however are all agreed that we might do a great deal more in this country than we now do in the way of rearing up young oysters and fattening them for the market. Dasté has visited the west coast of Scotland and he mentioned to me Campbeltown and Aros in the sound of Mull (a locality I know well) as being places that had struck him as being well suited for oyster culture. I have no doubt there are parts of our own district which are equally favourable. It is of importance if the oysters are kept in shallow water, that the temperature in winter should not be too low, and that is a point upon which I feel we require further information in regard to the various parts of our district.

As to the other conditions, a gravelly mud bottom sufficiently firm to bear up the weight of the shell so that the exceedingly delicate respiratory organs of the animal should not be injured by much mud being carried in by the water currents, possibly a certain admixture of fresh water, and *abundance of good food* are what seem most favourable to oyster growth. The food must be microscopic, and about 90% of it is usually Diatoms—so these lowly plants are the most important things to look for in estimating the oyster rearing capacity of a particular region.

Finally in regard to Mussels there seems to be a difference of opinion as to whether a hot season is favourable or the reverse. I was distinctly given to understand at Oléron that heat was not good for them, and that they were disappearing because of the hot summers, but on the other hand there is the positive fact which I came across at Arcachon that the uncultivated and unwished for mussels are increasing in numbers over the oyster parcs, where the temperature of the water is the highest I met with.

I have already given my conclusions in regard to the

bouchot system of mussel culture fully at the end of the section on the Bay of Aiguillon (p. 70). Expressed briefly, my opinion is that where mussels are now grown successfully on the bed system the best we can do is to farm these beds carefully, and it would be useless to erect bouchots, except perhaps on the seaward side for the purpose of collecting more spat; but in places where from local conditions beds cannot be formed and where we know that there are plenty of embryonic mussels in the water, as evidenced by the quantities of young mussels that settle down on any post, drain pipe, or other occasional submerged object, it is highly probable that a system of bouchots would attract abundance of spat, and there is no reason to think that the mussels could not be reared as successfully on bouchots here as they are in France. I would recommend then, that in some such spot in one of our estuaries a set of bouchots should be established on a small scale. Such an experiment is obviously the only way of settling definitely whether or not the French method would be a practical success on the Lancashire coasts.

I need scarcely say that I have made no attempt to abbreviate this lengthy report, as I feel that it is most important in a practical question of this nature that every fact and every opinion which is at all likely to be of value should be fully stated and carefully considered. I may say now in conclusion, as Professor Huxley said in his Royal Institution lecture in 1883, "I for my part believe that the only hope for the oyster consumer lies first in oyster culture, and secondly in discovering a means of breeding oysters under such conditions that the spat shall be safely deposited. And I have no doubt that when those who undertake the business are provided with a proper knowledge of the conditions under which they have to work both these objects will be attained."

Explanation of Plates.

Plate I.

Fig. 1. Oyster parc at Arcachon showing enclosures, pignons, and row of collectors.

Fig. 2. A collector ("Gabaret") showing arrangement of tiles.

Fig. 3. Shows a tile on which oyster spat has just been deposited.

Fig. 4. Part of an oyster parc showing rows of "ambulances."

Fig. 5. An "ambulance" opened.

Fig. 6. Corner of a parc showing sluice, construction of banks, and a ponton in the distance.

Plate II.

Fig. 1. Part of a tile showing young oysters ready to be removed.

Fig. 2. Primitive oyster parcs on shore at Pointe le Chapus.

Fig. 3. Basins of dégorgement at Pointe le Chapus.

Fig. 4. Oyster claires near Marennes.

Fig. 5. *Navicula fusiformis*, var. *ostrearia*, and allied forms, on which the oyster feeds.

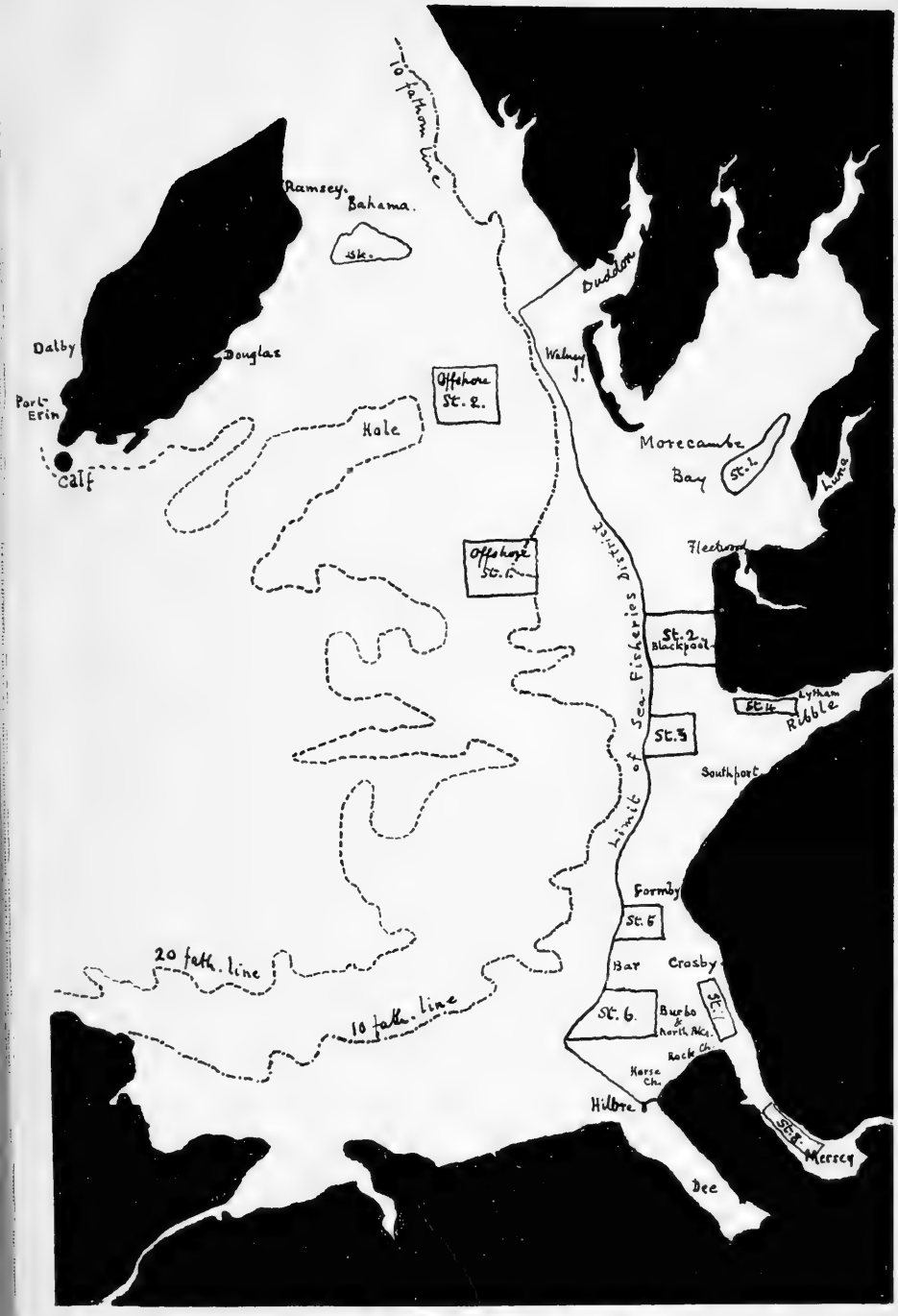
Fig. 6. Shellfish enclosures at Pointe le Chapus, with girls collecting "pèlerins."

Plate III.

Fig. 1. Sketch near Charron, Bay of Aiguillon, showing bouchots, acons, &c.

Fig. 2. The shrimp traps ("casiers") at Le Croisic.

Fig. 3. Oyster parcs and marais salants between Le Croisic and Le Bourg-de-Batz.


10 fathom line
Ramsey.
Bahama.
Isle
Dalby
Douglas
Port Erin
Calf
Hale
Offshore St. 2.
Offshore St. 1.
Duddon
Walney I.
Morecambe Bay
St. 1
Lune
Fleetwood
St. 2 Blackpool
St. 4
Lytham
Ribble
St. 3
Southport
Limit of Sea-Fisheries District
Formby
St. 5
Bar
Crosby
St. 6.
Burbo & North Rks.
Rock Ch.
Horse Ch.
Hilbre I.
St. 7
Mersey
Dee
20 fath. line
10 fath. line

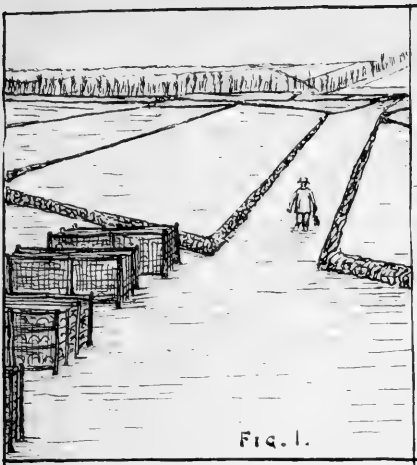


Fig. 1.

Fig. 2.

Fig. 3.

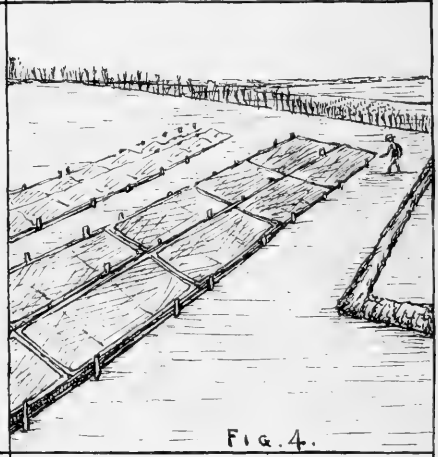
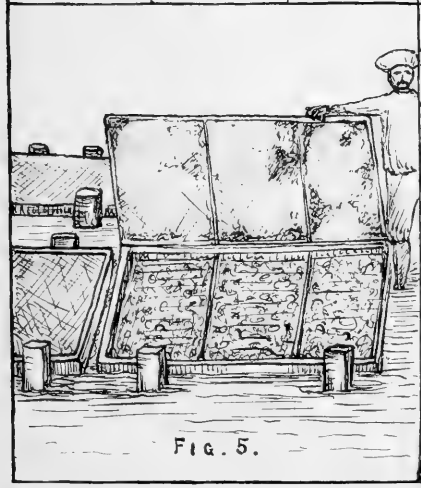


Fig. 4.



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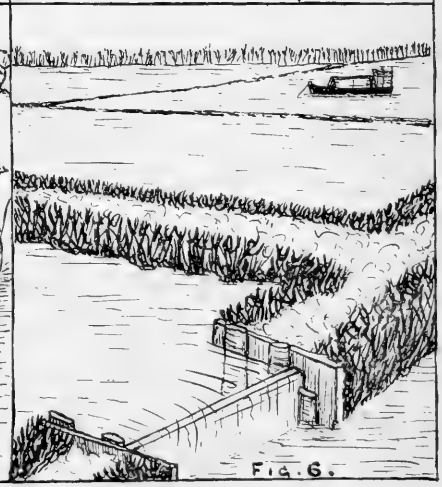

Fig. 6.

W.A.H., del.

SHELL-FISH CULTURE IN FRANCE.

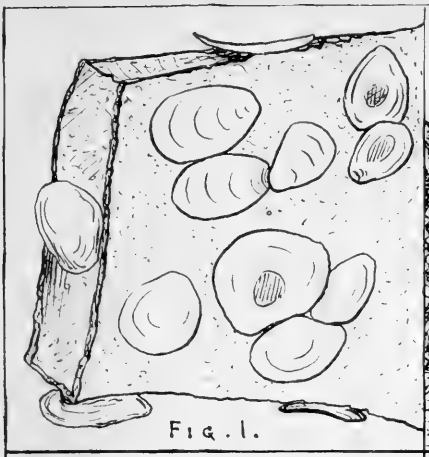

Fig. 1.

Fig. 2.

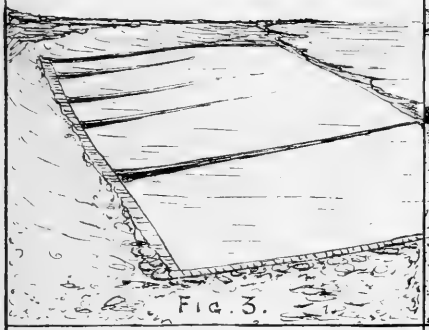

Fig. 3.

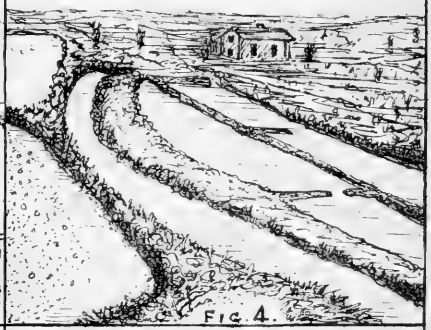

Fig. 4.

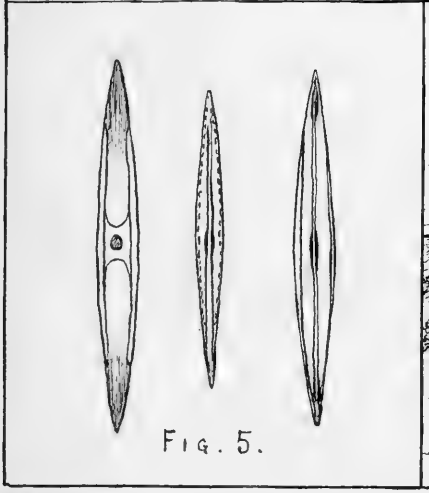

Fig. 5.

Fig. 6.

W.A.H., del.

SHELL-FISH CULTURE IN FRANCE.

FIG. 1.

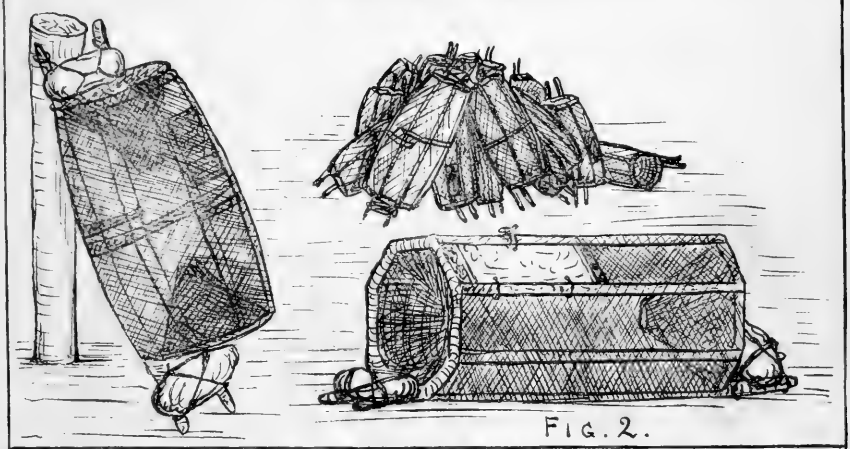

FIG. 2.

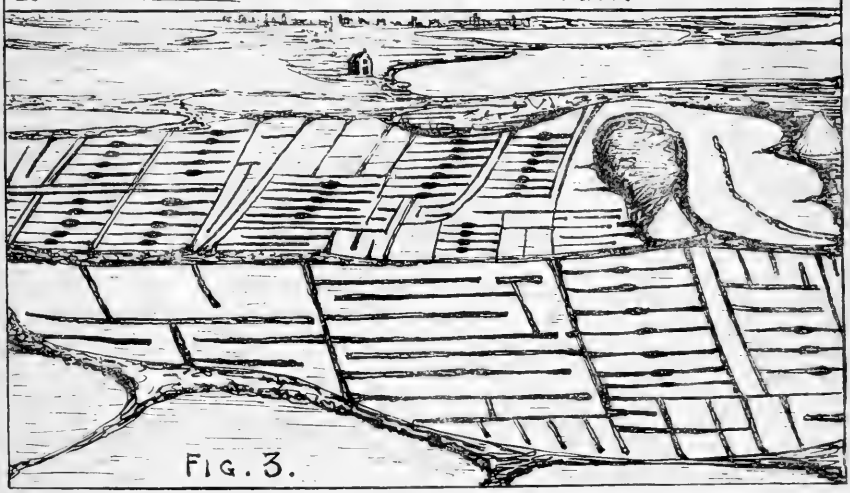

FIG. 3.

W.A.H., del.

SHELL-FISH CULTURE IN FRANCE.