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No. XIV.

REPORT FOR 1905,

ON THE

LANCASHIRE SEA-FISHERIES LABORATORY

AT

THE UNIVERSITY OF LIVERPOOL,

AND THE

SEA-FISH HATCHERY AT PIEL.

DRAWN UP BY

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

Hon. Director of the Scientific Work,

Assisted by Mr. Andrew Scott, A.L.S., and

Mr. James Johnstone, B.Sc.

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With Compliments from

Prof. W. A. HERDMAN,

UNIVERSITY,

LIVERPOOL.

John Van Vorsten
2547

REPORT on the INVESTIGATIONS carried on during 1905 in connection with the LANCASHIRE SEA-FISHERIES LABORATORY at the University of Liverpool, and the SEA-FISH HATCHERY at Piel, near Barrow.

Drawn up by Professor W. A. HERDMAN, F.R.S., Honorary Director of the Scientific Work; assisted by Mr. ANDREW SCOTT, A.L.S., Resident Fisheries Assistant at Piel; and Mr. JAMES JOHNSTONE, B.Sc., Fisheries Assistant at the Liverpool Laboratory.

(With plates, charts and figures in the text.)

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INTRODUCTION AND GENERAL ACCOUNT OF THE WORK.

THIS Record of 1905 naturally starts with three events of considerable importance in connection with scientific sea-fisheries work in the Irish Sea. These are:—

1st. A renewal of the agreement between the Lancashire and Western Sea-Fisheries Joint Committee and the University of Liverpool confirming the appointment of the Professor of Zoology as honorary head of the scientific work, and giving an improved status and tenure to the two scientific assistants.

2nd. The completion and formal inauguration of the new Laboratories of Zoology at the University, which provide greatly increased accommodation and facilities for both laboratory investigation and museum work on the fisheries of the district.

3rd. The recognition of these laboratories by the Board of Agriculture and Fisheries, and the award of a grant to the University, towards expenses, on account of the scientific fisheries work carried on in the department.

The new laboratories were opened on November 18th, 1905, by the Right Hon. the Earl of Onslow, formerly President of the Board of Agriculture and Fisheries—"the first Minister for Fisheries" this country has had—in the presence of a large gathering of Zoologists and Fisheries Authorities, including Mr. James Fletcher, Chairman of our Local Joint Committee, Mr. J. R. Ragdale, Chairman of the Scientific Sub-Committee, and other representative men; and amongst those who gave addresses on the occasion were Sir Thomas Elliott, K.C.B., Permanent Secretary of the Board of Agriculture and Fisheries, and Sir John Murray, K.C.B., the eminent Oceanographer.

In the accompanying fig. 1, showing the front elevation of the building, the arrows at the side point to the windows of the floor devoted to the Fisheries Laboratories, and the plan (fig. 2) shows the accommodation—three rooms, one large and two smaller, in addition to the Fisheries Museum. One of the smaller rooms is at present devoted to bacteriological work, the other is Mr. Johnstone's laboratory, and the larger room will accommodate two additional investigators.

As a result of conversation and correspondence with the Chairman of the Joint Committee and the Chairman of the Scientific Sub-Committee, I have been led to make the suggestion that it would be to the advantage and convenience of the members of the Scientific Sub-Committee that they should be brought into more intimate and more constant relation with the details of the work carried on in the Fisheries Laboratory by having periodic

Fig. 1.—New Zoological Department, University of Liverpool.

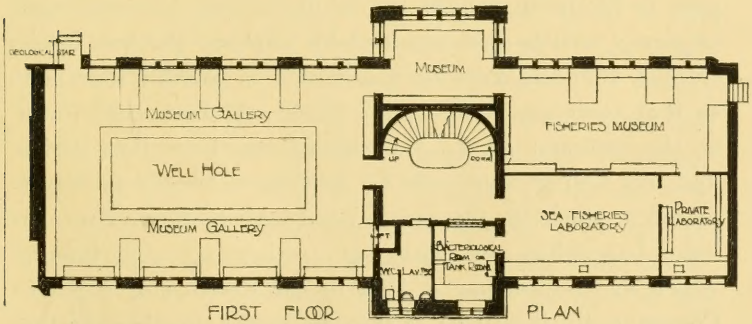


Fig. 2.—Sea Fisheries Laboratories and Museum.

Reports printed and submitted at the quarterly meetings of the Sub-Committee. This suggestion has been approved, and the remainder of this Introduction, summarising as it does the work carried on during the past year, will serve as the first quarterly report to be submitted at the February meeting. Succeeding Reports will deal naturally with the quarters to which they refer, and each will bring the account of the work up to the end of the month preceding that in which the meeting is held.

Sea Fish Hatching.

Mr. Scott's operations at Piel have resulted in very much the same measure of success as in the previous two years—we cannot expect any marked increase upon these numbers or any extension in the work with the present accommodation at the hatchery. The tanks will not hold more fish than the number now dealt with.

Although Port Erin is not in the L. and W. District, it is impossible in thinking of broad results to discriminate between the young fish set free in Lancashire waters and those set free round the Isle of Man. The Irish Sea is one natural sea-fisheries area, and whatever benefits one part is likely to benefit the whole. True economy and efficiency will be best attained by working the two institutions, Piel and Port Erin, as much as possible together, so that each supplements the other and both contribute to the common good. Lancashire can help Port Erin, and has helped this year by getting a supply of adult plaice to stock the spawning pond; while Port Erin can help Lancashire by carrying on rearing experiments which are impossible at Piel in the absence of a pond. Consequently it will be of interest to the members of the Lancashire and Western Committee to know that over

five millions of young plaice were hatched in 1905 at Port Erin, and were set free in the sea round the south end of the Isle of Man. It is important also to note that large numbers of fry from the previous year's operations which were left to develop in the pond passed through their metamorphosis and grew rapidly, being found of various sizes from one to five inches in length during their first year of life. The largest of these young plaice, spawned, hatched and reared in captivity, which we have taken from our pond, measured over six inches.

Marked-Fish Experiments.

This work was commenced by Mr. Johnstone last year, and has been carried on further with the co-operation of Dr. Travis Jenkins on the steamer. The essence of the experiment is that certain picked living fish are marked with distinctive numbers in the manner described further on by Mr. Johnstone, and are set free at localities duly noted—those of such fish which are subsequently captured being returned, with particulars, to our laboratory for observation and record. The object of the experiment is three-fold. The results may be expected to give us information:—1st as to the growth of the fish, 2nd as to the migrations of the fish, and 3rd as to the numerical proportion of the fish caught, and consequently as to the intensity of the fishing in our seas. The results are rather startling. For the details Mr. Johnstone's full account given below should be read, but the following may be taken as a summary of the matter:—In the case of the Lancashire stations about 50 per cent. of the marked fish have been re-captured—which may be an indication that the fishing is so intense that half of the available fish are captured in the year. Whether this is "over-fishing" it is impossible at present to say, but the

numbers certainly suggest that we may be getting dangerously near to the local extinction of the species. Of course in other parts of the district where the fishing is not so intense the proportion of the marked fish re-captured is not nearly so high. It is interesting to note that in the similar experiments carried on off the East coast of England during the International investigation of the North Sea 40 per cent. of the marked small fish transplanted from inshore to the Dogger Bank were recovered in the same neighbourhood. The total percentage of the marked fish recovered in the North Sea from all parts of the area was 19 per cent. per annum. In our experiments in the Irish sea the total over the whole area was 23·25 per cent., but in a number of the experiments a full year has not yet elapsed.

The evidence so far tends to show that the plaice grows about 3 inches in the year, during the summer (May to September), and that a fish 8 inches long in April and weighing $\frac{1}{4}$ lb. will by September be 11 inches long and will have doubled or trebled its weight with a corresponding increase in value—a strong argument for the protection of undersized fish.

Important information as to the migrations of the fish throughout the district seems forthcoming, but observations during another year at least are desirable before we draw conclusions. In winter they travel into the sheltered estuaries and bays, and chiefly in a northerly direction. In the summer they move offshore into deeper water, and chiefly in a southerly direction. The cost of these experiments is comparatively slight, and the information gained is most valuable—I have no hesitation in recommending to the Committee that the work be continued during 1906 on the same lines as in 1905.

Scheme of Scientific Work.

At the quarterly meeting of the Scientific Sub-Committee held at Preston on November 8th, 1905, I submitted a scheme of scientific work in progress and contemplated. The headings of this scheme (as drawn up in November) were as follows:—

"1.—Distribution of Fish Eggs.

"This has been attentively studied during the present year, and from one to two hundred bottles of plankton have been examined. In regard to future work, tow-nettings should be taken by the steamer as formerly, and surface and bottom gatherings made every time the net is hauled. Bottom tow-nettings need not be made at (1) Blackpool Closed Ground, (2) near Nelson Buoy, (3) off the River Mersey. Tow-nettings should be sent regularly by the bailiffs in the Western District. One should be taken every fortnight by the bailiffs at Carnarvon, Pwllheli, and New Quay.* So also with the bailiffs at New Brighton and Fleetwood. Hensen net collections should be made by the steamer, beginning early in January, and continued as often as is practicable.

"2.—Fish Foods.

"The food of the plaice, dab, and sole have been studied during the present year from the point of view of the competition between fish on the same ground. A large number of observations have been made and recorded, and will be published in the next Report. This work should be continued. It is best done by a scientist on board the steamer, but when neither scientist is on board a parcel of fish containing half a dozen soles, dabs

* The investigation of the plankton of Cardigan Bay is most important from the point of view of immigration of species into our area, and it would be well to obtain as many tow-nettings as possible from these parts.

and plaice not less than 9 inches long, FROM THE SAME CATCH, should be sent every fortnight either to Piel or Liverpool as is most convenient. Uncommon Invertebrates should be preserved and sent to the Liverpool Laboratory for identification.

"3.—Examination of Shellfish Beds.

"The Morecambe mussel beds and the cockle beds near the Ribble Estuary should be examined at intervals. Other shellfish beds should be treated in a similar manner as time permits. The transplantation experiments should be continued, and samples of the transplanted shellfish should be sent to Liverpool as often as they are taken.

The usual bacteriological examinations will be made from time to time as the Committee requires the information. But if desirable any one bed can be systematically examined and reported upon. Several inspections have been made during the present year of the Morecambe mussel beds, and a bacteriological examination has already been made of the mussels at Llanfairfechan.

"4.—Fish-marking Experiments.-

"Nearly 1,000 fish will have been marked and liberated before the end of the present year. A considerable number have been returned—varying from 5 per cent. to 50 per cent. of those liberated according to the "Station." Tables and charts are being prepared shewing the results, and the whole matter will be discussed in Professor Herdman's forthcoming report. Mr. Johnstone proposes to give a preliminary account of the results of these experiments at the next meeting of the Scientific Sub-Committee. It is proposed, if the Committee agree, to carry on these experiments during the next year, with whatever modification the results of the past experiments may suggest. It is proposed to mark flounders as well as plaice.

"5.—Fish Parasites and Diseases.

"A large amount of work has been done by Mr. Johnstone on board the steamer on the above subject. It is proposed to carry this on, but a Report is being prepared. This is work which can best be done on board the steamer, but when a scientist is not on board parcels of fish might be sent to Liverpool or Piel. Inedible fishes are also desired. Large ray and skate should be examined, but this can obviously only be done on board the steamer.

"6.—Hydrographical Work.

"If it is proposed to provide the steamer with a hydrographic research equipment (water bottle for collecting samples of water from the bottom or from intermediate depths, thermometers, &c., at a cost of about £25), and the necessary equipment for analysis ashore, then the following scheme might be adopted:—

"A collection of water samples, with exact observations of the temperature of the water at the surface, bottom, or intermediate depths, should be made quarterly along the following lines:—

"1. Fleetwood to the Skerries:
"2. Bardsey Island to New Quay;
"3. Holyhead Harbour to Calf of Man;
"4. Mull of Galloway to Point of Ayre;
"5. Ramsey Bay to Fleetwood.

This would take one week every three months; and several of the lines might be combined with the periodical inspection of the Manx territorial waters.

"Samples of water would be examined for salinity ashore."

Some of these subjects require no further explanation as they have been before the Committee in the past, the marked fish experiment is discussed above, and the others are all in progress with the exception of the hydrographical work which has not yet been started.

Food of Fishes.

I desire now to draw attention to the observations on the food of Plaice as compared with that of Dabs caught at the same time on the same ground. It has often been said that Plaice and Dab compete for the same food, but this does not seem to be the case. Mr. Johnstone's observations, made on the steamer and in the laboratory, show that on the whole the adult Plaice feeds chiefly on Mollusca (*Scrobicularia*, *Solen*, *Mactra*, *Tellina* and *Nucula*), less frequently on Polychaeta (*Nereis*, *Pectinaria*, &c.) with an occasional Echinoderm or Amphipod; while the Dabs of much the same size feed for the most part on Ophiurids ("brittle stars") and Crustacea, especially small crabs and hermit crabs (*Pagurus*, *Carcinus*, *Porcellana*, *Portunus*, *Hyas*, *Corystes*, *Crangon*, &c.), with some Polychaete worms, occasional Mollusca and Zoophytes. The contrast is evidently between Molluscs as the main food of the Plaice and Ophiurids and Crustacea as that of the Dab. But the Dab is evidently a greedy and omnivorous feeder, and many kinds of invertebrates may be found together in its stomach.

Some years ago, in the 1st, 2nd, 3rd and 4th of these Fisheries Laboratory Reports (for 1892-3-4 and 5) we recorded a series of observations made on the food of various fishes, both small and large, which showed fairly similar results. In 1894, in the case of the Plaice, Mollusca were found in over 72 per cent. of the stomachs and Polychaeta in fully 22 per cent., so that these two food matters occupied together about 95 per cent., and the following year the same two groups, although reversed in order, occupied 96 per cent. of the stomachs. In the case of the Dab our former records give no such uniformity of result, and merely show that there is considerable variety

in the food of this fish. It is possibly its omnivorous habits that enable it to get on so well in the struggle for existence with other fishes.

The contents of the stomach of a cod caught off Blackpool in December last are interesting, viz.:

3 dabs 6 to 8 inches long,
7 other flat fishes (too much decomposed for identification),
3 herrings (or sprats) 3 to 5 inches long,
9 other round fishes (not herrings, very much decomposed),
13 shrimps,
and a large mass of semi-digested matter, chiefly composed of fish bones.

Other Minor Investigations.

Herring in Carnarvon and Cardigan Bays.

Several lots of herring sent by the bailiffs on the instructions of Dr. Jenkins were examined in the laboratory. About half of these fish were "spent" and the other half were "full" herrings. It is evident that the winter herrings spawn somewhere on the coasts of Wales, and close attention will be paid to the occurrence and condition of this fish during the next year.

Trawling Observations.

During the last year some interesting hauls with fish and shrimp trawls were made in Luce Bay, in the Scottish District; and in Fishguard Bay in the Milford Haven District. These hauls are quoted and discussed further on in this Annual Report. Large plaice were still abundant in Luce Bay in October and November, 1905. In Fishguard Bay we took a varied and abundant catch of fishes in the shrimp trawl.

Occurrence of Rare Fishes.

Several rare fishes have turned up during the last year. Two scarce rays, *Raia fullonica* and *Raia microcellata* were recorded for the first time (with certainty) from Carnarvon and Cardigan Bays; a sole, the sand sole (*Solea lascaris*), which does not often occur in our area, was taken also in Cardigan Bay. Finally several young specimens of *Dentex vulgaris*, a fish which has not been seen in the Irish Sea area before, and is a Mediterranean rather than an English species, was taken off Pwllheli last September. In many ways the occurrence of rare animals last year was somewhat remarkable, and is to be connected with an exceptional northerly movement of sub-tropical Atlantic water.

Parasites and Diseases of Fishes.

Mr. Scott has been making some observations upon ectoparasites of fishes at the Piel Laboratory; and a number of tapeworms and "flukes" from the intestines of fishes have been investigated by Mr. Johnstone in the University Laboratory; all of these are described and figured further on in this Report. A peculiar disease infesting plaice at the Port Erin Hatchery, and causing considerable mortality, has been traced to a fungus which inhabits the liver and kidneys of the fishes, and destroys the tissues.

Shell-fish Transplantation.

The result of the mussel transplanting operations in the spring of 1905 has proved satisfactory. The mussels taken from the Heysham beds and deposited in the "Ringhole" (between the old harbour and the West end pier at Morecambe) have grown on an average about $\frac{3}{4}$ of an inch in seven months. Those left on the scars have only increased $\frac{1}{4}$ of an inch in length. This gives

a nett gain of $\frac{1}{2}$ an inch in favour of the transplanting. At the period of the transplanting, the mussels varied from $1\frac{5}{8}$ to $1\frac{7}{8}$ of an inch in length, so only the larger ones left have reached the minimum legal size and become marketable. It has been found that 100 transplanted mussels weighed five lbs. in December, while 100 from the scars that had grown to a marketable size, only weighed two lbs. A bag of mussels from the scars contains about two and a half times as many as a bag from the "Ringhole." The results from the transplanting in the Wyre and at Overton have been equally satisfactory. This work is described fully in an interesting article by Mr. Scott and Mr. Baxter, which will be found further on in this Report.

The tow-nettings collected by the steamer continue to yield valuable information. A sample of the organisms collected by the bottom tow-net while trawling off Aberystwyth on December 15th, 1905, contained one plaice egg in which the larva was well advanced. From the appearance of the larva it is estimated that this egg had been spawned ten days previous to capture. The earliest record for plaice eggs in the southern part of the Irish Sea, previously known, was January 26th. The occurrence of this egg seems to indicate that some of the plaice on the South Wales coast spawn early in December, and about very much the same time as plaice frequenting the North Sea.

Several other minor investigations have been undertaken by Mr. Johnstone and Mr. Scott, and will be found described below, but the above is probably sufficient to give members of the Committee a very fair knowledge of the work that has been devised and carried out during the year.

W. A. Herdman.

University of Liverpool,
February, 1906.

2548

SEA FISH HATCHING AT PIEL.

By Andrew Scott.

Our attention, as in former years, during the fish spawning period, was devoted to the incubation of the eggs of plaice and flounders, and the results for 1905 are practically the same as those obtained in 1904. The adult plaice were brought from Luce Bay by the fisheries steamer, and the flounders from the River Lune by the police cutter belonging to the Northern portion of the District.

The plaice commenced to spawn on March 2nd, and the flounders on the following day. The first fertilised eggs were obtained on March 10th and the last on May 5th. During the two months that the spawning lasted, about thirteen and a half millions of flounder eggs were collected and about one and a half millions of plaice eggs. The eggs were incubated in the usual way and yielded a little over thirteen millions of fry. The fry were set free in Morecambe Bay by Captain Wright. At the end of the spawning season the parent fish were liberated in the Barrow Channel. About a dozen of the largest and most vigorous plaice were retained for one of Mr. Johnstone's marking experiments. These were marked and set free on May 31st, when the steamer was employed in carrying on some investigations on the off-shore fishing grounds. The following tables give the number of eggs collected, and of the fry hatched and set free on the dates specified:

Plaice (*Pleuronectes platessa*, Linn.).

Eggs Collected.			Fry Set Free.		
March 10	...	15,000	13,000	...	April 3
,, 13	..	30,000	26,500	...	,, ,,
,, 16	...	40,000	34,500	...	,, ,,
,, 18	...	40,000	35,000	...	,, ,,
,, 21	...	50,000	44,000	...	,, 17
,, 24	...	60,000	51 500	...	,, ,,
,, 27	...	75,000	66,500	...	,, ,,
,, 29	...	90,000	79,000	...	,, ,,
,, 31	...	90,000	79,000	...	,, ,,
April 4	...	90,000	79,500	...	,, 26
,, 6	...	90,000	79,000	...	,, ,,
,, 10	...	90,000	79,500	...	May 4
,, 12	...	90,000	79,500	...	,, ,,
,, 14	...	80,000	70 000	...	,, ,,
,, 17	...	85,000	75,000	...	,, ,,
,, 19	...	70,000	62,000	...	,, 10
,, 21	...	75,000	66,500	...	,, ,,
,, 24	...	60,000	52,000	...	,, ,,
,, 26	...	60,000	52,500	...	,, 19
,, 28	...	40,000	35,000	...	,, ,,
May 1	...	50,000	44,000	...	,, ,,
,, 5	...	30,000	26,500	...	,, 23
Total Eggs		1,400,000	1,230,000		Total Fry

Flounder (*Pleuronectes flesus*, Linn.).

Eggs Collected.			Fry Set Free.		
March 10	...	200,000	177,000	... April	3
,, 13	...	280,000	248,000	... ,,	,,
,, 16	...	280,000	248,000	... ,,	,,
,, 18	...	300,000	266,000	... ,,	,,
,, 21	...	360,000	330,000	... ,,	,,
,, 24	...	450,000	400,000	... ,,	,,
,, 27	...	550,000	486,500	... ,,	17
,, 29	...	600,000	531,500	... ,,	,,
,, 31	...	800,000	712,500	... ,,	,,
April 4	...	1,000,000	887,000	... ,,	,,
,, 6	...	900,000	800,000	... ,,	,,
,, 10	...	1,000,000	887,000	... ,,	,,
,, 12	...	900,000	800,000	... ,,	26
,, 14	...	900,000	800,000	... ,,	,,
,, 17	...	800,000	712,000	... ,,	,,
,, 19	...	700,000	622,000	... May	4
,, 21	...	700,000	622,000	... ,,	,,
,, 24	...	650,000	577,500	... ,,	,,
,, 26	...	700,000	621,500	... ,,	,,
,, 28	...	600,000	531,500	... ,,	10
May 1	...	500,000	445,000	... ,,	,,
,, 5	...	300,000	267,000	... ,,	19
Total Eggs		13,470,000	11,972,000	Total Fry.	

Total Number of Eggs 14,870,000

Total Number of Fry 13,202,000

CLASSES, VISITORS, &c., AT PIEL.

By Andrew Scott.

The Education Committee of the Lancashire County Council again placed at the disposal of the Sea Fisheries Committee the usual sum of money for forty-five studentships, open to fishermen residing in the Administrative County of Lancaster. The studentship holders were divided into three classes of fifteen men in each, as shown by the following lists:—

Class held March 6th to 17th—J. Butler, Flookburgh; R. Johnson, Bolton-le-Sands; J. Threlfall, Morecambe; A. Woodhouse, Morecambe; J. Johnson, Junr., Morecambe; J. Moss, Fleetwood; N. Leadbetter, Fleetwood; D. Leadbetter, Fleetwood; R. Birch, Lytham; C. Whiteside, Lytham; H. Robinson, Marshside; M. Johnson, Marshside; J. Foster, Marshside; R. Johnson, Banks; J. Bond, Banks.

Class held March 20th to 31st—R. Butler, Flookburgh; W. Wilson, Baicliff; J. Bell, Morecambe; D. Bell, Morecambe; A. Wilson, Morecambe; J. Leadbetter, Fleetwood; H. Macmillan, Fleetwood; J. Meadows, Fleetwood; N. Johnson, St. Annes; T. B. Harrison, St. Annes; R. Rimmer, Marshside; H. Wright (Hutch), Marshside; J. Wright, Marshside; B. Abram, Banks; W. Leadbetter, Banks.

Class held April 3rd to 14th - G. Thompson, Baicliff; W. Woodend, Bardsea; H. Shaw, Flookburgh; J. Woodhouse, Morecambe; T. Woodhouse, Morecambe; J. Wilson, Morecambe; Rd. Brown, Morecambe; John Raby, Overton; R. Roskell, Fleetwood; R. Atkinson, Fleetwood; D. Herbert, Fleetwood; R. Wilson, Fleetwood; D. Abram, Banks; W. Rigby, Southport; B. Ball, Southport. In addition to the men originally selected for the third class, two fishermen, S. Rimmer, and W.

Parr, from Blackpool, were also present, the studentships being granted by the Blackpool Education Committee.

The usual votes of thanks to the Sea Fisheries Committee and to the Education Committee of the Lancashire County Council were proposed and carried by the fishermen. One of the most noteworthy fishermen students we have ever met with was a member of the third class, James Woodhouse, of Morecambe, a fisherman close on eighty-two years of age, and still following his arduous vocation with surprising activity. On several occasions during the summer, when fishing in the vicinity of Piel, he paid us a visit. Mr. Woodhouse proved an attentive student, and in a short speech stated he had learned much about the habits and life of fish that was new to him.

A class in Nature Study for school teachers was held on two week nights and Saturday afternoons during the last two weeks of April and first week of May. The class was attended by seventeen students, all teachers in the schools under the Barrow Education Committee. This is the fourth class in Nature Study for teachers that has been conducted at Piel.

The dates for the next classes for fishermen are practically settled. Two will be held before Easter—March 12th to 23rd, March 26th to April 6th—and one after Easter—April 23rd to May 4th. A fourth class, if required, could meet from May 7th to 18th.

Mr. M. A. Fenton, H.M. Inspector of Schools, has inspected the laboratory and equipment for teaching purposes. A report giving a summary of the apparatus in stock, and also of the previous classes for fishermen and school teachers, has since been forwarded to him.

Mr. Haweridge, Director of Education for Barrow, Mr. Hopkinson and Mr. Baxter, members of the Committee, and others have recently visited the establishment.

Lancashire Marine Laboratory.

General View of Piel (Roa Island, Barrow Channel) from the Sea.

(Photograph by Mr J. Wells, Piel).

The Scientific Sub-Committee and representatives of the various Education Committees in the country visited the establishment under the leadership of Mr. James Fletcher on two occasions while the classes for fishermen were going on.

A considerable number of additions to the Library have been made during the year, partly by purchase and partly by presentation. The most noteworthy are:-

Six volumes of the Challenger Reports—presented by His Majesty's Government.

Twenty-five volumes of publications relating to Marine Biology—presented by the Trustees of the British Museum.

Complete set, Journal of the Marine Biological Association—presented by the Association.

Forbes and Hanley, British Mollusca—purchased.

Vols. I., II., III. of Crustacea of Norway, By G. O. Sars—purchased.

British Hydroid Zoophytes, Hincks—purchased.

British Sessile-eyed Crustacea, Bate and Westwood—purchased.

British Starfishes, Forbes—purchased.

British Sea Anemones and Corals, Gosse—purchased.

The Study of Fishes, Gunther—purchased.

American Food and Game Fishes, Jordan and Evermann—purchased.

Nordisches Plankton, Brandt u. Apstein, Kiel, Pts. 1-4—purchased.

Also a large number of reprints of papers from the Reports on the Sea and Inland Fisheries of Ireland, 1902-1903—presented by Mr. E. W. L. Holt, Scientific Adviser, Department of Agriculture and Technical Instruction for Ireland, Fisheries Branch.

REPORT ON THE TOW-NETTINGS.

By Andrew Scott.

During the year 1905 three hundred and sixty-five tow-nettings have been examined. These collections were made in various parts of the Irish Sea, extending from Luce Bay in the North to Fishguard Bay in the South. Of this number, two hundred and ninety-seven were taken by the steamer, forty-one by the Welsh officers at Carnarvon, Pwllheli and New Quay, and twenty-seven by Mr. Chadwick at Port Erin. A continuous series from any particular area can scarcely be expected under the present system. The primary work of the steamer is to patrol the whole coast line of Lancashire and Wales, from Haverigg Point to Kemmaes Head, and occasionally visit the Isle of Man and Milford Haven Districts. The Fishery Officers have their particular sections to supervise, and Mr. Chadwick has many duties to perform. The tow-nettings can, therefore, only be taken when time permits, or in conjunction with other work such as collecting trawling statistics, and are liable to be interrupted through pressure of work or stress of weather. At some future period a more regular system of collecting may be attained by the provision of a special scientific steamer. Meanwhile we make the most of the material we get, and are very grateful for the opportunities afforded us. The information derived from these tow-nettings is gradually extending our knowledge of the periodic occurrence and distribution of the pelagic organisms in our area.

It is proposed in this report to deal specially with the result of the examination of the collections from Cardigan Bay, as it is the only area from which we have a series representing every month in the year.

The collections from other areas such as Blackpool, North Wales, and Port Erin have been interrupted from the causes already mentioned, but the information gained from these, as to distribution, &c., will be given where it appears useful. A report on the distribution of the organisms from year to year may be given at a future date, and will contain further details. The report given last year was only intended as a record of the monthly occurrences of groups of organisms without mentioning the genera and species, and was primarily prepared for use in the fishermen's classes.

The present report is the first, so far as we know, that deals with the organisms present each month of the year in the waters of Cardigan Bay. Sixty-six collections from this area have been examined. Of that number thirty-one were taken by the steamer in various parts of the bay, twenty-two by D. Pritchard, Fishery Officer at Pwllheli, and fourteen by E. Williams, Fishery Officer at New Quay. The following lists give the occurrence from month to month of the organisms identified in the Cardigan Bay tow-nettings.

January.

Autolytus prolifer, Sagitta bipunctata, "Mitraria," Meganyctiphanes norvegica, Calanus helgolandicus, Pseudocalanus elongatus, Paracalanus parvus, Centropages hamatus, Anomalocera patersoni, Acartia clausi, Oithona similis, Fish eggs (Plaice).

February.

Biddulphia, Coscinodiscus, Medusoid gonophores, Autolytus prolifer, Sagitta bipunctata, "Mitraria," "Mysis stage" of Crangon, Calanus helgolandicus, Pseudocalanus elongatus, Paracalanus parvus, Centropages hamatus, Temora longicornis, Anomalocera

patersoni, Acartia clausi and A. discaudata, Oithona similis, Cyclopina littoralis, Canuella perplexa, Euterpina acutifrons, Alteutha interrupta, Copepod nauplii, Nauplii of Barnacles, Oikopleura, Fish eggs (Plaice, Dab, Flounder, Haddock, Coal Fish, Bib, Rockling).

March.

Biddulphia, Coscinodiscus, Pleurobrachia pileus, Autolytus prolifer, Sagitta bipunctata, "Mitraria," Pseudocalanus elongatus, Paracalanus parvus, Centropages hamatus, Temora longicornis, Acartia clausi and A. discaudata, Oithona similis, Cyclopina littoralis, Copepod nauplii, Nauplii and Ostracod stages of Barnacle, Ascidian eggs, Fish eggs (Plaice, Flounder, Dab, Cod, Rockling).

April.

Biddulphia, Coscinodiscus, Pleurobrachia pileus, Sagitta bipunctata, "Mitraria," Crab zoea," "Mysis stage" of Crangon, Paracalanus parvus, Centropages hamatus and C. typicus, Temora longicornis, Acartia clausi, and A. discaudata, Copepod nauplii, Nauplii of Barnacles, Ostracod stage of Barnacles, Ascidian eggs, Oikopleura, Fish eggs (Plaice, Brill, Coal Fish, Sprat, Rockling, Common Dragonet). Post larval pleuronectids.

May.

Coscinodiscus, Pluteus larvæ of Starfish, Pleurobrachia pileus, Medusoid gonophores, Sagitta bipunctata, larval Polychæta, "Mitraria," "Mysis stage" of Crangon, Crab zoea, Calanus helgolandicus, Pseudocalanus elongatus, Paracalanus parvus, Centropages hamatus, and C. typicus, Temora longicornis, Acartia clausi and A. discaudata, Oithona similis, Copepod nauplii, Nauplii and Ostracod stages of Barnacles, Podon

intermedium, Ascidian eggs, Oikopleura, Fish eggs (Brill, Solenette, Sprat, Rockling). Post larval pleuronectids and gadoids, young rockling.

June.

Biddulphia, Rhizosolenia, Gelatinous algæ, Pluteus of Echinus, Pluteus of brittle starfish, Pleurobrachia pileus, Medusoid gonophores, young Aurelia, Sagitta bipunctata, larval Polychæta, "Mitraria," "Mysis stage" of Crangon, Zoea and Megalopa of Crabs, Idotea marina, Paracalanus parvus, Centropages hamatus and C. typicus, Temora longicornis, Acartia clausi, and A. discaudata, Copepod nauplii, Podon intermedium, Oikopleura, Fish eggs (Brill, Turbot, Solenette, Weever), one young Sole 7·5 mm. long, young Rockling.

July.

Rhizosolenia, Ceratium tripos, C. fusus, and C. furca, Pleurobrachia pileus, Medusoid gonophores, young Aurelia, Sagitta bipunctata, "Mitraria," "Mysis stage" of Crangon, Zoea and Megalopa of Crabs, Trachelifer stage of Jaxea nocturna, Erichtheus stage of Squilla, Pelagic stage of common lobster, Paracalanus parvus, Centropages hamatus, and C. typicus, Temora longicornis, Isias clavipes, Anomalocera patersoni, Labidocera wollastoni, Pontella lobiancoi, Acartia clausi, and A. discaudata, Oithona similis, Canuella perplexa, Monstrilla anglica, Podon intermedium and P. leuckartii, Evadne nordmanni, Oikopleura, Fish eggs (Weever), young Weevers, young Rocklings, young Garfish.

August.

Noctiluca, Sagitta bipunctata, Autolytus prolifer, "Mitraria," "Mysis stage" of Crangon, Zoea and

Megalopa of Crabs, Trachelifer stage of Jaxea nocturna, Erichtheus stage of squilla, Paracalanus parvus, Centropages hamatus and C. typicus, Temora longicornis, Isias clavipes, Anomalocera patersoni, Labidocera wollastoni, Pontella lobiancoi, Acartia clausi, and A. discaudata, Oithona similis, Euterpina acutifrons, Podon intermedium and P. leuckartii, Ascidian eggs, Oikopleura.

September.

Biddulphia, Coscinodiscus, Chætoceros, Ceratium tripos, C. fusus and C. furca, Pleurobrachia pileus, Medusoid gonophores, Sagitta bipunctata, larval Polychæta, "Mitraria," "Mysis stage" of Crangon, Paracalanus parvus, Centropages hamatus, Temora longicornis, Acartia clausi, Oithona similis, Canuella perplexa, Euterpina acutifrons, Podon intermedium and P. leuckartii, Larvæ of Gasteropods, Larvæ of Lamellibranchs, Oikopleura.

October.

Chætoceros, Bellerochea, Ceratium fusus, Pleurobrachia pileus, Sagitta bipunctata, Larval Polychæta, Pseudocalanus elongatus, Paracalanus parvus, Centropages hamatus, Temora longicornis, Acartia clausi, Oithona similis, Euterpina acutifrons, Oikopleura.

November.

Coscinodiscus, Noctiluca, Sagitta bipunctata, Tomopteris onisciformis, "Mysis stage" of Crangon, Megalopa of Crabs, Calanus helgolandicus, Paracalanus parvus, Centropages hamatus, Temora longicornis, Anomalocera patersoni, Acartia clausi, Oithona similis, Euterpina acutifrons, Oikopleura.

December.

Biddulphia, Coscinodiscus, Ceratium fusus, and C. furca, Noctiluca, Pleurobrachia pileus, Sagitta bipunctata, Autolytus prolifer, Tomopteris onisciformis, larval Polychæta, "Mitraria," "Mysis stage" of Crangon, Meganyctiphanes norvegica, Calanus helgolandicus, Pseudocalanus elongatus, Paracalanus parvus, Centropages hamatus, Temora longicornis, Anomalocera patersoni, Acartia clausii, Oithona similis, Euterpina acutifrons, Oikopleura, Fish eggs (Plaice).

Remarks on the Occurrence and Distribution of Organisms.

Taking the months in order, we find from collections which could only be secured during the second half of January that twelve different organisms were present, and the bulk of these were copepoda. *Pseudocalanus*, *Paracalanus*, *Centropages* and *Acartia* were the most conspicuous, only a few of the remaining three were noted. *Calanus* and the schizopod *Meganyctiphanes* were limited to bottom gatherings. *Sagitta*, though present in immense numbers at the bottom, were comparatively scarce near the surface. Observations elsewhere were rather limited in January owing to uncertainty of the weather, and only four inshore areas were dealt with, but these practically take in the coast line from Blackpool to New Quay Head. It is therefore noteworthy that though Diatoms were absent in the coastal waters, representatives of three genera occurred at Port Erin.

During January arrangements were completed for the Fishery Officers at Pwllheli and New Quay to take tow-nettings in their divisions at least once a fortnight, in addition to the collections made by the steamer when circumstances permitted. The extra gatherings were

begun in February and continued throughout the year. The tow-nettings for February comprised eight surface and five bottom samples. Copepoda, so far as number of species go, reached the maximum point in this month, when fourteen forms were noted, but only four of these (the same as in January) were at all common. *Sagitta* was again abundant near the bottom. Copepod nauplii and the nauplii of barnacles made their appearance in February. Seven species of fish eggs were noted and two species of diatoms. Five other coastal areas were examined, one off-shore station and Port Erin. Diatoms appeared to be scarce in distribution throughout the Irish Sea. Three genera were represented at Port Erin, two in Cardigan Bay and one in Fishguard Bay. Altogether thirty distinct organisms were detected in Cardigan Bay. Port Erin, with fourteen, was the next richest area.

In March owing to pressure of other work the steamer was unable to investigate Cardigan Bay, but the Fishery Officers sent in five samples, which were representative of the whole month. Twenty-three organisms were noted, including eight species of Copepoda and five species of fish eggs. The ostracod stage of barnacles and the eggs of species of Ascidians appeared for the first time in 1905 in this month. Five coastal areas were investigated, also four stations in the central portion of the Irish Sea, but Port Erin was not represented. Diatoms were apparently present throughout the whole of the Irish Sea in March, and were represented by the genera *Biddulphia* and *Coscinodiscus*.

The steamer was again engaged in other work in April, and the collections sent by the Fishery Officers contained the only material available. These were taken on the 12th, 18th (two tow-nettings) and 29th. The organisms numbered twenty-five, and included six

species of Copepoda and six species of fish eggs. The Zoea stage of crabs and the post larval stage of Pleuronectids, probably plaice, began to make their appearance amongst the plankton. Five coastal areas were examined, also three off-shore stations and Port Erin Bay. The distribution of many of the organisms had now become fairly uniform. Diatoms were present in every area except Carnarvon Bay, and were represented by *Coscinodiscus* and *Biddulphia*. *Chaetoceros* and *Rhizosolenia* occurred at Port Erin in addition to the two others mentioned, but nowhere else. Twenty-nine organisms, including the eggs of ten species of fish, were noted from Port Erin in April.

The tow-nettings taken in May numbered ten, and comprised four collections from the Fishery Officers, and three surface and three bottom gatherings made by the steamer. The organisms represented in the material, including the eggs of four species of fish, reached a total of thirty-one. Nine species of Copepoda were noted. Of these, *Centropages hamatus*, *C. typicus*, *Acartia clausi* and *A. discaudata* were the most abundant: the last two in some cases forming the bulk of the material collected. Post larval pleuronectids were less numerous than in April, and young gadoids made their appearance for the first time. The presence of gelatinous algæ interfered to some extent with the working of the tow-nets in three of the other coastal areas investigated, and probably had some connection with the abnormal results. At Blackpool only *Pleurobrachia* and this alga were noted. The collection from Port Erin on May 11th was also rather remarkable. It was practically a gathering of *Chaetoceros*.

In June twelve collections were made, of which four were from near the bottom. Gelatinous algæ had by this

time become very abundant along the Welsh coast extending to Fishguard Bay, but apparently did not come very close to the land. None of the tow-nettings taken by the steamer produced a single copepod, while those taken off Tremadoc, Aberaron and Kilan Head, yielded six species. Out of a total of thirty organisms only eight occurred between two and three miles from the land. The alga was entirely absent from the tow-nettings taken by the Fishery Officers. The collection from Port Erin showed a great change from the previous month, and twenty organisms were noted. *Chætoceros* had entirely vanished, its place being taken by a swarm of *Rhizosolenia* which was represented by a few individuals in May.

The organisms in Cardigan Bay plankton attained their highest number in July. Eleven collections were taken and thirty-six different forms, with a fairly uniform distribution, were found to be present in the area. No other portion of the Irish Sea, at any time during 1905 contained plankton so varied as occurred in this bay in the months of May, June, July and August. Various unusual forms appeared in July such as the larvæ of the crustaceans *Jaxea*, *Squilla*, and lobsters, also the rare copepods *Pontella lobiancoi* and *Monstrilla anglica*. The gelatinous alga was gradually disappearing from the water. The only areas that contained any were Carnarvon Bay and Bahama Bank off the Isle of Man. Diatoms were practically absent in all the regions investigated, a very few *Rhizosolenia* were noted at Port Erin and in Cardigan Bay, and *Coscinodiscus* at Port Erin only.

The tow-nettings taken during August numbered fourteen. Ten of these were collected by the steamer, and the remaining four by the Fishery Officers. A con-

siderable reduction in the number of organisms apparently set in early in the month; Diatoms, Ceratium and Coelenterata were entirely absent. The young lobsters had also gone from this area, but a few occurred in Carnarvon Bay and one in Lune Deep. The Protozoan *Noctiluca* made its first appearance in this bay during August, and was also diffused throughout the Irish Sea at that time. Young *Jaxea*, young *Squilla* and *Pontella lobiancoi* continued to be represented. Fish eggs and young fishes had disappeared from all the coastal waters. At Port Erin one or two eggs of the Norway topknot still remained. Diatoms became more plentiful in other areas. Representatives of four genera were noted between Red Wharf Bay and Rhyl, one in the Ribble and two at Port Erin.

In September five gatherings were taken. The number of organisms remained practically the same as in August, but a great change had taken place in the constituents of the plankton, not only here but all over the area. The larvæ of Crabs, *Jaxea* and *Squilla* had gone, and also some of the copepods, including the species of *Pontella*, *Anomalocera*, *Labidocera*, and a few others. Twelve species of copepoda were present in August and only seven in September. Diatoms, Ceratium and Coelenterata re-appeared, and small swarms of gasteropod and lamellibranch larvæ were met with. Diatoms had become well diffused throughout the Irish Sea. Three genera were represented in Cardigan Bay, four along the North Wales coast, one at the mouth of the Ribble, Blackpool and Port Erin. Three species of Ceratium were present in every one of the areas examined, excepting Port Erin. Coelenterata were uniformly distributed. A few zoea of crabs (*Porcellana* sp.), and late megalopa stages of other species were found along the North Wales coast and off the Ribble.

Only one collection could be made in October and so far as it goes it shows that the plankton had become almost as poor in constituents as we found during January. Practically only copepods remained, along with a few individuals belonging to other five groups. From the other areas examined we find that Diatoms were prevalent all over. Port Erin and Luce Bay were especially rich in species, no less than five being common to both. *Ceratium* was uniformly distributed in the northern division and *Noctiluca* extended from the coastal waters to the centre of the Irish Sea.

In November five collections were taken, and the plankton was very similar to that of October. Slight changes had occurred. *Chætoceros* was displaced by *Coscinodiscus*, and *Ceratium* by *Noctiluca*. Amongst the Copepoda *Anomalocera* had returned and *Calanus* took the place of *Pseudocalanus*. The Plankton in the other areas remained practically the same as in the previous month. *Acanthometra* appeared at Port Erin for the first time in the year.

The weather during December was unsettled, and the work in consequence was restricted to fewer areas. Eleven tow-nettings were taken in Cardigan Bay and revealed a considerable development in the plankton. The constituents numbered twenty-four. *Coscinodiscus*, Ceratium, Cœlenterata, and *Pseudocalanus* re-appeared. A single specimen of a developing egg of the plaice was found in a bottom collection on the 15th which makes the earliest record for the Irish Sea.

The year 1905 was remarkable for the huge swarms of single organisms that made their appearance from time to time throughout the whole of the territorial waters between the Duddon and Fishguard Bay. We do not remember any previous occasion on which these invasions

were so marked. In some cases these visits were strictly local, and in others diffused over a wide area. The following are the most striking instances, giving the date and locality of the occurrence, and also the name of the organism:

Jan. 26. Patches Buoy, Aberystwyth. *Sagitta.*
,, 27. Off Llanon, Cardigan Bay. ,,
Feb. 21. Tremadoc Bay. Diatoms (*Coscinodiscus*).
Mar. 28. Off the mouth of the Duddon. *Sagitta.*
April 4. Carnarvon Bay. Ostracod stage of Barnacles.
,, 18. Tremadoc Bay. Copepods (*Temora longicornis*).
,, 29. Off New Quay Head. ,, ,, ,,
May 11. Port Erin. Diatoms (*Chætoceros*).
June 11. Red Wharf Bay. Diatoms (*Coscinodiscus and Biddulphia*).
,, 15. New Quay Head. Copepods (*Centropages and Acartia*).
,, 19. Port Erin. Diatoms (*Rhizosolenia*).
,, 23. Fishguard Bay. Crustacea (Megalopa of Crabs).
,, 27. Llandudno Bay. *Noctiluca.*
,, 28. Off Puffin Island. ,,
,, 29. Entrance to Mersey. ,,
,, 30. Blackpool. ,,
July 5. Red Wharf Bay. ,,
,, 5. Beaumaris Bay. ,,
,, 7. Off St. Tudwall Islands. *Porcellana* zoea.
,, 7. Off Nelson Buoy, Ribble. *Noctiluca.*
,, 13. ,, ,, ,, ,,
,, 14. Off Ynys Fach, Cardigan Bay. Megalopa of Crabs.
,, 17. Tremadoc Bay. Copepods, *Temora and Acartia.*
,, 18. Off Nelson Buoy, Ribble. Cladocera (2 species of *Podon*).

July 20. Carnarvon Bay. *Noctiluca.*
.. 21. Tremadoc Bay. Copepods (*Acartia discaudata*).
.. 21. Patches Buoy, Aberystwyth. *Rhizosolenia and Ceratium.*
.. 22. Off Llanon, Cardigan Bay. *Rhizosolenia and Ceratium.*
.. 25. Off the mouth of the Duddon. Crab Megalopa.
.. 31. New Quay Head. Copepods *Temora and Acartia.*
.. 31. Tremadoc Bay. *Porcellana* zoea.
Aug. 1. Llandudno Bay. *Noctiluca.*
.. 3. Entrance to Mersey. ,,
.. 7. Off Nelson Buoy, Ribble. *Noctiluca.*
.. 8. Tremadoc Bay. *Porcellana* zoea.
.. 9. Off Llanon, Cardigan Bay. 100 *Squilla* larvæ, 105 *Pontella lobiancoi.*
.. 10. Carnarvon Bay. Zoea and Megalopa of Crabs.
.. 16. Off Nelson Buoy. ,, ,, ,,
.. 16. Llandudno Bay. Diatoms (four genera).
.. 17. Beaumaris Bay. *Noctiluca.*
.. 22. Off Nelson Buoy, Ribble. *Noctiluca.*
.. 26. Blackpool. *Noctiluca.*
.. 31. Patches Buoy, off Aberystwyth. 30 *Squilla* larvæ.
Sep. 14. Entrance to Ribble. *Noctiluca.*
Oct. 10. Off Liverpool N.W. Light Ship. *Noctiluca.*
.. 24. Entrance to Mersey. *Sagitta.*

The appended table shews the occurrence of pelagic fish eggs during the year.

The following table shows the distribution, month by month, in four divisions of the Irish Sea, of the species named:—

In Territorial Waters from Blackpool to Red Wharf Bay.

Months.	Plaice.	Dab.	Flounder.	Brill.	Turbot.	Norwegian Top Knot.	Solenette.	Cod.	Haddock.	Whiting.	Bib.	Coal Fish.	Rockling.	Gurnard.	Common Dragonet.	Spotted Dragonet.	Weever.	Sprat.
March										+	+	+	+					
April								+	+		+		+	+				+
May				+														+
June							+								+		+	+
July															+	+	+	

In Cardigan Bay.

January	+																	
February	+	+	+						+		+	+	+					
March	+	+	+					+					+					
April	+			+								+	+		+			+
May				+			+						+					+
June				+			+						+				+	+
July						+											+	
December	+																	

On Off-shore Grounds, N.W. of Piel to Liverpool N.W. Light Ship.

Months.	Plaice.	Dab.	Flounder.	Brill.	Turbot.	Norwegian Top Knot.	Solenette.	Cod.	Haddock.	Whiting.	Bib.	Coal Fish.	Rockling.	Gurnard.	Common Dragonet.	Spotted Dragonet.	Weever.	Sprat.
February	+								+				+					
March	+	+	+					+	+	+	+	+	+					
April	+		+						+	+	+		+	+				+
May														+				
June																	+	

In Vicinity of Port Erin.

April	+	+		+	+	+				+	+	+			+			+
May				+	+													
June															+			+
July					+											+	+	+
August					+													

The following Tables show the occurrence from month to month of the various organisms identified in the plankton from the areas named:—

January.

	Blackpool.	Ribble Estuary.	Mersey Estuary.	Rhyl to Red Wharf Bay.	Carnarvon Bay.	Cardigan Bay.	Fishguard Bay.	Off Shore Stn. No. 1.	Off Shore Stn. No. 2.	Off Shore Stn. No. 3.	Balana Bank.	Lune Deep.	Port Erin.	Luce Bay.
Chaetoceros													+	
Biddulphia													+	
Coscinodiscus													+	
Ceratium tripos													+	
Sagitta bipunctata		+		+		+							+	
Autolytus prolifer				+		+								
Tomopteris onisciformis													+	
"Mitraria"						+								
Meganyctiphanes norvegica				+		+								
Mysis stage of Crangon		+				+								
Calanus helgolandicus		+		+		+								
Pseudocalanus elongatus				+		+							+	
Paracalanus parvus		+		+		+							+	
Temora longicornis		+												
Acartia clausi				+		+								
Centropages hamatus		+				+								
Anomalocera patersoni						+								
Oithona similis						+							+	
Fish eggs						+								
	—	6	—	7	7	12	—	—	—	—	—	—	9	—

February.

	Blackpool.	Ribble Estuary.	Mersey Estuary.	Rhyl to Red Wharf Bay.	Carnarvon Bay.	Cardigan Bay.	Fishguard Bay.	Off Shore Stn. No. 1.	Off Shore Stn. No. 2.	Off Shore Stn. No. 3.	Bahama Bank.	Lune Deep.	Port Erin.	Luce Bay.
Chaetoceros													+	
Biddulphia						+	+						+	
Rhizosolenia													+	
Coscinodiscus						+							+	
Ceratium tripos													+	
Ceratium fusus													+	
Ceratium furca													+	
Sagitta bipunctata					+	+	+	+			+		+	
Autolytus prolifer	+				+	+								
Larval Polychaeta													+	
"Mitraria"						+								
Pleurobrachia pileus														
Medusoid gonophores	+					+								
Pluteus													+	
Mysis stage of Crangon	+					+		+			+			
Calanus helgolandicus						+	+				+			
Pseudocalanus elongatus	+				+	+	+	+			+		+	
Paracalanus parvus	+					+	+	+			+		+	
Temora longicornis	+					+								
Acartia clausi	+				+	+	+	+			+			
Acartia discaudata						+								
Centropages hamatus						+	+	+						
Centropages typicus						+								
Anomalocera patersoni						+								
Oithona similis						+	+				+		+	
Cyclopina littoralis						+								
Canuella perplexa						+								
Euterpina acutifrons						+	+							
Alteutha interrupta						+	+	+			+			
Copepod nauplii					+	+							+	
Cirriped nauplii						+								
Oikopleura						+								
Fish eggs					+	+	+	+			+			
	7	—	—	—	6	25	11	8	—	—	9	—	14	—

March.

	Blackpool.	Ribble Estuary.	Mersey Estuary.	Rhyl to Red Wharf Bay.	Carnarvon Bay.	Cardigan Bay.	Fishguard Bay.	Off Shore Stn. No. 1.	Off Shore Stn. No. 2.	Off Shore Stn No. 3.	Bahama Bank.	Lune Deep	Port Erin.	Luce Bay.
Biddulphia	+			+		+		+		+	+			
Coscinodiscus	+			+		+		+	+	+	+			
Ceratium fusus									+					
Sagitta bipunctata	+			+	+	+		+	+	+				
Autolytus prolifer	+					+			+	+				
"Mitraria"					+	+			+					
Pleurobrachia pileus						+								
Medusoid gonophores	+													
Pasiphea sivado									+					
Meganyctiphanes norvegica									+	+	+			
Mysis stage of Crangon	+			+				+	+	+				
Calanus helgolandica									+	+	+			
Pseudocalanus elongatus	+			+	+	+		+	+	+	+	+		
Paracalanus parvus	+			+		+			+	+	+			
Temora longicornis				+		+		+	+		+	+		
Acartia clausi	+			+	+	+		+	+	+	+	+		
Acartia discaudata						+								
Centropages hamatus	+			+		+			+	+	+			
Oithona similis						+			+		+			
Cyclopina littoralis						+								
Giardella thompsoni											+			
Alteutha interrupta	+							+	+	+	+			
Halithalestris croni									+					
Copepod nauplii				+		+			+					
Barnacle nauplii				+		+								
Barnacle ostracod stage						+								
Crab zoea	+			+					+		+			
Oikopleura											+			
Ascidian eggs						+			+					
Fish eggs	+			+	+	+		+	+	+	+			
Larvæ				+										
	13	—	—	14	5	19	—	9	21	13	15	3	—	—

April.

	Blackpool.	Ribble Estuary.	Mersey Estuary.	Rhyl to Red Wharf Bay.	Carnarvon Bay.	Cardigan Bay.	Fishguard Bay.	Off Shore Stn. No. 1.	Off Shore Stn. No. 2.	Off Shore Stn. No. 3.	Bahama Bank.	Lune Deep.	Port Erin.	Luce Bay.
Chætoceros													+	
Biddulphia	+		+	+		+		+		+	+		+	
Rhizosolenia													+	
Coscinodiscus	+		+	+		+		+		+	+		+	
Ceratium fusus													+	
Pleurobrachia pileus	+		+			+								
Medusoid gonophores	+		+		+									
Alcyonium eggs	+		+											
Sagitta bipunctata	+		+	+		+				+				
Autolytus prolifer	+			+				+		+				
Larval Polychæta				+						+				
"Mitraria"						+				+				
Pasiphaea sivado				+										
Meganyctiphanes norvegica								+						
Mysis stage of Crangon			+			+				+				
Calanus helgolandicus			+	+				+		+				
Pseudocalanus elongatus	+			+				+		+			+	
Paracalanus parvus	+		+	+		+		+					+	
Temora longicornis	+		+	+	+	+		+					+	
Acartia clausi	+		+			+		+					+	
Acartia discaudata						+								
Centropages hamatus	+		+	+		+		+					+	
Centropages typicus						+								
Anomalocera patersoni													+	
Oithona similis	+												+	
Alteutha interrupta								+						
Copepod nauplii	+		+	+		+		+					+	
Barnacle nauplii	+		+	+	+	+		+		+			+	
Barnacle ostracod stage				+	+	+							+	
Crab zoea	+			+		+		+		+				
Podon intermedium													+	
Podon leuckartii													+	
Oikopleura				+		+							+	
Ascidian eggs			+	+		+		+						
Fish eggs	+			+	+	+		+		+			+	
Fish larvæ			+	+		+		+		+			+	
Eurydice	+		+		+									
Idotea linearis	+		+											
Idotea marina	+		+											
	20	—	19	19	6	20	—	17	—	13	2	—	20	—

May.

	Blackpool.	Ribble Estuary.	Mersey Estuary.	Rhyl to Red Wharf Bay.	Carnarvon Bay.	Cardigan Bay.	Fishguard Bay.	Off Shore Stn. No. 1.	Off Shore Stn. No. 2.	Off Shore Stn. No. 3.	Bahama Bank.	Lune Deep.	Port Erin.	Luce Bay.
Chaetoceros													+	
Biddulphia				+									+	
Coscinodiscus				+		+							+	
Rhizosolenia													+	
Gelatinous algae	+			+	+									
Ceratium tripos													+	
Ceratium furca													+	
Pleurobrachia pileus	+				+	+				+				
Medusoid gonophores					+	+								
Pluteus						+								
Sagitta bipunctata				+		+								
Autclytus prolifer					+									
Larval Polychæta						+								
"Mitraria"						+								
Mysis stage of Crangon					+	+				+				
Eurydice					+									
Zoea of Crabs					+	+				+				
Calanus helgolandicus						+								
Pseudocalanus elongatus						+				+				
Paracalanus parvus						+				+				
Temora longicornis				+		+				+				
Acartia clausi						+				+				
Acartia discaudata						+								
Centropages hamatus				+		+				+				
Centropages typicus						+								
Anomalocera patersoni										+				
Oithona similis						+							+	
Copepod nauplii						+				+				
Barnacle nauplii				+		+				+				
Barnacle ostracod stage				+	+	+								
Podon intermedium						+								
Oikopleura						+							+	
Ascidian eggs					+	+								
Fish eggs				+	+	+				+			+	
Fish larvæ				+	+	+				+				
	2	—	—	10	11	26	—	—	—	13	—	—	9	—

June.

	Blackpool.	Ribble Estuary.	Mersey Estuary.	Rhyl to Red Wharf Bay.	Carnarvon Bay.	Cardigan Bay.	Fishguard Bay.	Off Shore Stn. No. 1.	Off Shore Stn. No. 2.	Off Shore Stn. No. 3.	Bahama Bank.	Lune Deep.	Port Erin.	Luce Bay.
Biddulphia						+							+	
Rhizosolenia						+	+						+	
Coscinodiscus							+						+	
Gelatinous algae				+		+	+							
Ceratium tripos													+	
Noctiluca	+		+	+			+						+	
Pluteus						+								
Echinus pluteus						+								
Spatangus pluteus													+	
Pleurobrachia pileus		+	+	+		+	+			+				
Medusoid gonophores				+		+							+	
Young Aurelia						+								
Sagitta bipunctata				+		+	+			+			+	
Autolytus prolifer				+										
Larval polychaeta				+		+								
"Mitraria"			+			+								
Meganyctiphanes norvegica							+							
Idotea marina						+								
Mysis stage of Crangon		+				+				+				
Crab zoea	+		+	+		+	+			+			+	
Crab Megalopa			+	+		+	+			+			+	
Calanus helgolandicus			+	+										
Pseudocalanus elongatus				+						+			+	
Paracalanus parvus			+	+		+				+				
Temora longicornis			+	+		+	+			+			+	
Acartia clausi			+	+		+				+			+	
Acartia discaudata						+								
Centropages hamatus			+	+		+								
Centropages typicus						+								
Labidocera wollastoni			+											
Oithona similis				+									+	
Copepod nauplii	+					+							+	
Barnacle ostracod stage				+										
Podon intermedium						+							+	
Evadne nordmani													+	
Oikopleura			+	+		+				+			+	
Ascidian eggs							+							
Fish eggs			+	+		+							+	
Fish larvæ				+		+				+				
	3	2	13	20	—	26	11	—	—	11	—	—	19	—

July.

	Blackpool.	Ribble Estuary.	Mersey Estuary.	Rhyl to Red Wharf Bay.	Carnarvon Bay.	Cardigan Bay.	Fishguard Bay.	Off Shore Stn. No. 1.	Off Shore Stn. No. 2.	Off Shore Stn. No. 3.	Bahama Bank.	Lune Deep.	Port Erin.	Luce Bay.
Biddulphia													+	
Rhizosolenia						+								
Gelatinous algae											+		+	
Ceratium tripos		+	+			+					+		+	
Ceratium fusus						+								
Ceratium furca						+								
Noctiluca		+	+	+	+									
Echinus pluteus											+			
Pleurobrachia pileus	+	+		+	+	+							+	
Medusoid gonophores		+		+	+	+							+	
Young Aurelia						+							+	
Sagitta bipunctata	+	+		+	+	+			+		+	+	+	
Autolytus prolifer														
Tomopteris onisciformis									+		+	+	+	
Larval Polychaeta		+												
"Mitraria"		+				+								
Mysis stage of Crangon		+		+	+	+					+		+	
Zoea of crabs	+	+	+	+	+	+			+			+		
Megalopa of crabs	+	+		+	+	+			+			+	+	
Erichtheus stage of Squilla						+								
Trachelifer stage of Jaxea						+								
Pelagic stage of lobster						+								
Centropages hamatus	+	+	+	+		+					+			
Centropages typicus						+								
Pseudocalanus elongatus									+		+	+	+	
Calanus helgolandicus				+	+				+		+	+	+	
Paracalanus parvus		+				+						+		
Temora longicornis	+	+	+	+	+	+					+		+	
Acartia clausi	+	+	+	+	+	+					+		+	
Acartia discaudata						+								
Isias clavipes		+				+					+			
Anomalocera patersoni		+				+								
Labidocera wollastoni	+	+	+			+						+		
Pontella lobiancoi						+								
Oithona similis						+			+				+	
Canuella perplexa						+						+		
Euterpina acutifrons														
Alteutha interrupta		+												
Monstrilla anglica						+								
Podon intermedium		+				+							+	
Podon leuckartii		+				+							+	
Evadne nordmanni		+				+								
Copepod nauplii													+	
Ostracod stage of barnacle		+												
Oikopleura		+				+					+	+	+	
Ascidian eggs		+							+					
Fish eggs	+	−	+	+		+					+	+	+	
Fish larvæ	+					+								
Young Loligo				+										
	10	25	8	13	11	34	—	—	8	—	14	11	20	—

August.

	Blackpool.	Ribble Estuary.	Mersey Estuary.	Rhyl to Red Wharf Bay.	Carnarvon Bay.	Cardigan Bay.	Fishguard Bay.	Off Shore Stn. No. 1.	Off Shore Stn. No. 2.	Off Shore Stn. No. 3.	Bahama Bank.	Lune Deep.	Port Erin.	Luce Bay.
Biddulphia				+									+	
Rhizosolenia				+									+	
Coscinodiscus		+		+									+	
Chætoceros				+										
Gelatinous algæ													+	
Ceratium tripos		+		+								+	+	
Ceratium fusus		+		+									+	
Ceratium furca		+		+								+	+	
Noctiluca	+	+	+	+		+								
Pleurobrachia pileus	+											+		
Medusoid gonophores	+													
Sagitta bipunctata	+	+		+		+							+	
Autolytus prolifer				+		+						+		
Larval Polychæta				+			+					+		
"Mitraria"		+		+		+	+							
Mysis stage of Crangon		+		+		+						+		
Zoea of Crabs		+	+	+	+	+						+		
Megalopa of Crabs		+	+	+	+	+						+	+	
Erichtheus stage of Squilla						+								
Trachelifer stage of Jaxea						+						+		
Pelagic stage of Lobster					+							+		
Calanus helgolandicus							+							
Pseudocalanus elongatus													+	
Paracalanus parvus	+			+		+	+					+		
Temora longicornis		+		+		+	+					+	+	
Acartia clausi		+	+	+	+	+	+					+	+	
Acartia discaudata		+				+								
Centropages hamatus	+		+	+	+	+	+					+		
Centropages typicus						+	+							
Isias clavipes						+	+							
Anomalocera patersoni		+			+	+	+							
Labidocera wollastoni						+								
Pontella lobiancoi						+								
Parapontella brevicornis							+							
Oithona similis						+	+						+	
Euterpina acutifrons				+		+								
Alteutha interrupta							+							
Hersiliodes littoralis														
Copepod nauplii													+	
Podon intermedium		+				+	+					+	+	
Podon leuckartii		+				+	+					+	+	
Eurydice		+										+		
Idotea marina												+		
Oikopleura		+				+							+	
Ascidian eggs		+				+								
Fish eggs													+	
	6	19	5	20	6	25	15	—	—	—	—	18	17	—

September.

	Blackpool.	Ribble Estuary.	Mersey Estuary.	Rhyl to Red Wharf Bay.	Carnarvon Bay.	Cardigan Bay.	Fishguard Bay.	Off Shore Stn. No. 1.	Off Shore Stn. No. 2.	Off Shore Stn. No. 3.	Bahama Bank.	Lune Deep	Port Erin.	Luce Bay.
Biddulphia				+		+								
Rhizosolenia	+			+								+	+	
Coscinodiscus		+		+		+								
Chætoceros				+		+								
Ceratium tripos	+	+		+		+						+		
Ceratium fusus	+	+		+		+						+		
Ceratium furca	+	+		+		+						+		
Noctiluca	+	+		+								+		
Spatangus pluteus				+										
Pleurobrachia pileus	+	+		+		+							+	
Medusoid gonophores		+				+							+	
Sagitta bipunctata	+	+		+		+						+	+	
Tomopteris onisciformis				+									+	
Larval Polychæta	+	+				+						+		
"Mitraria"				+		+								
Mysis stage of Crangon	+	+		+		+						+		
Zoea of Crabs		+		+										
Megalopa of Crabs		+		+										
Calanus helgolandicus													+	
Pseudocalanus elongatus													+	
Paracalanus parvus	+	+		+		+						+	+	
Temora longicornis	+	+		+		+						+		
Acartia clausi	+	+		+		+								
Centropages hamatus	+	+		+		+						+		
Anomalocera patersoni		+		+								+		
Labidocera wollastoni		+		+										
Oithona similis	+	+		+		+						+	+	
Canuella perplexa						+								
Euterpina acutifrons				+		+								
Hersiliodes littoralis				+										
Copepod nauplii													+	
Podon intermedium						+							+	
Podon leuckartii						+							+	
Eurydice	+	+												
Idotea linearis	+											+		
Idotea marina	+	+										+		
Oikopleura		+		+		+						+	+	
Ascidian eggs		+				+						+		
Young gasteropods						+								
Young lamellibranchs						+								
	17	23	—	26	—	25	—	—	—	—	—	18	13	—

October.

	Blackpool.	Ribble Estuary.	Mersey Estuary.	Rhyl to Red Wharf Bay.	Carnarvon Bay.	Cardigan Bay.	Fishguard Bay.	Off Shore Stn. No. 1.	Off Shore Stn. No. 2.	Off Shore Stn. No. 3.	Bahama Bank.	Lune Deep.	Port Erin.	Luce Bay.
Biddulphia	+												+	+
Rhizosolenia				+									+	+
Chaetoceros						+							+	+
Coscinodiscus	+	+	+	+					+	+			+	+
Bacteriastrium													+	+
Bellerochee	+					+								
Dictyilium														+
Thalassiothrix														+
Ceratium tripos	+		+						+				+	+
Ceratium fusus	+		+			+			+				+	+
Ceratium furca	+		+						+				+	+
Noctiluca	+	+	+						+	+				
Starfish pluteus			+										+	+
Pleurobrachia pileus	+					+			+				+	
Medusoid gonophores	+									+				
Sagitta bipunctata	+	+	+	+		+			+				+	+
Autolytus prolifer	+													
Larval Polychaeta	+												+	
"Mitraria"						+							+	+
Mysis stage of Crangon	+			+					+					
Meganyctiphanes norvegica														+
Megalopa of crabs				+					+					
Calanus helgolandicus				+										+
Pseudocalanus elongatus														+
Paracalanus parvus	+		+	+		+				+			+	+
Temora longicornis	+		+	+		+				+				+
Acartia clausi	+			+		+			+	+			+	+
Centropages hamatus	+	+	+	+		+			+	+				
Anomalocera patersoni			+											
Labidocera wollastoni	+			+						+				
Oithona similis	+			+		+			+	+			+	+
Euterpina acutifrons	+		+	+		+							+	+
Hersiliodes littoralis				+										
Copepod nauplii														
Idotea marina	+													
Oikopleura				+		+							+	+
Ascidian eggs													+	
	21	4	12	15	—	13	—	—	12	9	—	—	19	22

November.

	Blackpool.	Ribble Estuary.	Mersey Estuary.	Rhyl to Red Wharf Bay.	Carnarvon Bay.	Cardigan Bay.	Fishguard Bay.	Off Shore Stn. No. 1.	Off Shore Stn. No. 2.	Off Shore Stn. No. 3.	Bahama Bank.	Lune Deep.	Port Erin.	Luce Bay.
Biddulphia													+	
Rhizosolenia				+										
Chaetoceros			+							+				
Coscinodiscus			+	+		+			+	+			+	
Ceratium tripos				+					+				+	
Ceratium fusus				+									+	
Ceratium furca				+					+				+	
Noctiluca			+	+		+			+	+				
Acanthometra													+	
Pleurobrachia pileus			+	+						+				
Medusoid gonophores				+										
Sagitta bipunctata			+	+		+	+		+	+			+	
Autolytus prolifer				+										
Tomopteris onisciformis						+								
Larval polychaeta													+	
"Mitraria"													+	
Meganyctiphanes norvegica							+							
Mysis stage of Crangon				+		+	+							
Megalopa of crabs				+		+	+		+					
Calanus helgolandicus						+	+							
Pseudocalanus elongatus							+						+	
Paracalanus parvus				+		+	+		+	+			+	
Temora longicornis			+	+		+				+				
Acartia clausi			+	+		+	+		+	+			+	
Centropages hamatus			+	+		+	+		+	+				
Isias clavipes			+											
Anomalocera patersoni						+							+	
Labidocera wollastoni				+										
Oithona similis			+	+		+				+			+	
Euterpina acutifrons						+								
Hersiliodes littoralis							+							
Corycaeus anglicus							+							
Podon intermedium				+										
Oikopleura				+		+			+	+			+	
	—	—	10	20	—	15	11	—	10	11	—	—	15	—

December.

	Blackpool.	Ribble Estuary.	Mersey Estuary.	Rhyl to Red Wharf Bay.	Carnarvon Bay.	Cardigan Bay.	Fishguard Bay.	Off Shore Stn. No. 1.	Off Shore Stn. No. 2.	Off Shore Stn. No. 3.	Bahama Bank.	Lune Deep.	Port Erin.	Luce Bay.
Coscinodiscus	+		+	+		+							+	
Biddulphia				+		+							+	
Rhizosolenia														
Chætoceros													+	
Ceratium tripos			+	+									+	
Ceratium fusus	+		+	+		+								
Ceratium furca	+					+								
Noctiluca	+		+	+		+								
Acanthometra													+	
Pluteus													+	
Pleurobrachia pileus	+		+	+		+							+	+
Medusoid gonophores													+	
Alcyonium eggs													+	
Sagitta bipunctata	+		+	+		+								+
Autolytus prolifer						+								+
Tomopteris onisciformis						+							+	+
Larval Polychæta			+			+							+	+
"Mitraria"						+							+	
Meganyctiphanes norvegica						+								
Mysis stage of Crangon						+								
Calanus helgolandicus						+							+	+
Pseudocalanus elongatus			+			+							+	+
Paracalanus parvus	+		+	+		+							+	+
Temora longicornis	+		+	+		+							+	+
Acartia clausi	+		+	+		+							+	+
Centropages hamatus	+		+	+		+								
Anomalocera patersoni						+								
Oithona similis			+	+		+							+	+
Euterpina acutifrons						+								
Monstrilla anglica														+
Monstrilla longicornis													+	+
Oikopleura						+							+	
Fish eggs						+								
	10	—	13	12	—	24	—	—	—	—	—	—	20	13

2550

FAUNISTIC NOTES.

By Andrew Scott.

(1) *Acanthometra* sp.—This Radiolarian only occurred at Port Erin in November and December. In 1904 it was noted at Port Erin in February, and off Rhyl in March.

(2) *Noctiluca miliaris*.—A most extensive visitation of this organism took place in 1905, and its movements at the beginning appear to be peculiar. It was first noted in a collection from the Mersey on June 7th, then at Port Erin on the 19th, and at Fishguard Bay on the 23rd. It did not occur in the tow-nettings taken on the North Wales Coast on June 6th, 20th or 21st, nor in twenty-three gatherings from Cardigan Bay, representing the whole of June and July. At the end of June it had become well diffused in the Northern area, and continued to be so for the rest of the year. It turned up in Carnarvon Bay on July 20th and in Cardigan Bay in August. These records seem to point to a southerly drift rather than a northerly, though one naturally expects that the invasion would come from the South with the greater volume of water that enters the area by the South Channel. An earlier collection at Port Erin, in June might have thrown more light on this point. In any case, some time would elapse before the organism reached the Lancashire side after appearing at the Isle of Man if the distribution took place from the North, and *Noctiluca* was not present at Port Erin on May 11th. Some of the tow-nettings taken during June, July and August off the Lancashire coast were pure collections of this protozoan. So far as we know *Noctiluca* has not occurred at Port Erin previous to 1905.

Every opportunity of examining fish for parasites of all kinds is taken full advantage of. Mr. Johnstone is working out the Protozoa and internal worms, the leeches, trematodes and crustacea being left to me. A number of trematodes have already been recorded in a former paper, but the group is by no means worked out.

(3) *Epibdella* sp.—Plate VIII., fig. 1.

Several specimens of a form closely resembling *Epibdella hippoglossi* (Müller) were found on the skin of the common dog-fish (*Scyllium canicula*). The fish were caught in the trawl net when the steamer was at work South of the Calf of Man in June, 1905. The parasites were confined to the head of the fish and were mostly round the gill slits. A single specimen was taken some years ago, but owing to its contracted state could not be worked out. The parasite measures about 2 mm. and the body is of an oval form, thin and flat. The suckers are rather difficult to make out, and so far as can be seen the posterior one has no hooks. Until more specimens are secured it is probably better to merely record its occurrences and leave it unnamed.

(4) *Acanthocotyle* sp.—Plate VIII., figs. 2-4.

A much contracted specimen, about 1·8 mm. long, belonging to this genus, described by Monticelli in 1888, was found when examining washings from trawl refuse brought up in Fishguard Bay in June, 1905. The usual habitat of the members of this genus is on the skin of skates and rays, and as a number of rays were taken in Fishguard Bay it is practically certain that the Trematode had been detached after the fish were captured. The genus is easily recognised by the large posterior sucker armed with numerous rows of teeth, and by the presence of a small secondary sucker or adhesive disk on the margin of the large one. The shape and position of the

adhesive disk is one of the characters by which species are defined. In three species the disk is circular, and in a fourth lingulate. Figure 4 shows the shape and position of the adhesive disk in the specimen from Fishguard Bay. This is the first time we have found the genus in the Irish Sea.

A number of bass (*Labrax*) and mackerel were examined during 1905. The Trematodes already recorded from these fish were again found.

(5) *Microcotyle labracis*, van Ben. and Hesse.—Plate IX., fig. 3,

(6) and *Diplectanum aequans*, Diesing.—Plate IX., fig. 4, are from the bass. The former is a large species, but appears to be rare, while the latter, a very small form, is always plentiful on the gills of the fish taken near Piel.

(7) *Octobothrium alosae*, Hermann.—Plate IX., fig. 1.

A large number of specimens were found on the gills of a shad, *Clupea alosae*, sent to us by Mr. Robert Jones, Fishery Officer at Carnarvon. Not previously recorded for the district.

(8) *Octobothrium scombri* (Kuhn)—Plate IX., fig. 2, is the mackerel trematode. This is a very slender species and easily overlooked.

Two members of the HIRUDINEA were added to our list during 1905.

(9) *Trachelobdella lophii* (van Ben. and Hesse), from the gill chamber of an angler fish (*Lophius piscatorius*) brought to the Piel laboratory by the steamer.

(10) *Platybdella soleae* (van Ben. and Hesse).

This is the little brown thread-like body often seen on the black side of the common sole. A number of the soles caught between Lancashire and the Isle of Man in 1905 were covered with the *Platybdella*.

(11) Larvae of Lobsters.—We have not previously met with these in the tow-nettings, and their occurrence amongst the plankton is worthy of special notice. One was taken off Ynys Fach on July 14th, one off Llanon on the 22nd, twelve in Carnarvon Bay on August 10th, and one in the last pelagic stage in Lune Deep on August 25th.

(12) The Erichtheus stage of *Squilla* was recorded for Cardigan Bay in the report published last year. It was found again in the same area in 1905. In July and August these larvae appeared to be fairly uniform in their distribution between Ynys Fach and St. Tudwall Islands, and extended seaward as far as the Patches Buoy off Aberystwyth. Over 100 specimens were found in a tow-netting off Llanon on August 9th.

(13) The Trachelifer stage of *Jaxea* has also been previously recorded. It occurred in 1905 in Cardigan Bay during the months of July and August, and in Lune Deep in August. Mackerel caught off Walney early in July were found to be feeding entirely on larval crustaceans, such as Zoea and Megalopa of Crabs, &c. One or two had been feeding exclusively on young *Jaxea*, and their stomachs were well filled.

(14) *Pontella lobiancoi*, Canu.—Plates I. and II.

A regular invasion of this rare Copepod into Cardigan Bay was noted in July and August. It has not been taken at any time on the British coasts until 1904, so far as we know. Two males and one female were found in a tow-netting taken off Llanon on October 27th of that year. In 1905 we have noted its occurrence on the following occasions:—July 3rd off St. Tudwall Islands, 14th off Ynys Fach, 17th Tremadoc Bay, 21st Tremadoc Bay, 22nd off Llanon, 31st both at New Quay Head and Tremadoc Bay. August 9th off Llanon (105 specimens), 15th New Quay Head. This is one of the Pontellas that has a lens

in the rostrum, but I find that the lens is somewhat rudimentary in the female though well developed in the male, as shown by the figures now given.

(15) *Monstrilla anglica*, Lubbock.—Plate IV.

Mention is made on page 46 in last year's Report of the occurrence of a *Monstrilla* in Luce Bay which appeared to be rather different from any of the described species. A number of males of the same form were taken off Llanon on July 22nd. After a careful examination of the appendages, I am inclined to regard it as only a variety of Lubbock's species. The fifth feet of the female are much longer and narrower than in typical specimens, and the male has a peculiar comb-like structure on the inner margin of the last joint of the antennules.

(16) *Corycaeus anglicus*, Lubbock.

Specimens of this rare Copepod were taken in a plankton collection from Fishguard Bay on November 11th, 1905. The late I. C. Thompson found it at Port Erin, but this is the first record of its appearance in the coastal waters of Wales.

(17) *Giardella thompsoni*, n. sp.—Plate III.

Description of the male: Length, exclusive of furcal hairs, 1·37 mm.; body seen from above, cyclopoid in outline, moderately robust; antennules slender, seven jointed, about as long as the cephalic segment, third joint very short, fourth and seventh joints longer than any of the others; antennae and mouth organs (figs. 3-7) nearly similar to those of *G. callianassae*, Canu; swimming feet also like those of the type; endopodites in every pair longer than the exopodite; fifth feet two-jointed, narrow, and longer than the genital segment, outer margin of second joint furnished with two small spines; apex of the joint with a spine and a hair; abdomen five-jointed, fourth joint much shorter than the others; furca

moderately long and narrow, and equal to the combined lengths of the last three abdominal segments.

One specimen in a surface collection from Bahama Bank, March 7th, 1905.

This new species has a general resemblance to the type *G. callianassae*, but differs in having a more slender fifth foot, which has two marginal spines on the second joint instead of only one as shown by Canu, and by the shorter furca. The furca in Canu's species are nearly as long as the whole abdomen.

The species is dedicated to the memory of my colleague, I. C. Thompson, who studied the Copepods of Liverpool Bay for many years with marked success, as shown by his numerous reports on the subject.

(18) *Caligus scomberi*, Bassett Smith.—Plate V.

This parasite is occasionally found when examining the gill chambers of mackerel, and has already been recorded for the district. C. B. Wilson in Part I. of his work on the North American Parasitic Copepods* is inclined to doubt the validity of this species and the accuracy of the figures given by British authors. It appears desirable, therefore, that figures of the form from the Irish Sea should be given. We have not yet been fortunate enough to find the male, and the illustrations give the characteristic features of the female only. The parasite measures 5·57 mm. in total length, and the abdomen is composed of a single joint. There is a decided contraction near the distal end, but no trace of a division. The fourth feet are similar in structure to other Caligi, and have a basiopodite with a three-jointed exopodite. Sternal fork slender, sides rounded and tapering to a

* Proceedings of the United States National Museum, vol. xxviii., pp. 479-672 (reprint No. 1404),

blunt point. The width of each prong is about equal to one-third of the incision.

(19) *Anchorella scomberi*, Bassett Smith.—Plate VI.

This species is here recorded for the first time from the Irish Sea, and has been found on the gill rakers of mackerel caught off Walney and in Carnarvon Bay in 1905.

(20) *Anchorella paradoxa*, van Beneden.—Plate VII.

Another Copepod parasite from the mackerel, not previously recorded for the area. It is found on the gill filaments, and thus differs in its habit from *A. scomberi*. This species is quite distinct from all the other British members of the genus, and is probably not an *Anchorella* at all. The male of *A. scomberi* has two pairs of maxillipeds, but I find after a careful examination that the male of *A. paradoxa* has only one pair.

(21) Fish Eggs.—A table showing the distribution from month to month is given on page 33. Two interesting records have been obtained from the examination of the plankton collected in 1905. The first and most important is the occurrence of plaice eggs at an earlier date than any previously known to us. On January 26th a spent female plaice was caught in the steamer's trawl net when at work off Aberystwyth, and two plaice eggs were captured in the surface tow-net. A bottom tow-netting taken on the same ground on December 15th contained one plaice egg in which the developing larvae was clearly visible. From the appearance of the larvae it is concluded that this egg had been spawned ten days earlier than the date on which it was captured. The occurrence of this egg seems to indicate that some of the plaice on the South Wales coast spawn early in December, and about very much the same time as plaice frequenting certain areas of the North Sea. The other point is the finding of the eggs of the spotted

dragonet *Callionymus maculatus*. The fish has already been recorded from the Irish Sea, but the eggs have not been met with in the district. So far we have only found them on two occasions—at Red Wharf Bay on July 5th, and at Port Erin on the 8th. They can only be distinguished from the eggs of the common dragonet by measuring the size of the hexagonal markings. The hexagons are much smaller in the egg of *C. maculatus* than in *C. lyra*.

(22) *Young Fishes.*—A large number of post larval pleuronectids were found amongst the plankton collected in March and April extending from Cardigan Bay to Liverpool Bar Lightship, and also in the neighbourhood of Port Erin. One young sole, 7·5 mm. long, was taken in Tremadoc Bay on June 21st, post larval brill near Puffin Island on June 28th and off Blackpool on July 4th, post larval *Zeugopterus* in Ramsey Bay on July 11th. Post larval stages of gadoids, *Belone*, rockling, weevers and *Liparis* also occurred occasionally in various parts of the district.

Explanation of Plates.

Plate II.

Pontella lobiancoi, Canu.—

Fig. 1—Female seen from above, n.s. 4 mm. × 18.
,, 2 ,, antennule. × 45.
,, 3 ,, rostrum. × 68.
,, 4 ,, endopodite of first foot. × 143.
,, 5 ,, fifth pair of feet. × 68.
,, 6 ,, abdomen seen from left side. × 45.

Plate III.

Pontella lobiancoi, Canu.

Fig. 1—Male seen from above, n.s. 3·7 mm. × 18.
,, 2 ,, rostrum. × 90.
,, 3 ,, right antennule. × 45.
,, 4 ,, right antennule, hinge joints. × 136.
,, 5 ,, fifth pair of feet. × 68.

Plate IV.

Giardella thompsoni, n. sp.—

Fig. 1—Male seen from above, n.s. 1·37 mm. × 68.
,, 2 ,, antennule. × 90.
,, 3 ,, antenna. × 90.
,, 4 ,, mandible. × 293.
,, 5 ,, first maxilla. × 293.
,, 6 ,, second maxilla. × 190.
,, 7 ,, maxilliped. × 136.
,, 8 ,, first foot. × 136.
,, 9 ,, third foot of endopodite, 2nd and 3rd joints only. × 136.
,, 10 ,, fourth foot. × 136.

Plate V.

Monstrilla anglica, Lubbock.—

Fig. 1—Female seen from above, n.s. 2·4 mm. × 22.
,, 2—Male seen from above, n.s. 1·4 mm. × 45.
,, 3— ,, inner edge of last joint of antennule. × 570.
,, 4—Female abdomen. × 102.
,, 5— ,, fifth pair of feet. × 190.
,, 6—Male fifth pair of feet. × 190.

Plate VI.

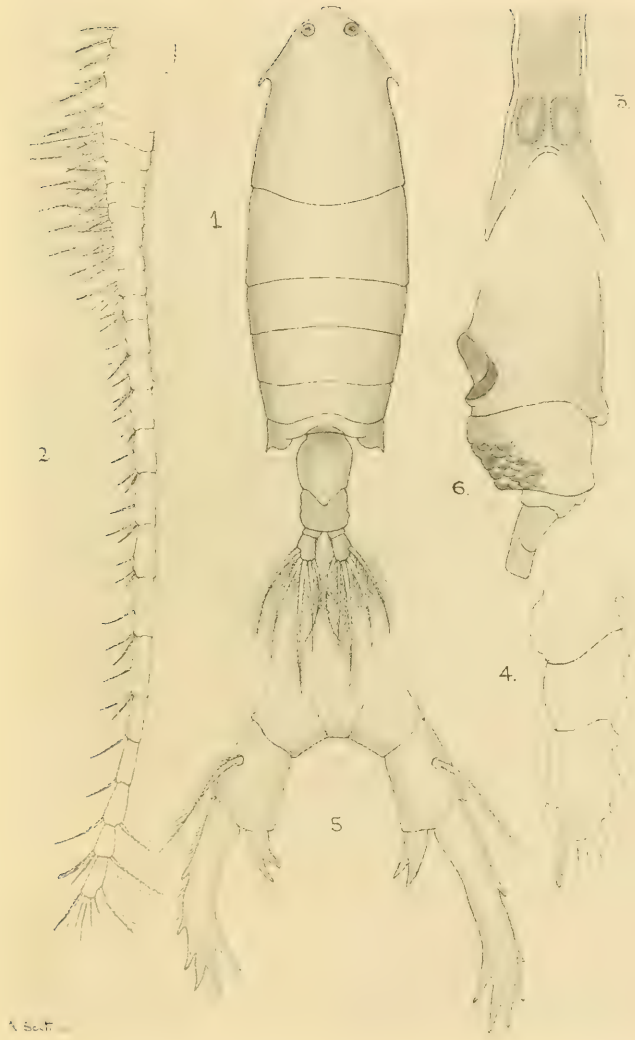
Caligus scomberi, Bassett-Smith.—

Fig. 1—Female seen from above, n.s. 5·57 mm. × 18.
,, 2— ,, antennule. × 136.
,, 3— ,, antenna. × 90.
,, 4— ,, first maxilliped. × 90.
,, 5— ,, second maxilliped. × 90.
,, 6— ,, fourth foot. × 68.
,, 7— ,, sternal fork. × 190.

Plate VII.

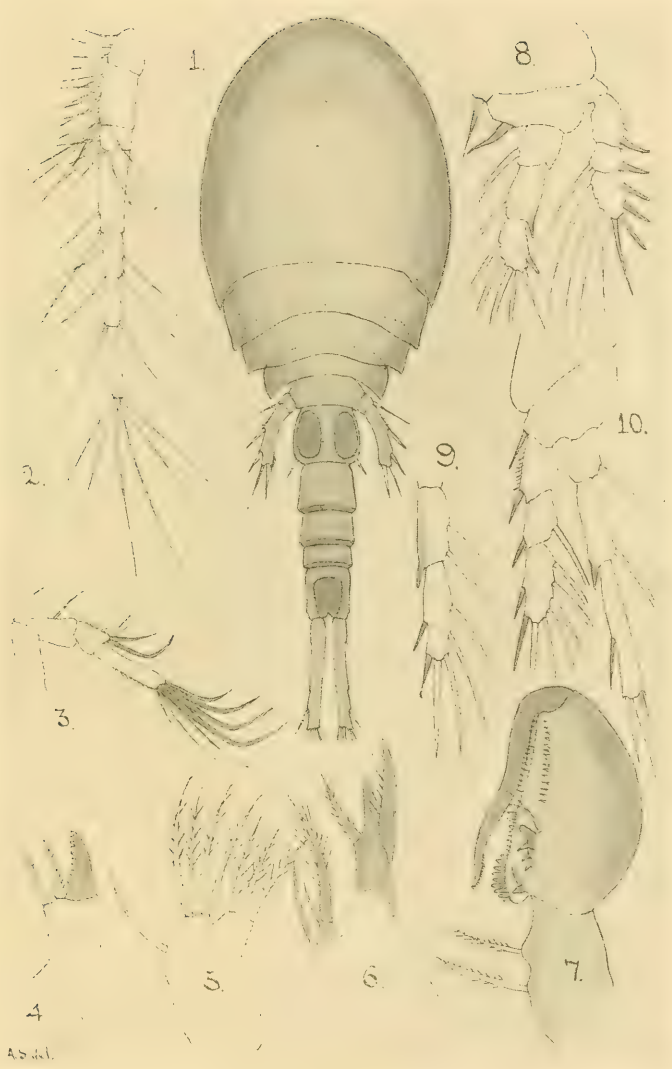
Anchorella scomberi, Bassett-Smith.—

Fig. 1—Female *in situ*. × 4·5.
,, 2—Female. × 7·5.
,, 3—Male. × 45.
,, 4—Female antennule. × 293.
,, 5— ,, antenna. × 293.
,, 6— ,, mandible. × 586.
,, 7— ,, maxilla. × 293.
,, 8— ,, maxilliped. × 190.
,, 9—Male first maxilliped. × 293.
,, 10— ,, second maxilliped. × 293.

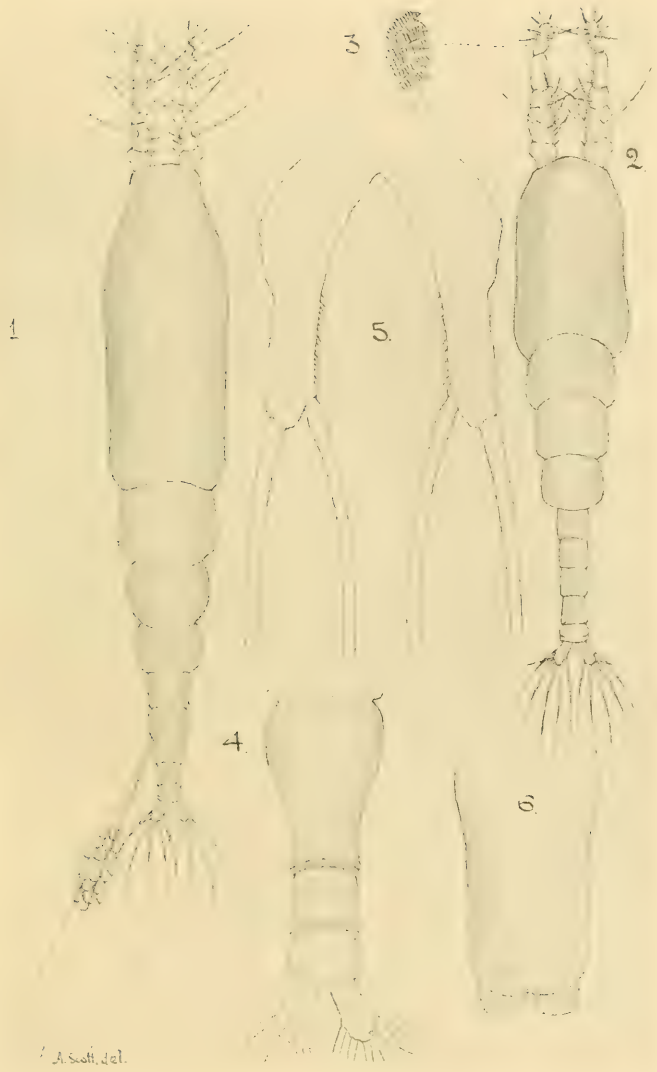


PONTELLA LOBIANCOI, Canu., female.

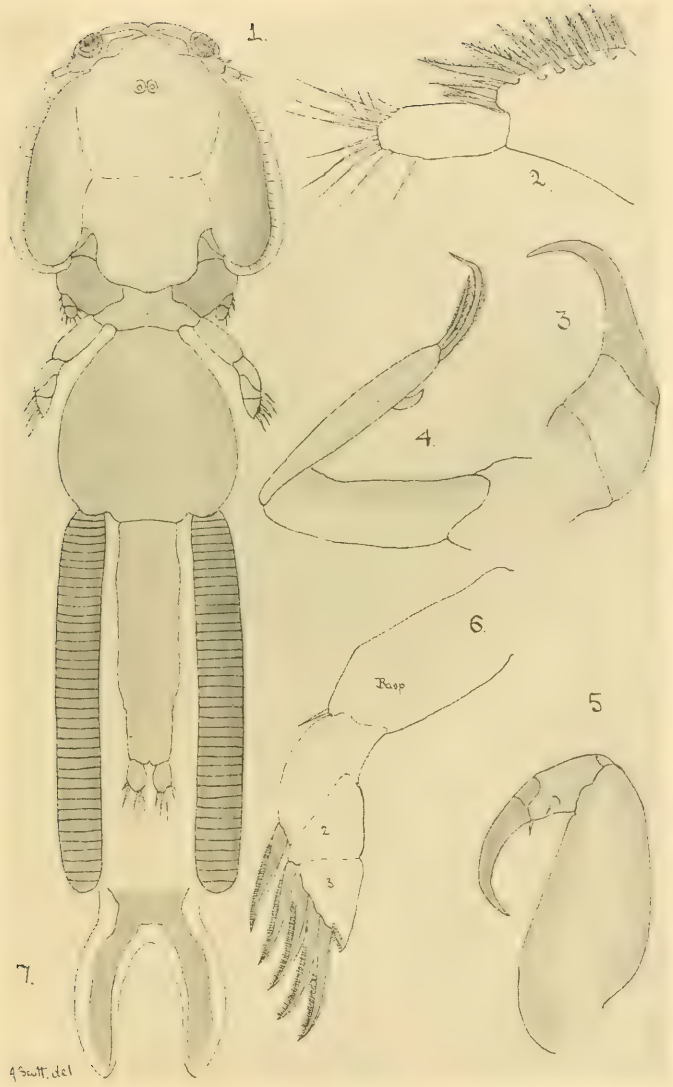
Pontella lobiancoi, Canu, male.



GIARDELLA THOMPSONI, n. sp.

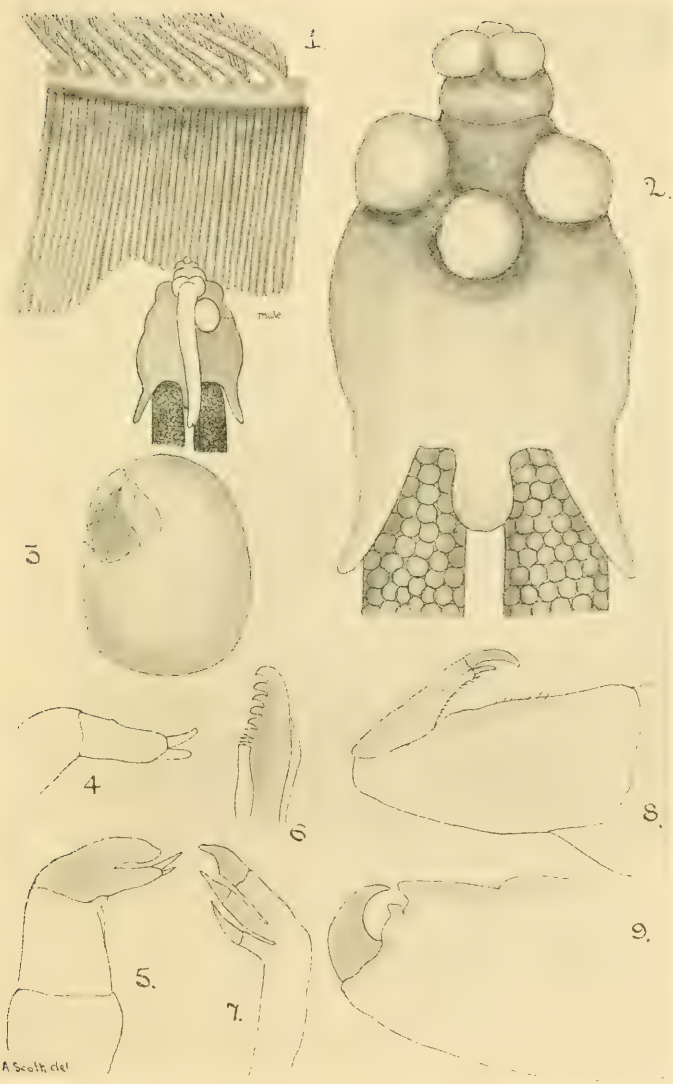


MONSTRILLA ANGLICA, Lubbock.



CALIGUS SCOMBERI, Bassett-Smith.

ANCHORELLA SCOMBERI, Bassett-Smith.



ANCHORELLA PARADOXA, van Beneden.

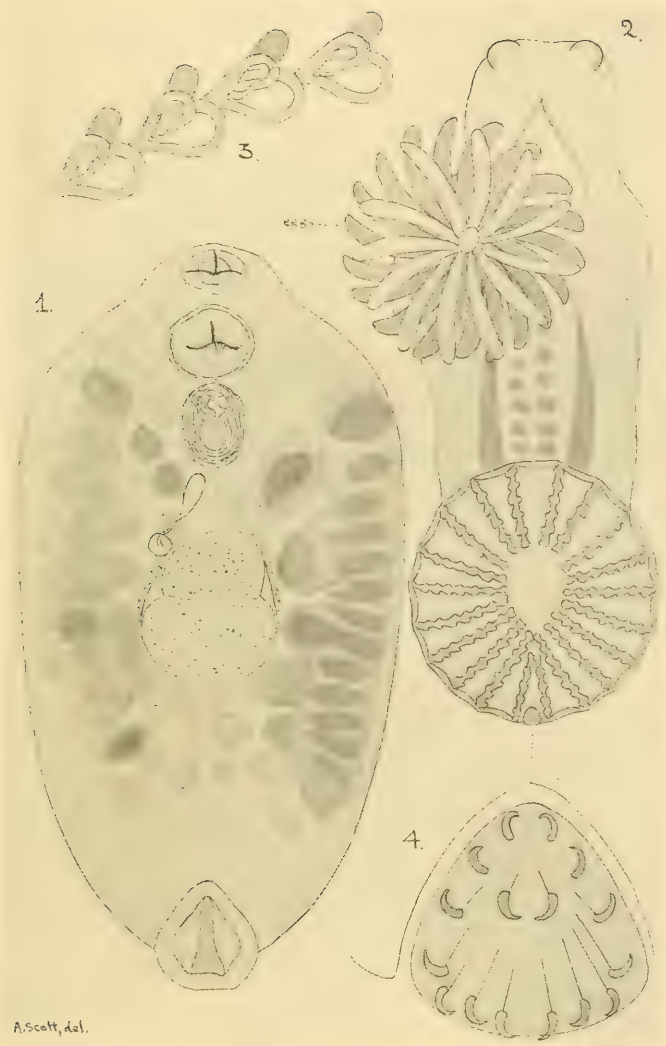


FIG. 1. ? EPIBDELLA, sp.
FIGS. 2-4. ACANTHOTYLE, sp.

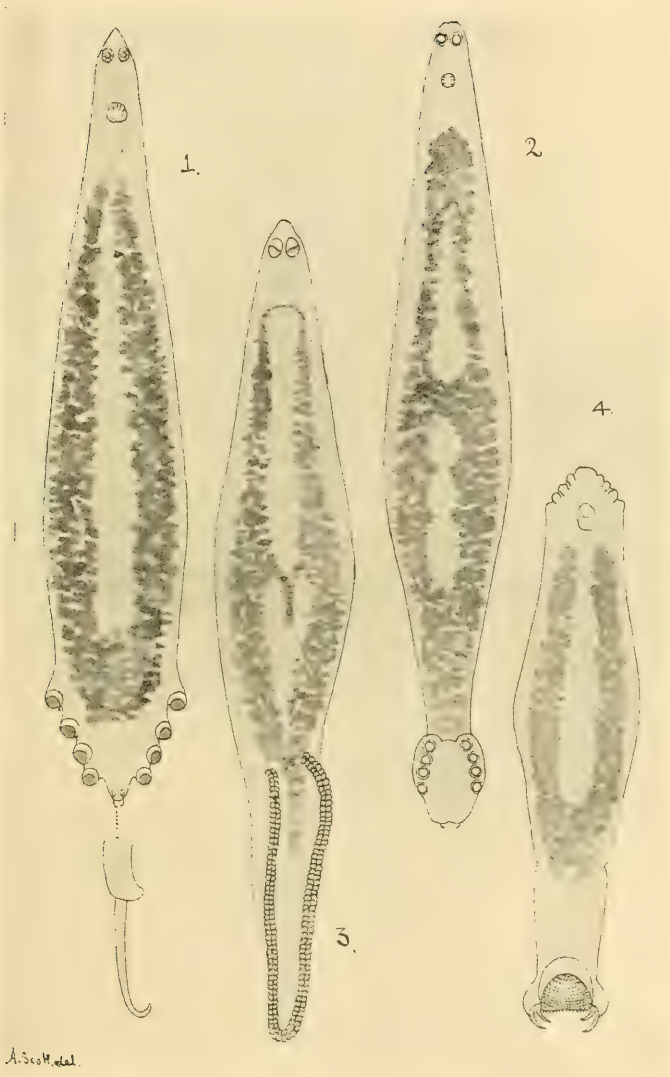


FIG. 1. OCTOBOTHRIUM ALOSAE, Hermann.
FIG. 2. ,, SCOMBERI (Kuhn).
FIG. 3. MICROCOTYLE LABRACIS, v. Ben. & Hesse.
FIG. 4. DIPLECTANUM AEQUANS, Diesing.

Plate VIII.

Anchorella paradoxa, van Beneden.—

Fig. 1—Female *in situ*. × 45.
,, 2— ,, (back view). × 18.
,, 3—Male. × 24.
,, 4—Female antennule. × 293.
,, 5— ,, antenna. × 190.
,, 6— ,, mandible. × 293.
,, 7— ,, maxilla. × 293.
,, 8— ,, maxilliped. × 190.
,, 9—Male maxilliped. × 136.

Plate IX.

Epibdella, sp.—

Fig. 1—Seen from ventral surface. × 45.

Acanthocotyle, sp.—

Fig. 2—Seen from ventral surface. × 45.
,, 3—Teeth of one of the rays. × 353.
,, 4—Adhesive disc. × 586.

Plate X.

Fig. 1—*Octobothrium alosae*, Hermann, seen from ventral side. × 15.
,, 2—*Octobothrium scomberi* (Kuhn), seen from ventral side. × 18.
,, 3—*Microcotyle labracis*, van Ben. and Hesse, seen from ventral side. × 14.
,, 4—*Diplectanum aequans*, Diesing, seen from ventral side. × 34.

MUSSEL TRANSPLANTATION AT MORECAMBE.

By Andrew Scott, A.L.S., and
Thomas Baxter, Member of the Sea Fisheries Committee.

History of the Beds.

The mussel beds at Heysham, near Morecambe, usually known as the Morecambe mussel beds, have long been famous. They are undoubtedly the most extensive mussel producing grounds in the district under the control of the Lancashire and Western Sea Fisheries Committee, and perhaps also on the whole of the western seaboard of England. The quantity of mussels present at any time amounts to many thousands of tons. There are probably more mussels on these beds, than on all the other beds in the district put together. The animals are in good condition during the season, and are favourably regarded by the consumer. That this is actually so is shown by the fact that various fish-salesmen throughout the county, and especially in Manchester, place orders at the beginning of the season with many of the Morecambe fishermen for a definite number of bags each week. Consequently we find from the returns supplied by the Midland, and London and North Western Railway Companies, at Morecambe, that large quantities are sent away annually. The average quantity sent off during the past five years, up to the end of March, 1905, amounts to close on one thousand nine hundred tons per annum.

Although we have not been able to find very much information that could throw light upon the point, we regard the mussel beds at Heysham as having been in existence for a very long time. It is possible that many of the ancestors of the present mussels were used in

making the mortar for building the first church at Heysham. The mortar consists of burnt sea-shells and is almost indestructible. The original church, traces of which are still discernable, is supposed to have been founded by a colony of Irish Christians in the sixth or seventh century. Heysham or Hessam is mentioned in the Domesday Survey, and was one of the towns of the Saxon Manor of Halton. The salmon fishery of the Lune at Lancaster was granted to the Abbey of Furness by Stephen, Earl of Boulogne, confirmed by Henry I., and further confirmed by Henry III., but we are unable to state whether this grant also included the fishery at Heysham or not. At any rate, it is well known that the mussel beds of Heysham were at one period farmed by the Lord of the Manor, and receipts over six hundred years old, for farming the beds, are preserved with the early documents of Hornby Castle. There is also evidence that the beds were in existence three hundred years ago. From an interesting work "An History of Richmondshire in the "North Riding of York, together with those parts of the "Everwicschire of Domesday which form the Wapen-"takes of Lonsdale, Ewecross, and Amunderness, in the "Counties of York, Lancaster and Westmoreland, by "Thomas Dunham Whitaker, LL.D., F.S.A., Vicar of "Whaley and Blackburn, Lancashire," Volume II., 1823, we quote the following statement compiled from a survey of Heysham parish in 1584, which throws a good deal of light on the customs of former days. "This "manor (Heysham) was divided between free tenants and "tenants at will, of whom the free tenants paid annually "to the lord £18 6s. 9d. and a pair of spurs; tenants at "will, £18 11s. 6d. . . . . Boon journeys were due "to the Barton of Heysham. . . . There were four-"teen persons who farmed the mussel fishery for the rent

"of £11 5s. in return for which, they were free to gather "mussels on the lord's sands. . . . The lord had also "profit of court, estrays, goods of felons, and wrecks of "the sea, the last of which might be very productive." The manor of Heysham in the time of Henry VIII. is stated to have been worth rather more than £50 per annum. It thus appears that the mussels in those remote days were of considerable importance and money value to the local fishermen. They were also a valuable asset to the lord of the manor, producing fully one-fifth of the profits of the whole manor. In the article on mussels in the Encyclopædia Britannica, Vol. XVII., 1898, p. 110, it is stated, "The chief localities of natural scalps on the "British coast are Morecambe Bay in Lancashire, the "flat eastern shores, especially that of the Wash in "Lincoln and similar shallow bays."

Coming to our own experience, we find, from conversations with the older fishermen in Morecambe, that the conditions of the mussel skears to-day are practically the same as they were fifty and sixty years ago. This area, like all other shellfish beds, is subject to various influences over which man has no control. New banks are formed by the action of the tides, and growth of the shellfish. The channel may alter a little and smother the mussels with sand, or undermine the outlying beds so that they are gradually disintegrated by the currents. Every winter many hundreds of tons are swept away by the gales into deeper water and lost. An invasion of starfish may depopulate a whole skear, leaving only a mass of empty shells behind them. Before the advent of railways or the institution of Sea Fisheries Committees, the fishermen and local farmers used large quantities of the smaller mussels for manure. This system of destruction, which may be regarded now as an extremely

wasteful one, perhaps did more good than harm. It helped to secure a better quality of mussel than could possibly be derived from an over-populated bed. The clearing away of large quantities of small mussels gave those that were left more room to spread over the skears, increased growing space and a better chance to obtain an efficient food supply. The result eventually, as we find now, would be a larger mussel, and a well-filled shell, instead of a stunted one with very little inside it. We look upon the removal of the smaller mussels in days gone by, as a crude attempt to improve the condition of the skears, and a forerunner of transplanting now conducted, with the authority and assistance of the Sea Fisheries Committee. In former days all the mussels removed for manure were utterly lost, but the present system involves no waste of any kind. The mussels are simply removed from an over-populated or starved bed to a fresh area where there is plenty of growing room and food.

In the pre-railway days the large mussels were hawked about the neighbouring villages and sent inland in great quantities. On the completion of the railway, then known as the Little North Western, to Morecambe, in 1847, a better and more rapid method for distributing these shellfish was opened to the fishermen which was quickly taken advantage of. The improved facilities for conveying the mussels to the large towns of the county gave rise to an increase of the fishing population, and was one of the causes that led up to the great trial in 1874 between the fishermen and the lords of the manor.

The original grant of the fishery at Heysham, which is thought by some people to have been given in the tenth century, included all the area from the middle of the Kent flowing into Morecambe Bay, to the middle of the

Lune, and no fishing could take place without the consent of the lords of the manor. Thus Morecambe, or Poulton as it was formerly called, had no free fishery. The enhanced value of the mussel beds through the opening of railway communication became apparent, and led to much friction between the lords of the manor and the fishermen. The former asserted their right to claim rents for permission to remove the mussels, while the latter disputed the existence of any documents that gave the lords of the manor control of the fishery. The dispute ended in a trial at Lancaster, when the verdict went in favour of the fishermen being entitled to free fishing. Shortly after this verdict was given, the lords of the manor asked leave to appeal against the decision of the court on the grounds that important evidence had been secured since the trial. The judge, however, ruled against the lords and from that time onwards the fishing has remained free.

At the present time considerably over 100 men, or fully one per cent. of the present population of Morecambe are more or less engaged in mussel fishing. At the last census the population was 11,798.

The following statistics of the mussels sent off by rail during the last five years, are supplied by Mr. Edward Gardner, Honorary Fishery Officer at Morecambe:-

	1900-01.	1901-02.	1902-03.	1903-04.	1904-05.
	Cwts.	Cwts.	Cwts.	Cwts.	Cwts.
September ...	2431¾	2063¼	6882¾	4857¾	3747
October	7459½	6143¼	10051¼	6502½	7817¾
November ...	7334½	7244	8761¾	5787	6086¼
December ...	4062¼	4436½	5976¼	4162	3488
January	6202½	6131¾	6465½	3761	4807¾
February	3880¾	4659¼	5495¾	4240	3931¼
March	3422¼	2703½	4488½	3873	2940¾
April	2098¼	2141¼	1711¼	1533	—

Description of the Skears.

The mussel beds at Morecambe are locally known as "skears," a term which is also applied to any rough ground, and each has a particular name amongst the fishermen. A few of the beds are situated in front of the town itself, but the most extensive and most valuable are those at the top of Heysham Lake. The latter present, at low water of a spring tide, an almost unbroken line, over two miles in length, and are in the form of a tongue-shaped projection extending from the shore in front of the Grosvenor Hotel, very nearly due West into Grange Channel. At the shore end the beds are nearly half a mile wide, but gradually taper off as they reach the deep water. This extensive bank is divided in the centre by two narrow passages that never ebb dry. The floor of the beds in general is hard ground which has become covered in many places by the tubes of the "knaar"-forming worm, *Sabellaria alveolata*. After a "strike" of mussels takes place mud accumulates and in time the mussels appear to be growing on the top of a mud bank. When the mussels have been removed during a fishery, or by the action of storms, the hard ground is exposed again. At high water the whole of the beds is covered to a depth of many feet, and they can then only be fished with the long "craam," and this instrument has to be worked from a boat. The handle or shaft of the long craam is sometimes between thirty and forty feet in length.

The accompanying chart* shows the skears and gives the name of each one. We are much indebted to Mr. Edward Gardner, the honorary bailiff at Morecambe, for information relating to the mussels, which has been of much assistance to us, and to several of the fishermen who

*The chart has been carefully copied from the rough draft, and is the work of Mr. Johnstone.

represented Morecambe as Fishermen Students in the various classes held at Piel, for help in the survey of the beds and in the preparation of the chart.

In front of Morecambe, the most important areas are the "Ringhole," now used for depositing the mussels removed from the overcrowded beds, "Baiting Knott" and "Stone Skears." These two are small banks where mussels grow very rapidly and take on shells of a fine uniform structure. A little beyond the West End Pier, a large bank with three mussel beds is shown, the major portion of this is the "Old Skear," on the top of which is a hedge baulk ("old Dick Bond's") for catching fish, a structure composed of stakes driven into the ground and the whole interlaced with twigs. The other two beds, though small, produce fine mussels, and are known as "Seldom Seen" and "Reap Skear." The three beds are connected with each other by skear ground, which is also suitable for growing mussels. The beds at Heysham though more or less continuous have all local names. Starting from the shore under the hotel there is a tract of sand, and then another of stones. These lead to "Heysham Flat," a mussel bed nearly half a mile square. The westerly portion of this area is usually covered with good mussels and was one of the regions thinned in April, 1905, when 1,362 bags of mussels were removed to the "Ringhole" in three days. There is a hedge baulk ("Fell's") on the top of the bank. A large boulder of granite many tons in weight lies on the middle of the flat, and on the South side there are a number of small boulders locally known as the "freestones." Attached to "Heysham Flat" are two more beds known as "Knott End" and "Whelk Hill" Skears. "Knott End Skear" is about one quarter of a mile square, and is covered with a vast number of mussels. In six days during the trans-

planting work in 1905, 3,272 bags, or over 240 tons of undersized mussels were removed to the "Ringhole." "Whelk Hill" is another valuable skear. The "Old Gunnel," on the North side of "Heysham Flat," is a deep water mussel bed that never comes adry. The "Great Gunnel" and "Little Gunnel," separated from each other at low water by "Little Out-skear," are narrow water-ways leading between Morecambe Channel and Heysham Lake. "Little Out-skear" is a small but important bed, and close to it is another little mussel skear known as "Cockup." The bottoms of the two gunnels are also covered with mussels. The outer portion of the Heysham beds forms a continuous bank over a mile in length, by about a quarter of a mile wide at the shore end and tapering off as it reaches the channel. It is known by the names of "Great Out-skear," "Bank Side Skear," and "Jacky John Skear," the latter being the end of the whole series of mussel beds. "Bank Side" and "Great Out-skear" were found to be covered with mussels about a year old, when visited in June, 1905. "Low Skear" is a valuable bed situated at the bottom of Grange Channel. "Walmsley Skear" outside "Heysham Flat," was formerly a mussel bed, but is now smothered with sand. "Patrick Skear" in Heysham Lake is another small but productive bed, and is covered with large sand knaars. "Lake Skear," below the entrance to the Harbour at Heysham, is occasionally fished when the weather permits.

Special Notes on the Skears.

The above Skears may be divided into two sets. (1) Those that ebb dry at low water of an ordinary spring tide: Stone Skear, Baiting Knott, Reap Skear, Old Skear, Heysham Flat, Knott End, Little Out-skear, Great

Out-skear: and (2) the deep water skears that seldom or never dry at low water even of a very high spring tide, where the mussels have to be fished for with the "long craam": Little Skears, Ringhole, Seldom Seen, Old Gunnel, Whelk Hill, Cockup, Great Gunnel, Little Gunnel, Bankside, Jacky John, Low Skear, Patrick Skear.

The depths of water on the skears at low water of a sixteen feet tide is as follows:—

Little Skears ...	4 to 6 ft.	N. side of Gunnels	10 to 14 ft.
Ringhole ...	10 to 20 ft.	Great Gunnel ...	5 to 15 ft.
Reap Skear ...	4 to 10 ft.	Little Gunnel...	5 to 10 ft.
Seldom Seen ...	4 to 10 ft.	Bank Side ...	6 to 20 ft.
Old Gunnel ...	4 to 10 ft.	Jacky John ...	18 to 25 ft.
		Low Skears ...	20 to 30 ft.

History of the Transplanting.

When the Lancashire Sea Fisheries Committee was established about the end of 1891, the wholesale removal of mussels, for purposes other than food or bait, was put an end to. One of the Bye-laws prohibited fishing for mussels except by hand; or with a rake not exceeding three feet in width, and used only from a boat when the bed was covered with at least four feet of water. Another Bye-law prohibited the removal of any mussels less than two and a quarter inches in length. These Bye-laws worked well for some years, and would have remained satisfactory for an indefinite time, or so long as the production of new generations did not greatly exceed the quantity of legal sized ones removed by the fishermen. The mussel beds in the district are of all sizes, and the conditions in some places more favourable for the production of new stock than in others. So far as our knowledge goes the Heysham Skears are the most prolific

in the whole area supervised by this Committee. These skears were amongst the first to show the effect of the Bye-laws. The over-production was much greater than the removals, and in a few years the beds became overcrowded with the new generations. The additions settled on the top of the older stock and soon grew over them. In some instances the older layers were eventually smothered. In others an efficient food supply was prevented from reaching them and they slowly starved. The result was, the fishermen found it more and more difficult to get their orders completed with legal sized mussels, and they occasionally took the smaller ones. This brought the men into conflict with the officers of the Committee, and prosecutions naturally followed. The difficulty in complying with the two and a quarter inch size limit, without evil consequences to themselves, led the fishermen to approach the Committee with a petition, for the reduction of the size limit to two inches. After much agitation on the part of the men, the Bye-law was revised and two inches became the minimum legal size in 1902. This concession in the size limit was practically made to allow a greater thinning to be done. So far as Heysham was concerned, the reduction in limit had very little effect. The over-production still greatly exceeded the removals and the difficulty in obtaining sufficient legal size mussels continued. A further reduction in the size limit would have proved unsatisfactory from the consumers' point of view. Large mussels have the preference over the smaller ones and also command a higher market value. Other solutions to this problem had to be looked for, and finally a system of thinning was adopted. This thinning had a two-fold object. (1) To remove large quantities of small mussels from over-crowded beds leaving the remainder more growing space; and (2) to re-stock older

beds that had been depleted from various causes, or establish new beds on suitable ground, either with the mussels removed from their original site or with others taken from areas altogether unfavourable for growth.

We might point out here that this solution had been advocated for some years in the Annual Reports on the Sea Fisheries Laboratory. Professor Herdman in the first of these Reports,* referring to the destruction that occurred amongst the mussels in the southern Division, says, "This miserable waste could probably be prevented "by providing fixed objects for the mussels to attach to, "and by taking care of the young beds when once they "were established, by thinning out from some places and "laying down in others," &c., and again in the general conclusions in the Report upon the methods of oyster and mussel culture in use on the West coast of France†, "Expressed briefly my opinion is that where mussels are "grown successfully on the bed system the best we can "do is to farm these beds carefully." Further, in the conclusion on the Report on the mussels and mussel beds in the Northern Division, by one of us,‡ referring to the favourable conditions for the production and rearing of the mussels, the following solution was offered. "All "that is necessary is to remove some of the seed mussels "from the beds where they are too crowded to places "where they are few in number or entirely absent. Many "of the mussels on the various beds under the present "conditions are certain to be lost, through having too "little room to grow, when consequently they either get "choked off and perish miserably, or become so stunted

* Lancashire Sea Fisheries Laboratory Report for 1892, page 39.

† Lancashire Sea Fisheries Laboratory Report for 1893. Appendix, page 79.

‡ Lancashire Sea Fisheries Laboratory Report for 1895, page 30.

" in their growth as to be of little or no marketable value " either as bait or food. Under the present conditions " the beds are allowed to seed themselves, and consequently " it takes much longer for the mussel to spread over any " considerable area than if the young mussels were trans- " planted from places on the present beds where they are " too close to new ground. By this means the mussels " would certainly reach a marketable size much sooner " than if left to look after themselves, and a convenient " time for moving the seedlings would be when the close " season begins, as they would be less liable to be dis- " turbed than if done at any other period, and by the " time the close season had expired they would, no " doubt, have firmly established themselves under their " new conditions." We reproduce these remarks in case any of the Members of the Committee have no copies of the earlier reports, and to show that over-production has been going on for a long period.

Early in 1903 the Sea Fisheries Committee passed a resolution granting a sum of £50 to enable the Morecambe fishermen to thin the overcrowded beds.* The money was not intended to be regarded as a payment for the work, but rather a small inducement to the men to do something that would eventually be for their own benefit. In April of that year a large number of men gave several days to the work for a very little sum, and one or two days for practically nothing. The transplanting was not completed when the money had all been expended, but the fishermen, recognising the importance of the work, and to mark their appreciation of the assistance from the Committee, continued the operations for a few days longer. The quantity of mussels transplanted then was

*Mr. John Fell, then Chairman of the Committee, did much to bring about the initiation of this successful result, and the improvement in the mussel fishery at Morecambe dates from that time.

estimated to be about two hundred tons. The results from the thinning and transplanting proved satisfactory, and the Committee felt justified not only in continuing the work but also extending it to other places.

In March, 1904, the Joint Committee granted £75 for re-stocking mussel beds at Morecambe, Overton in the Lune, and Flookburgh. The Finance Committee allocated the money as follows:—Morecambe £50, Overton £15, and Flookburgh £10. The work at Morecambe commenced on the 18th of April and went on to the 5th of May. About sixty men were employed in the operations, and the mussels were removed to the selected places by boat. The sum paid to each man was 3s. per tide. This left a deficit of 5s., but the payment of that and also of some men who worked an extra tide was arranged for by the Morecambe Fishermen's Association. The quantity of mussels removed to new beds was about 3,174 bags or nearly two hundred tons. The following table shows the quantities taken from certain particularly over-crowded skears and where the surplus mussels were laid down*:—

Date.	Places.	No. of bags taken.
April 18th, May 4th and 5th	Taken from Heysham Flat near Fell's Baulk and laid down in Ringhole	1180
April 26th and May 3rd	Taken from Heysham Flat near Fell's Baulk and laid down in Old Gunnel and Ringhole ...	580
April 27th	Taken from Big and Little Out Skears and laid down in Old Gunnel and on Seldom Seen Skear	300
April 28th and 29th	Taken from Big Out Skear and laid down on Seldom Seen Skear	834
April 30th	Taken from Heysham Flat near Fell's Baulk and laid down in Old Gunnel	280
	Total ...	3,174

Transplanting at Overton took eight days, and during that period 1,345 bags were removed from existing beds and deposited in the Channel as shown in the table. Here again the grant was expended before the work was finished, but the men continued without pay and completed the operation* :—

Date.	Places.	No. of bags taken.
April 18th & 19th	Taken from Anchor Skear, and laid down in the Channel near the Weir	510
April 20th	Taken from Abbey Light Skear, and laid down in the Channel above and below the Lighthouse	195
April 21st	Taken from Crook Skear, and laid down in the Channel above the Lighthouse ...	280
April 23rd	Taken from Crook Skear, and laid down in the Channel below the Lighthouse ...	210
April 25th	Taken from Crook Skear, and laid down in the Channel near the Weir	250
	Total	1,445

At Flookburgh thirty-three men and fourteen boats were employed during two tides and 220 bags of mussels were transplanted. The mussels were taken from "Roosebeck Skear" and deposited on "Flookburgh Skear." In June, 1904, some of the Southport fishermen made an experiment in transplanting cockles. A quantity was removed from the over-crowded beds to

* *Vide* Superintendent's Quarterly Report for June, 1904.

another place where there were none, and a favourable report was given regarding the results.

The work of transplanting shellfish was continued and still further extended in 1905. At the Joint Committee Meeting held in March, a sum not exceeding £250 was voted for re-stocking shellfish beds. The allocation of the money was left to the Scientific Sub-Commitee, who decided to expend the following sums. For re-stocking mussel beds, Morecambe £75, Overton £15, Flookburgh £15, Knott-end (Fleetwood) £5, Hambleton (near Fleetwood) £5, and Bardsea (near Ulverston) £2 10s. For re-stocking cockle beds, Southport £15 and Lytham £5. The total expended on mussels was, therefore, £117 10s., or an increase of £42 10s. over the sum spent in 1904.

At Morecambe, where the bulk of the money was expended and the most important part of the operations were carried out, the transplanting began on April 12th and finished on May 2nd. The work was done during the neap tides and in the period of three weeks there were nine working days. On some of the days sixty-four men and thirty-two boats were employed. Over 4,634 bags, estimated at 347 tons of mussels, varying from one and five-eighths to one and seven-eighths inches in length, were removed and deposited in the "Ringhole," from which the mussels previously laid down had been removed. To mark their high appreciation of the efforts of the Committee to assist the shellfish industry, the Members of the Morecambe Fishermen's Association passed a resolution that no fishing of the transplanted mussels would take place before November 13th—a resolution which was loyally kept.

The following table shows the number of bags removed each day:—

Date.	Places.	No. of bags taken.
April 12th	Taken from old Dick Bond's Baulks (Old Skear), and laid down in the Ringhole	480
April 13th	Taken from old Dick Bond's Baulks (Old Skear), and laid down in the Ringhole	448
April 14th	Taken from old Dick Bond's Baulks (Old Skear), and laid down in the Ringhole	434
April 15th	Taken from Knott end Skear and laid down in the Ringhole	640
April 25th	Taken from Knott end Skear and laid down in the Ringhole	460
April 26th	Taken from Knott end Skear and laid down in the Ringhole	625
April 28th	Taken from Knott end Skear and laid down in the Ringhole	532
April 29th	Taken from Knott end Skear and laid down in the Ringhole	475
May 2nd	Taken from Knott End Skear and laid down in the Ringhole	540
	Total	4,634

The transplanting at Overton was done in four days, and 946 bags were removed to new areas. The quantity is less than in 1904 and is accounted for by the fact that the mussels were carried a greater distance. In some cases boats were used, in others carts, for conveying the mussels. The work gave employment to thirty men. (Superintendent's Quarterly Report, June, 1905, from which these figures and those below are taken):—

Date.	Place.	No. of bags taken.
April 12th	Taken from Abbey Skear and laid down in the Channel	240
April 13th	Taken from Abbey Skear and laid down in the Channel	204
April 14th	Taken from Crook Skear and laid down in the Channel	276
April 15th	Taken from Crook Skear and laid down in the Channel	144
	Total	*864

At Flookburgh two days—April 10th and 11th,—were given for the transplanting. On the first day, thirty-five men and fourteen boats were employed, on the second day, eighteen men and nine boats. The mussels were taken from "Roosebeck Outer Skear" and laid down on "Cope Skear." The total number of bags was 230 and the average size of the mussels removed was about one and three quarter inches.

The transplanting at Bardsea was also done in two days, May 2nd and 3rd. Six men and two carts were employed and thirty-four cartloads of under-sized mussels were removed to a new area.

At Hambleton, 420 bags of mussels were taken from the River Wyre and laid down in "Staining Hole," and at Knott End 330 bags were removed from various unfavourable skears and laid down in deep water. Although this is the first time that the industry in the Wyre and at Bardsea has been assisted by the Committee, the men belonging to Hambleton made an experiment in transplanting in 1904 which gave very satisfactory results.

The following is a short account of the procedure adopted in the transplanting at Heysham. A

* In May an additional hundred bags were taken from the Skears and laid in the Channel.

meeting of the Morecambe Fishermen's Association is held and instructions are given to the men to the effect that a definite sum of money has been allocated to them for transplanting undersized mussels. Suitable days are fixed, and also the hour when the work should commence. The skears to be dealt with are also decided upon. On the day appointed, the fleet of boats, each manned by two or three fishermen, set off from Morecambe so that the skears are reached some time before low water. The

Fig. 3.—General view of Skears, with men at work.

boats are there either anchored or run ashore, and the men at once begin work. Each man has a basket and a craam, a sort of toothed rake; with this instrument he rapidly rakes the mussels into the basket. When it is filled, the whole contents are washed in the sea water and then transferred to the boat.* The operation is repeated until

* Occasionally some of the mussels are fished from the deeper water by means of the long craam. According to the fishermen these give the best results.

the boat has as much as it can carry in safety—from ten to fifteen bags, representing a weight of from three-quarters of a ton to over one ton of mussels. As soon as the boats are loaded they sail for the selected area. Each one anchors as it arrives, and all are inside a portion that has been previously marked by buoys. Two men station themselves beside the mussels each armed with a shovel, while a third man attends to the anchor rope. Captain Wright, the Chief Officer of the Northern Division,†

Fig. 4.—Collecting and washing the mussels.

usually supervises the arrangements. As soon as he sees that every boat is ready and not too close to its neighbours, a signal is given to unload. As the men discharge the mussels, the man attending to the anchor pays out the rope and allows the boat to drift slowly with the tide. The boat is kept moving so that the mussels will not be deposited in a heap on each side. On every successive

† Who has given us much valuable assistance.

day a new portion of the selected area is buoyed, and there is thus no overcrowding. In 1905 all the transplanted mussels were deposited in the "Ringhole," a local name for that portion of Morecambe channel extending from the West End Pier to about midway between the old harbour and Central Pier. At the end of the operations the "Ringhole" was inspected at a very low ebb by one

Fig. 5.—A loaded boat and fishermen using the craam.

of us, when it was found that the bottom was well covered with mussels and all had become attached. The illustrations in the text are reproductions from photographs taken on April 15th. On that date sixty-four men and thirty-two boats were employed and forty-eight tons of mussels were transplanted in a single tide.

The money voted for re-stocking cockle beds resulted in the transplanting of about 300 bags at Lytham and 260 bags at Southport.

Result of the Transplanting.

The transplanting work has been a complete success from its inception. In the late Mr. R. A. Dawson's Report for the Quarter ending September, 1903, referring to the Morecambe mussels, it is stated:—"The mussels "that were transplanted here last spring have grown "rapidly, and the fish are of first rate quality. I am "informed the merchants prefer these to the mussels

Fig. 6.—Discharging mussels in Ringhole.

"taken from other beds in that vicinity." That was the result of the first transplanting experiment. Many of the mussels transplanted in 1903 were what are known amongst fishermen as "blue nebs"—very old mussels with thick shells of a dead blue colour, much corroded, especially in the hinge region, and having no epidermis on them. When the shell is opened the animal is usually found to be thin and watery. These mussels are

commonly met with on the sea shore. They are exposed to the air for a long time between each period of high water, and are beyond the reach of a continuous supply of food. "Blue nebs" may justly be regarded as mussels that have ceased growing and are only existing. They are of no money value as food, hence any good return from the transplanting of such mussels would be readily noticed. The result was almost incredible. At the end of about five months, the old, starved, undersized "blue nebs" had grown three-eighths of an inch and reached legal size. The animals were in fine condition and the mussels found a ready market. The fresh growth was sharply defined from the old. This new addition was quite uniform, thin, and of a polished black colour on the outside, a marked contrast to the old ill-shapen and corroded shell. A mussel which under its original condition could never be any use as food had been turned into a valuable commodity at very little trouble and expense. To induce two blades of grass to grow in place of one is the desire of the agriculturist. The result from transplanting "blue nebs" that had not increased in length for years might well be compared with inducing crops to grow on land that had never before produced any. The money value of these mussels that had been transplanted for £50 is estimated to have been at least £500.

The result from transplanting "blue nebs" raised the expectation that something better could be had from thinning the overcrowded and more healthy beds and depositing the excess in new areas. This is now being done at Heysham each season. In 1901 the mussels were taken from various skears that constitute the Heysham beds and deposited in three new areas, viz., "Ringhole," "Old Gunnel" and "Seldom Seen" Skears. The mussels laid down in the former place gave the best results, and in

1905 all the mussels were deposited there. In order to protect the mussels as much as possible from ordinary steamer traffic and fish trawling, they are laid on the landward side of the hole. The mussels in the "Ringhole" are practically always under water. At a very low ebb a few may be exposed for a short time. They are thus placed in reach of a continuous supply of food.

The mussels transplanted to the "Ringhole" in 1905 varied from one and five-eighths to one and seven-eighths of an inch in length. During the months of May, June and July the mussels all over the Northern Division grew very slowly. At the end of August a marked advance was recognisable in the condition of the transplanted mussels. In September the new growth reached half-an-inch. Early in November the mussels had increased five-eighths of an inch, and in December, or seven months after removal, the average increase was found to be six-eighths of an inch. In other words the mussels had grown from about one and seven-eighths to two and five-eighths of an inch – a result largely due to transplanting. The mussels left on the original site had also grown during the seven months. The majority left on the particular beds that had been thinned in April were one and seven-eighths of an inch long or one-eighth under legal size. At the beginning of December they had only grown one-quarter of an inch and had attained a length of two and one-eighth inches, or an eighth of an inch above the minimum legal size. The mussels taken to the "Ringhole" had, therefore, advanced a nett half inch more than those left untouched. Not only that, but the fishermen receive one shilling per bag more for "Ringhole" mussels than they obtain for mussels taken from Heysham Skears.* From November 13th to December

* An ordinary bag of mussels, when sent to the markets, weighs 1¼ cwts.

31st, 262 tons have been recovered.† A hundred average sized mussels taken from the Heysham Skears in December weighed two pounds, and an ordinary bag will contain about 7,000 mussels. A hundred mussels from the "Ringhole" in December weighed five pounds, or 2,800 mussels to the bag. The transplanting had thus increased the bulk two and a half times. The original quantity transplanted was 4,634, which multiplied by two and a half becomes converted into 11,585 bags. Each of these bags has improved one shilling in actual money value above the mussels that have reached a legal size on the original site during the interval. This represents a sum of £579 for transplanted mussels. So that for the expenditure of £75 in April in removing mussels from Heysham to the "Ringhole" there is a nett gain of over £500. The enhanced value of the fishery, however does not end there. It has to be remembered that the thinning of the original beds had led to an improvement in the condition of the mussels that were left, and more mussels have become marketable than could have been possible under the old state of affairs. Taking the fishery all through, we find that there are more marketable mussels to meet the demand and a greater employment for fishermen than formerly. They can now work from their own homes instead of visiting other areas for their supplies. A few years ago, owing to the scarcity of legal sized mussels, some of the men had to reside at Piel and fulfil their orders with mussels from Roosebeck Outer Skear. Taking all things into consideration and allowing for loss from various causes, both in the "Ringhole" and on the thinned beds, since the middle of April, 1905, we venture to state that the money value of the Morecambe mussels

† By the end of February, 1906, a much greater quantity of mussels was taken out than had originally been put in.

will have been increased by at least £800 at the end of the fishing season in 1906, a result entirely due to the grant of £75 from the Sea Fisheries Committee to enable the fishermen to thin the beds.

We find that the increase of length varies according to the time that the mussels are left untouched. A number of those deposited in the "Ringhole" in 1904 have recently been recovered, and the addition to the original shell in some cases is well over an inch. The weight has also increased, 100 weighing ten pounds or about 1,400 to the bag.

The results in the Wyre have been quite as good as at Morecambe and from the samples that have been examined we conclude that the conditions there are in every way favourable for transplanting.

The transplanting in the Lune also has been a success. Mr. Richard Gardner, of Sunderland Point, has supplied us with much valuable information regarding the effect of the work at Overton. All the mussels transplanted in 1905 were the ordinary "blue nebs." When these mussels were fished again at the beginning of the season it was found that the old shells had taken on a brown skin which almost obscured the old blue appearance. From the opening of the fishing season in 1905 to the middle of January, 1906, about 6,000 bags had been sent away from Overton– a weight of 375 tons. Mr. Gardner estimates that about two-thirds of these mussels were transplanted ones. The mussel fishermen at Overton recognise the value of the work and make the improvement go as far as possible. Each bag of mussels sent away contains a small proportion of untransplanted mussels, which by themselves were of no value whatever, and now the average price received by the fishermen is 3s. per bag. Further, unless transplanting had been

carried out at Overton, there could only have been one month's fishing in the season 1905-1906 instead of at least four months, and many of the local fishers would have been compelled to go elsewhere to find work. The average number of people engaged in mussel fishing at Overton from the beginning of the season to the middle of December is stated by Mr. R. Gardner to have been fifty.

Growth of Mussels and Description of Overcrowded Skears.

Under favourable circumstances it is probable that the mussels will grow fully half an inch in length each year, and at the end of three years reach the minimum legal size of two inches. The mussels on "Roosebeck Outer Skear" which were investigated in 1895 and 1896, and found to be in flourishing condition, grew half an inch between September of one year and August of the next. The skear was much overcrowded and could not be regarded as suitable for growing mussels quickly. The "Roosebeck Skear" was not then over-populated to anything like the condition that the Heysham Skears are at all times. On the latter the mussels, as we have already seen, grow about one-quarter of an inch in seven months. The same mussels, when transplanted to favourable areas grow three-quarters of an inch. Our experience is that even in a good situation the rate of growth varies inversely (roughly speaking) as the number of mussels present. Fewer and more equally distributed mussels grow faster than those that are plentiful and closely packed together.

The meaning of the expression "overcrowded skear" can be much better understood from an actual visit than

from any amount of detailed description. The accompanying text figure is a reproduction from a photograph of the Heysham ("Knott End") Skears, taken in April, 1905, immediately before transplanting commenced. It gives a fair idea of the general condition of the beds at that time. In some parts the mussels were much smaller and even more crowded than is shown in the illustration, occasionally three generations of mussels could be recog-

FIG. 7.—An overcrowded mussel skear.

nised living together on the same bed. Other parts were nearly clean, a condition due to the fishing that had taken place during the season. The photograph indicates roughly the depth of the mussels and shows that they were simply growing one on top of the other. At that part of the bed the shellfish were nearly one foot deep, and about 18 per cent. just failed to pass through the two inch gauge. The

average size was one and a half inches, and one hundred of these mussels weighed seventeen ounces. Another skear "Great Out Skear," covered with mussels one year old, that is, three-eighths to five-eighths of an inch, was found to be populated to the extent of 16,000 per foot square. In some places a few two year old mussels were mixed with the younger ones, and an area one foot square contained 10,000 one year old mussels, 200-300 two year old mussels being also present. The mussel in its natural state usually lives with the pointed end downwards, and consequently a large number can accommodate themselves to very little space. Mussels of the same age are never of a uniform size when they grow up, but when they first settle upon the skear as spat they are all nearly alike. Some slight favourable circumstance soon enables a few to grow faster than the others. This advantage becomes all the greater as the mussels increase in age. At the end of the first year one may find a margin of a quarter of an inch between the largest and smallest ones. The competition between them becomes keener, and ere long many of the smaller sizes are overwhelmed and smothered, while the survivors continue to grow and still further overcrowd the bed. The mussel, to enable itself to keep at the surface, lengthens its byssus, and in time the whole skear may be covered with mussels that are only attached to their fellows, with practically no attachment to the ground. The sea gradually undermines the bed, and very soon these mussels can be torn away in masses or rolled up like a carpet. When the mussel bed reaches this condition the end comes with the first storm. The seas sweep the mussels into masses, pounding them to pieces or carrying them away into deeper water, where they become buried under the shifting sands of the channel bottom. This process of destruction goes on year

after year, and often when the fisherman is looking forward to a profitable fishery his anticipations are ruthlessly shattered in a single night. A bed that twenty-four hours previously may have been populated by tons of marketable mussels of considerable money value becomes changed into a clean bank with a hard bottom. Then the process of re-formation of the bed begins, and in time the bank becomes again covered with mussels.

When the Heysham Skears were visited again, about two months after the transplanting, it was found that the removal of nearly 350 tons resulted in very little appreciable change in the appearance of the beds. The clearings that had been made in April had certainly been more or less covered again by the mussels spreading out, but the overcrowding was just as bad. The proportion of minimum legal sized mussels had advanced from 18 per cent. to nearly 25 per cent., but in many places, however, the stones, zoophytes and mussels themselves had a covering of spat from the spawning that had taken place in the interval, and four generations could be distinguished.

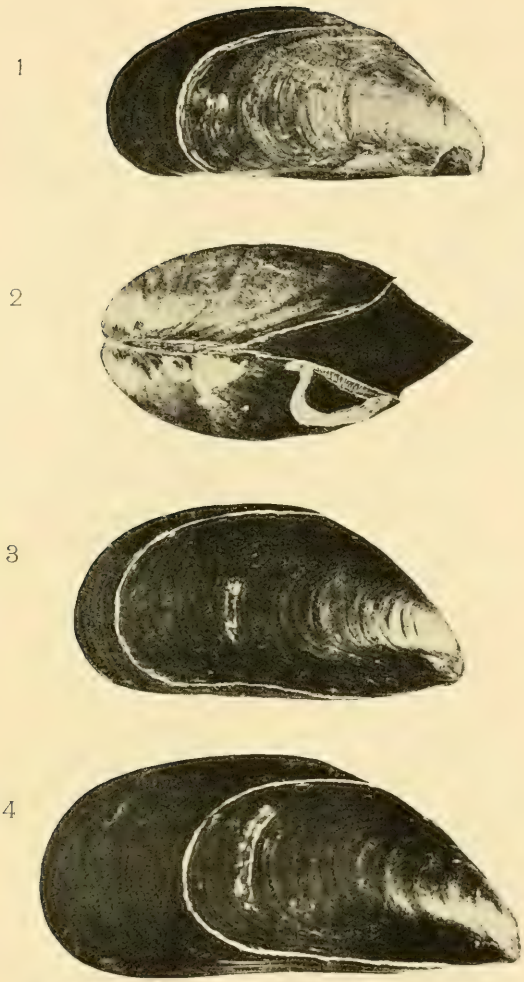
We conclude by giving a summary of the results obtained:

Amount expended: 1903, £50; 1904, £50; 1905, £75.

Estimated profit: 1903, £500; 1904, £500; 1905, £800.

A sample of the "Blue nebs" transplanted at Wardley's in 1905, has been sent to Piel for examination, within the last few days, by Captain Wright. Careful measurements of the new growth have been made, and it is found that the average increase during a period of ten months is thirteen-sixteenths of an inch. The following is the amount of new shell, in sixteenths of an inch, added in each of eight mussels during the time stated.

No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.	No. 8.
$\frac{15}{16}$	$\frac{14}{16}$	$\frac{12}{16}$	$\frac{12}{16}$	$\frac{16}{16}$	$\frac{13}{16}$	$\frac{11}{16}$	$\frac{11}{16}$



FIGS 1, 2 and 4. Transplanted Mussels.
FIG. 3. A Mussel that has not been transplanted.
All from Morecambe.

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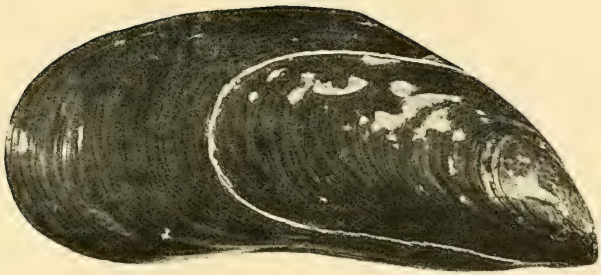

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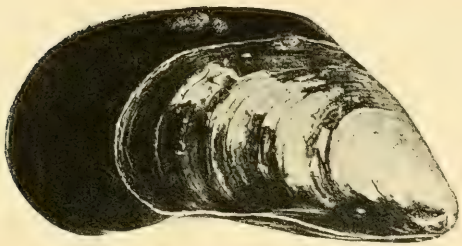

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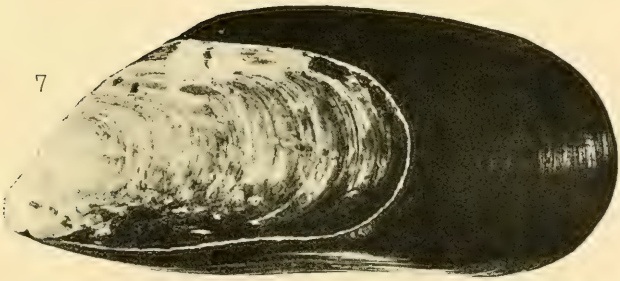

FIG. 5. Mussel transplanted to Ringhole in 1904.
FIG. 6. Mussel transplanted at Wardleys in 1905.
FIG. 7. Mussel transplanted at Wardleys in 1904.

ER SANDS
RIVER KEER
Stone Skear
Little Skears
Baiting Knott
4 Reap Skear 2
RING HOLE
CENTRAL PIER
OLD HARBOUR
Ring Sand
MORECAMBE
WEST END PIER
GROSVENOR HOTEL
CHART
SHOWING THE POSITIONS
OF THE
MUSSEL BEDS OR SKEARS
AT
MORECAMBE.
MUSSEL BEDS:
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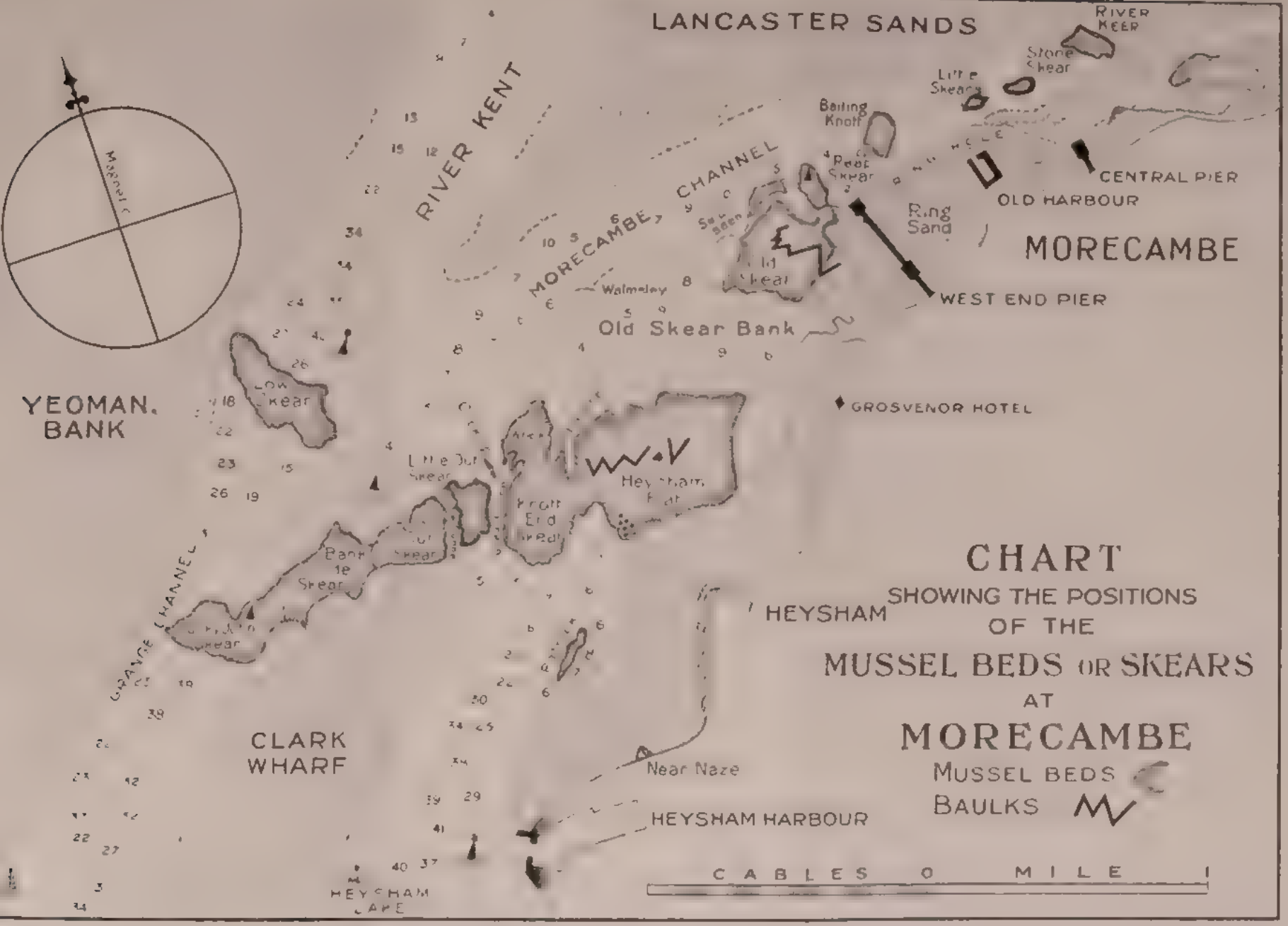
LANCASTER SANDS
RIVER KENT
MORECAMBE CHANNEL
MORECAMBE
Walmsley
Old Skear Bank
Bailing Knott
Reef Skear
Ring Sand
Stone Skear
RIVER KEER
CENTRAL PIER
OLD HARBOUR
MORECAMBE
WEST END PIER
GROSVENOR HOTEL
YEOMAN BANK
Low Skear
Little Dur Skear
Heysham Flat
Bank Ie Skear
GRAVE CHANNEL
CLARK WHARF
HEYSHAM
Near Naze
HEYSHAM HARBOUR
HEYSHAM LAKE
CHART
SHOWING THE POSITIONS
OF THE
MUSSEL BEDS OR SKEARS
AT
MORECAMBE
MUSSEL BEDS
BAULKS
CABLES 0 MILE 1

Description of the Plates.

All the figures are natural size, and are reproduced from photographs of the mussels. They represent average samples.

Plate XI.

Fig. 1.—An old "blue neb" from the first transplanting experiment at Morecambe (1903) showing the result after a period of four months in a favourable area. The black portion is the new shell.

Fig. 2.—The same mussel seen from the back. The old shell has been broken to show the thickness.

Fig. 3.—A mussel from Heysham Skears, showing the growth in seven months when left in its original situation. The white line indicates the size of the shell in April, 1905.

Fig. 4.—A mussel from Heysham Skears showing the result in seven months after removal from the skears and laying down in the Ringhole. The white line indicates the size of the shell when laid down in April, 1905.

Plate XII.

Fig. 5.—A mussel from Heysham Skears laid down in the Ringhole in April, 1904, and recovered in November, 1905. The white line indicates the original shell.

Fig. 6.—An old "blue neb" taken from the River Wyre, laid down in "Staining Hole," near Hambleton, in April, 1905, and recovered in November of the same year. The black portion shows the growth in the seven months.

Fig. 7.—Old "blue neb" from River Wyre, laid down in "Staining Hole" in April, 1904, and recovered in November, 1905. The black portion is the new growth that has been added in a period of nineteen months.

Plate XIII.

Chart showing the mussel beds at Morecambe.

TRAWLING OBSERVATIONS.

By Jas. Johnstone.

1. TRAWLING OPERATIONS IN LUCE BAY.
2. TRAWLING IN FISHGUARD BAY.
3. FOOD OF PLAICE, DABS AND OTHER FISHES.
4. REPRODUCTIVE PHASES OF HERRINGS IN CARNARVON AND CARDIGAN BAYS.
5. SEA TEMPERATURE AND CATCHES OF WHITING.
6. OCCURRENCE OF LARGE PLAICE AT NEW QUAY.

1. Trawling Operations in Luce Bay.

During 1905, as for several years past, the Fishery Board for Scotland has kindly permitted the Committee's steamer "John Fell" to trawl in Luce Bay for the purpose of obtaining spawning plaice. Two visits were made in 1905—one on October 12th and 13th, and a second on December 6th and 7th. On the first occasion the weather was all that could be desired, and the trip was made without any trouble; but the second trip was unfortunately deferred until December, and as very unfavourable weather was experienced time was lost. The trip was a most unpleasant one, and the results were not nearly so successful as they might otherwise have been.

On 12th October, one haul was made with the shrimp trawl: the net was one with a half-inch mesh bent on to a 30 feet beam. There was no object in making this haul except to obtain some idea of the immature fish present in the Bay. The results of this haul are given in Table I. They are very similar to those obtained in 1904, except

that small dabs were very much more numerous on this occasion than formerly. As in 1904, a large proportion of the small plaice obtained in the shrimp trawl were infested with the peculiar Trematode *Gasterostomum* sp., a parasite which we have not observed in fishes from any region in our area other than Luce Bay.

TABLE I.

Luce Bay, 12th October, 1905. Shrimp Trawl.

Fish caught.	Number.	Sizes in inches.
Soles	1	9
Plaice	1	14
,,	2	13
,,	1	12½
,,	175	2—6
Dabs	311	1½—9
Brills	8	2½—5
Arnoglossus laterna	1	4½
Rays	6	4½—10½
Codlings	3	3—4
Grey Gurnards	4	3
Siphonostoma typhle	10	—
Gasterosteus spinachia	Numerous.	—
Cottus scorpio	1	—
Agonus cataphractus	12	—
Callionymus lyra	Numerous.	—
Centronotus gunnellus	6	—
Gobius minutus	Very numerous.	—
Acanthias vulgaris	1	—
Shrimps	1 Gill.	—
Pandalus annulicornis	2 Gills.	—

Four hauls on the 12th and six on the 13th were then made with a fish trawl consisting of a net with a 7-inch mesh throughout bent on to a 30-feet beam. There was considerable difficulty in working the trawl on this occasion on account of the extraordinary amount of seaweed on the ground. In 1904 the same part of Luce Bay was comparatively free from weed; but in 1905 it was in parts very foul, so much so that it was found quite impossible to get the net aboard on the third haul on October 12th, owing to the great mass of weed which it had taken and which had caused the net to catch also a quantity of sand. It was, therefore, necessary to cut the tails, and the catch was almost entirely lost. Then other parts of the same area were tried so as to avoid this *debris*, but it was found that the largest plaice were among the seaweed; hauls III. and IV. were made on comparatively clean ground, and it will be seen that the proportion of large plaice taken was much lower than in the other hauls. To avoid the fouling of the net, and the damage to the fish entailed by the weight of the weed and the time it required to get the haul aboard we were, therefore, obliged to resort to the foul ground again. Short hauls, varying from three-quarters of an hour to 50 minutes were made, and by this means Captain Wignall was able to steer between the Scylla of too much rubbish in the net, and the Charybdis of too many small and useless fish. But even with all due precaution some of the plaice obtained were badly crushed and scarred and subsequently died.

Tables II. and III. shew the results of the trawling on 12th and 13th October.

TABLE II.

Luce Bay, 12th October, 1905. Fish Trawl. 4 hauls.

Fishes caught.	I.	III.	IV.
Soles			1
Plaice over 14 inches	16	7	1
,, under 14 ,,	10	52	120
Dabs	24	16	26
Brill	1	1	—
Flounder	1	—	—
Grey gurnards	—	—	1
Yellow do.	—	—	1
Herring	—	—	1
Raia batis	—	—	5
Raia clavata, circularis and maculata	34	75	71
Total Edible Fishes	86	152	227

TABLE III.

Luce Bay, October 18th, 1905. Fish Trawl. 6 Hauls.

Fishes caught.	V.	VI.	VII.	VIII.	IX.	X.
Plaice over 14 inches	19	26	12	18	17	13
do. under 14 do.	76	12	5	10	16	58
Dabs	38	22	7	14	12	25
Brill	1	—	—	—	—	4
Turbot	—	—	—	—	1	—
Flounders	—	—	—	10	5	—
Whiting	—	—			—	2
5-bearded Rockling	1	—	—	—	—	—
Raia batis	—	—	1	—	—	—
Raia clavata, circularis and maculata	34	27	14	4	13	12
Total Edible Fishes	169	87	39	56	64	114

Sizes of the Fish Caught.

As a general rule the fish caught on board the "John Fell" and the Bailiffs' cutters are not measured individually; only the largest and smallest fishes caught are measured and recorded. On the present occasion, however, an attempt was made to determine the characteristic sizes of the plaice on the "large-plaice" grounds which we were seeking. Hauls 2, 7, 8, 9 and 10 were made on this ground; it is obvious from an inspection of the tables that Hauls 4, 5, 6 and 11 were made on a ground which was different in respect of the distribution of plaice. In Hauls 2, 7, 8, 9 and 10 all the plaice caught were measured and the sizes recorded.

The average size of the plaice taken in these hauls is 14·44 inches. But this number gives us no clear idea of the sizes of the fishes present on the ground, and I have therefore prepared a chart (p. 93) which shows the numbers of plaice taken in these hauls arranged in groups in which the size varies from inch to inch.

This Chart shews that the greater number of fish taken in the hauls selected were from $11\frac{1}{2}$ to $16\frac{1}{2}$ inches in length. Few were caught which were smaller than $11\frac{1}{2}$ inches or larger than $16\frac{1}{2}$ inches. The "mode" or predominant size of the plaice present is $13\frac{1}{2}$ inches. If the curve is "smoothed" the position of the "mode" changes slightly and is about 14 inches.

It should be observed that no one form of fishing apparatus used alone gives a representative sample of the fish present on a fishing ground. In the haul of the shrimp trawl quoted it will be seen that only four plaice were caught which were larger that six inches. This is because the "draught" of water through the shrimp net is so much less than through the 7-inch mesh employed in the other hauls that very few large fishes were retained

in the net. It will also be seen that slight changes in the position of the ground trawled over influence the nature of the catch very greatly; and that the presence of weed or *debris* in the net has also a great effect. To obtain a true picture of the kind of fish even on such a small area as the shallow waters of Luce Bay, a number of hauls would have to be taken, employing not only a shrimp net but also such a large-meshed net as was used in the present experiments, and perhaps also, a net of intermediate mesh—say four inches.

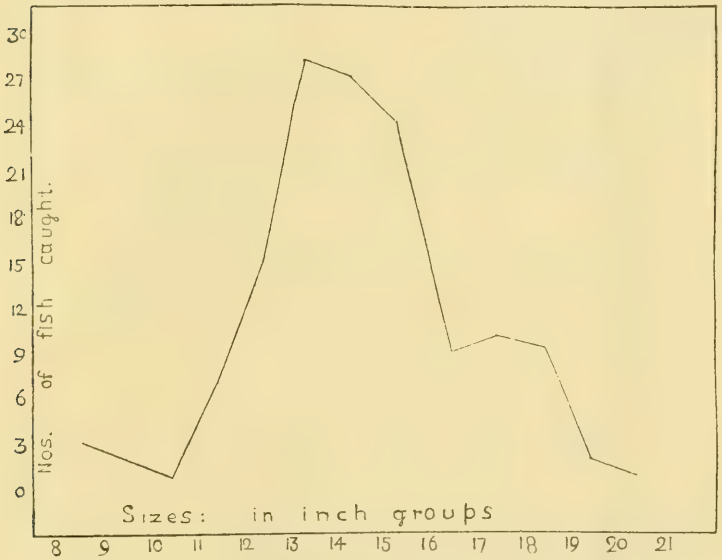

Fig. 8.—Sizes of the plaice caught in Hauls 2, 7-10.

Strict account was, however, kept of the plaice over and under 14 inches in length. Those over 14 inches are usually mature, and with the exception of a few males those under that size limit are immature. The results are:—

Plaice over 14 inches in length	129
Plaice under 14 inches in length	343

The larger fish were therefore **27·3** per cent. of the total quantity caught.

The largest dab caught was $15\frac{3}{4}$ inches.

The largest flounder caught was $17\frac{3}{4}$ inches.

Both were unusually large fishes.

A turbot was also taken which measured $30\frac{1}{2}$ inches and weighed 20 lbs.

Dabs and Plaice.

Except in the single haul with the shrimp net comparatively few dabs were caught. The ratio of dabs to plaice was 1 : 2·5.

The usual Physical Observations were taken. These were:-

Wind: N.W., light to fresh.

Weather: Rainy and dull at first, fine later.

Sea Temperature: 10·1° C. to 11·8° C.

Air Temperature: 46° F. to 55° F.

Specific gravity of the sea water at the surface: 1026·3 to 1026·4.

Transparency of the sea water: 16 to 18 ft.

Invertebrates taken in the nets.

Simple and compound Ascidians (very numerous).

Mollusca:—*Mactra stultorum, Pecten opercularis, Modiolus, Eolis* sp., *Loligo media* (common), *L. vulgaris* (7 specimens), *Buccinum, Fusus* and *Cyprina* (dead shells).

Crustacea:—*Pandalus annulicornis, Crangon vulgaris, Cancer pagurus, Carcinus mœnas, Portunas holsatus, P. puber, Stenorhynchus longirostris, Porcellana longicornis, Eupagurus bernhardus, Homarus vulgaris, Hyas araneus.*

Polyzoa:—*Flustra* was taken and other encrusting forms were observed but not identified.

Echinodermata: *Solaster papposus, Ophiura* spp.,

Astropecten, Asterias rubens, Echinus miliaris, Echinocyamus pusillus, Thyone sp., and *Cucumaria plancei* (very abundant).

Cœlenterata :—*Actinia equina, Alcyonium digitatum* and *Rhizostoma pulmo*. Many zoophytes were, of course, taken but were not identified.

Five Hauls on December 6th and 7th, 1905.

On this occasion the same fish-trawl net was employed as on October 12th and 13th. All the plaice taken which were over 13 inches in length were retained for hatching purposes and taken to Port Erin. No special observations were made on this occasion and I give only a table shewing the results of the five hauls. The plaice caught were, as a rule, smaller than in the fishing operations in October of this year.

Luce Bay, December 6th & 7th, 1905. Fish Trawl. 5 Hauls.

Fishes caught.	I.	II.	III.	IV.	V.
Plaice over 13 inches.	28	2	15	24	20
do. under 13 do.	94	56	18	48	46
Dabs	33	2	42	28	27
Brill	—	—	2	1	1
Lemon soles	—	—	2	1	3
Cod	1	—	2	3	5
Herring	—	—	—	1	3
Gadus minutus	—	1	—	—	—
Raia batis	2	2	—	4	3
Raia clavata, circularis and maculata	38	25	28	48	34
Total Edible Fishes...	196	88	109	158	142

2. Haul with a Shrimp-trawl in Fishguard Bay, Milford Haven Fishery District, on June 23, 1905.

1.—Physical conditions, &c.

Wind: calm.
Weather: fine.
Sea: smooth.
Bar.: 30·6.
Air temp.: Dry 66·5, wet 64·5.
Sea temp.: 14·2 at surf.
Spec. grav.: 1026·2.
Transp.: 18 feet.
Net used: Shrimp trawl net, $\frac{1}{2}$in. mesh, 30ft. beam.
1 hour haul, 3·55 p.m.—5 p.m.
13$\frac{1}{2}$ to 8 faths.: bottom of black sand becoming light later.

2.—Catch.

Soles: 10, 8$\frac{3}{4}$in.-15$\frac{1}{2}$in.
Plaice: 16, less than 8in.
Plaice: 73, over 8in.
Dabs: 22, less than 8in.
Dabs: 30, over 8in.
Ray: 5, under 4in. } Mostly *R. clavata*.
Ray: 6, over 4in. }
Brill: 1, 23$\frac{1}{4}$in.
Grey gurnards: 4, 10$\frac{1}{2}$in.-12in.
Grey gurnards: 13, 4in.-9in.
Sprats: 1,890.

Inedible Fishes.

Solenettes: 11.
Galeus vulgaris: 1.
Callionymus lyra: very numerous.

Invertebrates caught.

Mollusca:—*Nucula*, *Scaphander lignarius* (feeding on *Nucula*), *Mactra stultorum*, *Psammobia* sp., *Natica catena* (one specimen var. *alba*), *Loligo media* (very numerous), *Sepiola atlantica*, *Rossia macrosoma*, *Philine aperta*, *Natica* spawn.

Crustacea:—*Corystes*, *Portunus*, *Atelecyclus heterodon*.

Echinoderms:—*Ophiura* spp., *Asterias rubens*, *Echinus esculentus* and *E. miliaris*.

Just outside Fishguard Bay, in water of $16\frac{1}{2}$ to 20 fathoms, we had another haul with the shrimp trawl on the 24th June. The results were:

Dabs: 2, $7\frac{1}{4}$in. to 9in.
Whiting: 4, $7\frac{1}{2}$in. to 11in.
Raia maculata: 2, $14\frac{1}{2}$in. to $15\frac{1}{2}$in.
Sand eel: 1, 6in.
Onus tricirrhata: 3, 6in.
Gadus minutus: 33, 3in. to 5in.
Shrimps: 1 specimen.
Callionymus lyra: not abundant.

The invertebrates were very few indeed. One specimen of *Pasiphea sivado* was taken; *Loligo media* was numerous; *Pecten opercularis*, *Echinus esculentus* and *E. miliaris* were the only other invertebrates noticed.

It is interesting to compare the three closed areas: Luce Bay, Blackpool Closed Ground, and Fishguard Bay. In the former we have a rich fish fauna (rich in point of number and species) and a peculiar distribution of plaice and other flat fishes in respect of sizes—plaice of all sizes being found on the same shallow-water area. Blackpool Closed Ground presents a great abundance of individuals belonging to a very few species, and this

abundance varies exceedingly from season to season, the variations in the nature and abundance of flat and other fishes being greater than can possibly be accounted for by accidental circumstances; again, during the months of October, November and December, in which we have trawled in Luce Bay we have observed hardly any variation in the numbers and kinds and sizes of fishes which might not be due to the accidents of the observations. In Fishguard Bay there was a fish fauna both abundant and various. It ought to be stated, however, that we have only one or two observations of the fish on this ground, and it may easily be the case that variations in distribution as marked as those on Blackpool Ground may occur in different seasons of the year. Obviously, closure of an area does not always produce the same results; many other circumstances physical conditions, fishing in adjacent water, and the like, must operate in masking the effects of the closure.

The haul outside Fishguard Bay presents no features worthy of note.

3. Food of Plaice and Dabs.

The following observations relate to the examination of the stomachs of plaice and dabs taken together on the same ground, and in the same hauls with the trawl-net. Comparatively few fishes have so far been examined, but it is hoped to devote considerably more time in the future to this branch of work. The examinations have been made from the point of view of the supposed competition of the two species with each other in respect of food. The individual sizes of the fishes examined are not given, but in the great majority of cases the plaice were from 8in. to about 12in. in length (9in. would represent the average size), while the dabs were rather smaller (about 8in. long).

The quantities of the two kinds of fishes taken in the hauls are also given.

June 20th, 1905.—Near Puffin Island. 109 plaice and 110 dabs:

No. examined.		Food.
6 plaice	... ...	*Scrobicularia* (common), *Solen, Pectinaria, Echinocyamus.*
6 dabs	... ...	Hermit crabs (common). *Ophioglypha* (common), polychaetes.

23rd June, 1905.—Fishguard Bay. Shrimp trawl: 73 plaice over 8in., 30 dabs over 8in.:

3 plaice	... ...	all *Mactra.*
3 dabs	... ...	all young *Carcinus moenas*, $\frac{1}{8}$ to $\frac{1}{4}$ inch in breadth.

July 6th, 1905.—Beaumaris Bay. 101 plaice 6½in. to 11¼in.; 53 dabs 9½in. to 12in.:

10 plaice.	10 dabs.
All feeding on *Mactra* and *Scrobicularia*,	1. *Ophioglypha* and *Natica*.
1 also on polychaete worms.	2. do. do.
	3. do. do.
	4. do. do.
	5. do. do.
	6. Hermit crabs.
	7. Soft crabs.
	8. Polychaete worms.
	9. *Mactra* and *Scrobicularia*.
	10. *Scrobicularia*.

In this case three of the dabs and three of the plaice were feeding on the same animals.

July 12th, 1905.—Bahama Bank. 29 plaice and three dabs:

3 dabs.	
1. Hermit crabs.	All the plaice caught were used for the marking experiment.
2. *Solen*, Hermit crabs.	
3. *Solen*, Polychaetes.	

20th July, 1905.—Three miles W.N.W. from Llandwyn. Six plaice and 20 dabs:—

5 dabs examined.

1. Crabs.
2. do., *Solen*.
3. do., *Mactra*.
4. *Solen*.
5. Ophiuroids, *Solen*,

21st July, 1905.—Three miles W.S.W. from Tremadoc Bar Buoy. 11 plaice and 316 dabs:—

8 dabs examined.

1. Soft crabs.
2. Polychaetes, *Portunus holsatus*.
3. *Porcellana longicornis*.
4. *Aphrodite*, *Philine aperta*, crabs.
5 & 6. *Mactra*.
7. Ophiuroids.
8. Crabs.

24th July, 1905.—17 miles S.W. by W. from Calf of Man. No plaice, 14 dabs:—

11 dabs examined.

1. *Ophiura albida*, Nereids, small crabs.
2 & 3. *Ophiura albida*, small crabs.
4. Crabs, large quantity of some zoophyte.
5. *Ophiura albida*, *Eulima bilineata*.
6, 7 & 8. *Ophiura albida*.
9 & 10. *Ophiura albida* and hermit crabs.
11. *Ophiura albida*, hermit crabs, small *Carcinus*.

13th September, 1905.—Red Wharf Bay. 50 plaice and 75 dabs:

6 plaice examined.

All feeding on *Scrobicularia*.

6 dabs examined.

1. *Carcinus*.
2. *Carcinus* and other crab remains.
3. Crabs and polychaete worms.
4. *Corystes*, *Tellina*, *Solen*.
5. Ophiuroids and *Scrobicularia*.
6. *Tellina* and *Scrobicularia*.

12th October, 1905.—Luce Bay. 59 plaice, 16 dabs:

7 plaice examined.	6 dabs examined.
1 & 2. *Nucula.*	1. *Pecten, Carcinus, Cardium, Solen, Scrobicularia.*
3 & 4. Polychaetes.	2 & 3. *Solen* and *Hyas.*
5. *Pectinaria, Cucumaria.*	4. *Ophioglypha, Solen.*
6. *Solen.*	5. *Scrobicularia* & *Solen.*
7. *Solen* and *Scrobicularia.*	6. *Scrobicularia* and *Nucula.*

23rd November, 1905.—Off Conway Bar Buoy. 122 plaice, 36 dabs:-

6 plaice.	5 dabs.
1 & 2. *Tellina.*	1. *Virgularia mirabilis, Obelia longissima, Bougainvillea ramosa, Hydrallmania falcata, Lafœa dumosa.*
3. *Tellina* and *Scrobicularia.*	2. Crabs.
4. *Nereids.*	3. Crabs and *Ophiura* sp.
5 & 6. *Nereids* and *Scrobicularia.*	4. Crabs and *Psammobia.*
	5. Shrimp and *Psammobia.*

7th December, 1905.—Luce Bay. 66 plaice, 27 dabs:-

10 plaice.	11 dabs.
1 to 8. Stomachs empty.	1 & 2. Empty.
9. Small Amphipod.	3 & 4. *Cardium echinatum.*
10. Errant Polychaete.	Crab, simple ascidians.
	5. Hermit crab, *Solen.*
	6. Philine, 2 simple ascidians.
	7. Five Simple ascidians.
	8. Ophiuroids.
	9. Hermit crabs and *Stenorhynchus.*
	10. Actinian, foot of large lamellibranch.
	11. Foot of (?) *Cardium.*

In this last haul, nearly all the stomachs of the dabs examined were half empty.

16th December, 1905.—Off Patches Buoy, Aberystwith:

8 plaice.		8 dabs.	
1.	*Solen* and polychaetes.	1.	*Ophiura albida.*
		2 to 4.	do. do.
2.	Amphipod and *Solen.*	5.	Nereids.
3 to 8.	Empty.	6.	*Solen, Serpula. Eupagurus bernhardus.*
		7.	*Eupagurus bernhardus*
		8.	*Ophiura albida, Philine aperta,* crabs

One cod, caught off Blackpool on 8th December, 1905. The fish was a female 37½in. long, was in bad condition when received, and the contents of the stomach had undergone considerable *post-mortem* digestion. They were:

3 dabs, 6in. to 8in. long;
7 other pleuronectid fishes;
3 herrings (or sprats), 3in. to 5in. long;
9 other round fishes—not herrings;
13 shrimps.

There was, in addition, a large mass of semi-digested food matter in the stomach, most of which consisted of the disarticulated bones of fishes.

4. Reproductive condition of Herring in Cardigan and Carnarvon Bays in Winter.

Three lots of herring caught in these areas were sent to me by the bailiffs on Dr. Jenkins' instructions. They were examined for the condition of the roes, and for the food contents of the stomachs. The details are:—

(1) 13 herrings caught in Nevin Bay, Carnarvon Bay, one mile from shore in three fathoms on December 1st, 1905

8 were spent females:

5 were spent males.

In all cases the stomachs were empty.

(2) 12 herrings caught off New Quay on December 4th, 1905, at night

1 was a spent female:

3 were spent males;

4 were full females:

4 were full males.

All the stomachs were empty.

(3) 12 herrings caught close inshore in Nevin Bay, Carnarvon Bay, on sand and on gravel on 13th December, 1905—

5 were spent females;

3 were spent males:

1 was a full female:

3 were full males.

All the stomachs were empty.

These results are extremely interesting. It is evident that full herring are to be found off the Welsh coast in winter, and probably deposit their spawn there. It is most desirable that samples of herring from all the Welsh fisheries should be obtained and examined.

5. Sea temperature and catches of Whitings.

The connection between hydrographical observations and the abundance of food fishes is well illustrated* by a discussion of the sea temperature and the catches of haddock made by steam trawlers fishing off Granton on the East coast of Scotland. A curve is given in the

* See D'Arcy Thompson, Granton Trawling Statistics. Report on North Sea Investigations, p. 265, 1905.

article referred to, which shows the closest correspondence between the catches of this fish and the temperature of the sea. I have tried to see if a similar correspondence existed between any food fish and the sea temperature in our own area, but we do not possess data to enable such a comparison to be made as it should be. The shrimp trawl statistics taken by Mr. Eccles on the Liverpool Shrimping Ground during the years 1893-1899 do, however, yield a reliable series of figures. Most unfortunately we have no good records of sea temperatures. On board the "John Fell" the temperature of the sea at the surface is always taken at the beginning of a haul with a trawl net, and the thermometer, which is a reliable one, is always correctly read to one-fifth of a degree centigrade. Unfortunately the "John Fell" has a wide district and the number of temperature observations in Liverpool Bay are rather few for our purpose. The average monthly temperatures are calculated from the records of the "John Fell" and the New Brighton police cutter. I think the latter temperature data are not quite reliable but they are the best we can obtain.

The figures shewing the variation in the abundance of whiting from month to month during the year are, I think, quite reliable. All the figures for each month during the period 1893-9 have been grouped together and averages have been calculated. Accidental fluctuations are got rid of by the statistical device of taking three-monthly averages for every month. That is, the average for January is really the average for the three months December-January-February; that for February is the average of the months January-February-March, and so on.

The figures so obtained are as follows:

Average catches of immature whiting on the Mersey Shrimping Grounds during the years 1893-9; with the temperature of the sea for the year 1905:-

	No. of hauls.	Average catch.*	Average temperature of the sea at the surface (°C).
January	35	33	5·1
February	38	62	6·4
March	38	213	5·5
April	56	99	8·6
May	75	83	11·7
June	74	28	15
July	89	711	17·7
August	90	911	17·3
September... ...	99	759	14·5
October	68	466	10·1
November	45	250	8·3
December	37	48	

* "3-monthly averages taken monthly."

That they may be the more easily understood I have represented these results on the chart. The curve has been "smoothed."

Now, one must remember that the temperature observations are few and imperfect, and that the form of the curve might be different if a more extensive series of observations were available. Nevertheless, it will be seen

that there is a correspondence between the abundance of whiting and the temperature of the sea water. It must be confessed that results like this are very tantalising and make one wish for more extensive series of statistical figures.* I think, too, that they indicate the value of exact hydrographical investigations.

The form of the curve for whiting should be noticed. This curve is constructed from a great number of observations and probably yields a tolerably accurate picture of

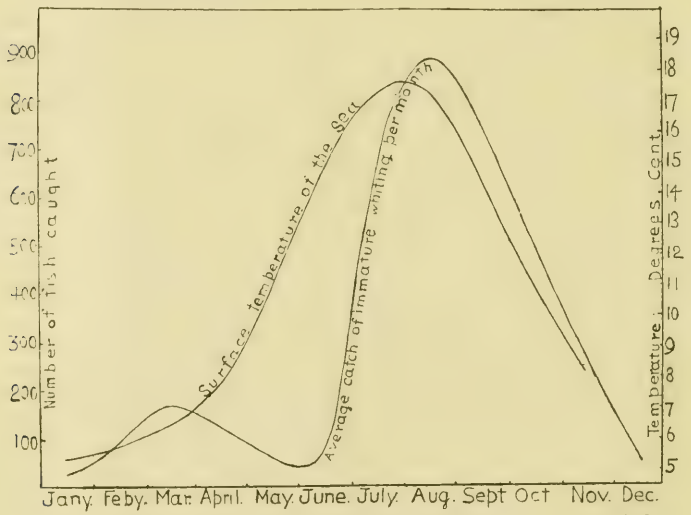

Fig. 9. Relation between abundance of immature whiting and the temperature of the sea.

the abundance of young whiting on the Mersey Shrimping Grounds. There is a minor maximum of abundance of whiting in the month of March. This is due to an immigration of fish of the previous year's spawning. Then in June the fish become scarce and immediately begin to become more abundant, attaining the maximum

* It ought to be possible to obtain daily temperature records from the various lightships off the coasts of Lancashire and Wales. I would suggest that this be attempted.

for the year in the month of August. The fish present at this time are probably those resulting from the same year's spawning. Then when the temperature of the sea falls whiting become less abundant, and a minimum is reached in December and January.

6. Occurrence of large Plaice at New Quay.

Two hauls made by Mr. E. Williams, the Bailiff stationed at New Quay, are of interest as shewing that large and mature plaice are not necessarily confined to comparatively deep water, but may occur close in shore. The hauls were:—

7th March, 1905.—Off New Quay head, four miles N.E.:

Fish Caught.

Plaice: 80, 23in. to 7in. in length.
Brills: 2, 19in. to 16in. in length.
Whitings: 15, 18in. to 14in. in length.
Skates: 2, 19in. in length.

27th March, 1905.—Near the same place:

Soles: 5, 14in. to 12in. in length.
Plaice: 30, 17in. to 8in. in length.
Whitings: 6, 16in. to 13in. in length.
Skates: 7, 12in. to 8in. in length.

That large and mature plaice occur only sporadically in inshore waters is due, I think, to the fact that such large fish are necessarily few in number, and are easily fished out in comparison with those of smaller size, and not to any necessary connection between the habits of the fish and the depth of water.

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REPORT ON EXPERIMENTS WITH MARKED FISH DURING THE YEAR 1904.

By Jas. Johnstone.

A preliminary account of these experiments was given in the report for 1904,* and the methods adopted (which were those elaborated by the International Fishery Investigation Staff) were explained. At the time when this preliminary report was written, 391 fishes had been marked and liberated, but since then 464 other fish have been dealt with. Many of the latter experiments are still incomplete; inasmuch as sufficient time has not yet elapsed to allow of the recapture of the fishes. It is only with regard to Experiments I. to X., which were made before the end of March, 1905, that any conclusions can be drawn, and many more fish will doubtless be recaptured from the later experiments.

The first few batches of fish marked and liberated were to some extent experimental, as we had not at that time sufficient experience of the method to enable us to avoid errors. Much difficulty, for instance, was experienced in finding suitable labels. The first hundred of these were obtained from the Marine Biological Association, and were used in the first Luce Bay experiments. Then 100 aluminium labels were tried, but these proved to be most unsuitable. The colour of the metal and its lightness induced us to try it, but we soon found that the corrosion caused by electrolytic action between the label and the silver wire was very rapid, and only a small percentage of these was returned. Then some hundreds of thin brass labels were obtained, but again these were imperfect, inasmuch as the metal was

* Report Lancashire Sea Fisheries Laboratory for 1904, pp. 91-97.

soft and the label was too thin. None of these had resisted corrosion in the sea for a longer time than 12 months, and even after six months the corrosion was, in some cases, so great that it was difficult to read the number. The later labels obtained were made of thicker and harder brass, and have been quite satisfactory.

The great majority of the fish marked have been plaice. A dozen soles were marked and liberated, but I did not regard the method as suitable for this fish and no more were dealt with. None of these soles has been returned. A few other fishes were also marked, and out of four dabs so treated one has been returned. The only flounder marked has also been re-caught. There is no reason why these marking experiments should be restricted to plaice and flounders, but it must be said that the difficulties of marking other fishes are very much greater, and suitable methods will take some time to devise.

It was hoped that 1,000 fish would be marked before the end of 1905, but the stress of other work interfered, and two or three trips were abandoned because of unsuitable weather.

I give below a summary of the experiments made up to the end of 1905, and of the results obtained.

It gives me great pleasure to acknowledge the assistance received from all who have been asked to co-operate in these experiments. Both Dr. Jenkins and Captain Wignall have given me every facility which was possible, and have been most kind. We are greatly indebted to those who have returned marked fishes. The Officers of the Committee, Messrs. Wright, Gardner, Eccles, Jones, Pritchard and Williams, have given all the assistance possible. Several Members of the Committee, Messrs. Dean, Garnett and Harley in particular, have

TABLE I.

GENERAL SUMMARY: STATION AND NUMBER OF FISH LIBERATED AND RETURNED.

	Station.	Date.	Number of Fish Liberated.	Number of Fish Returned.	Percentage Returned.
I.	Luce Bay	18/10/04	50 plaice	3	6%
II.	Ramsey Bay	19/10/04	34 plaice	4	12%
III.	1 mile N. from Puffin Island	12/11/04	42 plaice 2 soles.	9 plaice	21%
IV.	1½ miles N.W. from Great Orme Head	12/11/04	49 plaice 5 soles.	6 plaice.	12%
V.	2 miles N.W. by W. from Newcome Knoll Buoy	12/11/04	53 plaice 1 sole.	21	40%
VI.	Blackpool Closed Ground	13/11/04	78 plaice 5 soles 1 flounder	38 plaice 1 flounder	50%
VII.	Luce Bay	18/11/04	71 plaice 1 cod	8 plaice	11%
VIII.	2½ miles W. from Liverpool Bar Lightship	24/1/05	49 plaice	22 plaice	45%
IX.	10 miles W. from Carnarvon Bar Buoy	25/1/05	50 plaice	12	24%
X.	5 miles W. from Morecambe Bay Lightship	17/3/05	74 plaice	35	47%

XI.	14 miles W. from Morecambe Bay Lightship ...	29/5/05	44 plaice	8	18%
XII.	14 miles S. W. from Chickens Light	31/5/05	11 plaice	0	0
XIII.	Off Kenmaes Head	23/6/05	30 plaice	5	17%
XIV.	2 miles W.S.W. from Liverpool Bar Lightship ...	6/7/05	35 plaice 1 dab	16	46%
XV.	2 miles W. from Morecambe Bay Lightship	11/7/05	19 plaice	1	5%
XVI.	Near Bahama Lightship	12/7/05	21 plaice 3 dabs 1 brill	1 plaice 1 dab	5%
XVII.	Blackpool Closed Ground	13/7/05	31 plaice	5	16%
XVIII.	3 miles N.W. from Nevin	20/7/05	6 plaice 5 ray	0	0
XIX.	3 miles S.W. by W. from Aberystwyth	21/7/05	9 plaice	0	0
XX.	5 miles N.W. by W. from Aberystwyth	22/7/05	11 plaice	0	0
XXI.	Luce Bay	13/10/05	20 plaice	1	5%
XXII.	2 miles N. from Pillar Buoy, Entrance to Formby Channel.....	26/10/05	43 plaice	3	7%
	Totals to end of 1905.....		830 plaice	193	23·2%
			13 soles	—	—
			5 ray	—	—
			4 dabs	1	—
			1 flounder	1	—
			1 brill	—	—
			1 cod	—	—
			855 fishes	195	

most kindly acted as our agents and received marked fishes and paid rewards. Finally, many gentlemen not connected with our Committee have given us much assistance. I refer more particularly to Mr. R. Knox, of Douglas, Mr. G. Holmes, of the Cumberland District, and Mr. Rust, of the Milford Haven Fishermen's Association. Both the Irish Department of Agriculture and Technical Instruction and the Fishery Board for Scotland have instructed their officers to give us every assistance. It is needless to say that without this cordial co-operation the experiments would not have been possible.

The total number of plaice returned is, therefore, 195, or $23\frac{1}{4}$ per cent. of the whole. But of the 855 fishes dealt with 142 were liberated in Luce Bay while trawling there for spawning plaice, and as there is very little fishing (and no trawling) in this area, it was not expected that many of these fish would be recaught. Again, 290 fish were liberated since the end of March, and many more of these will doubtless be recaptured. If we consider only the fish which have been liberated in the Lancashire and Western District area before the end of March, 1905, the results are very encouraging. Of 432 such fishes 148, or $34\frac{1}{2}$ per cent., have been returned.

It is quite certain that a number of fish have been recaptured and have not been reported. I have heard of several such cases. One was only discovered after being exposed in Douglas Fish Market, and several were sent from other markets or fishmongers' shops. In some cases the approximate localities where these fish were caught could be traced, but this was impossible in others. In one case a fish-label was sent to me which had certainly been fried. In this case the mark could not have been noticed until the fish had been cooked—a fact which does not say much for the care with which the cook cleaned the fish.

In another case three labels were sent to me which had certainly lain in the finder's waistcoat pocket for some months. They were accompanied by a very unconvincing statement of the circumstances under which the fishes were caught. Another case was reported to me as follows: " . . . . I heard yesterday from a fish hawker of . . . . that he bought some fish of a trawler at . . . . and he had a marked fish and he laid it to one side and the cat ran off with it. He says the No. was L 307. Of course I said 'No label, no pay'. . . ." Other analogous leakages have no doubt occurred.

Then again, the proportion of fish caught depends obviously on the amount of fishing which goes on in the areas to which the marked fish migrate. Thus, the small proportion of fish returned from Luce Bay is to be attributed simply to this cause; and the same may be said of the relative lack of success which has attended the marking of fish in Carnarvon and Cardigan Bays. A glance over the general summary will bear this out. A high percentage of the fish liberated on Blackpool Closed Ground has been returned because these fish have for the most part travelled alongshore into the shallow waters of Morecambe Bay, the Ribble Estuary, and the Mersey Grounds; and so also with the fish liberated off the Mersey Banks. Although a number of fish have been returned from offshore grounds, it must nevertheless be borne in mind that fishing there is less intense than along the shore, where, in addition to trawling by half-decked boats, stake nets, trammels and "tees" also play their parts.

The chances that a fish living on the Eastern side of the Irish Sea will be captured comparatively early in its lifetime are greater than one imagines. We have a record of one plaice which was captured three times before it was three years of age. This fish (No. L 485) was first of

all caught in the Barrow Channel by Mr. John Wright, Head Bailiff at Fleetwood, and brought into Piel Hatchery, where it was marked. It was then taken out to beyond the Morecambe Bay Lightship and liberated. It returned again into Barrow Channel, and about ten weeks after its first capture it was again caught by Mr. Wright. It was then kept alive in the Piel tanks for a couple of days and again taken out to beyond the same Lightship. But hardly a month afterwards the unfortunate fish was recaught by the Fleetwood smack FD 99 and sent to the Liverpool Laboratory.

At least four plaice have crossed the Irish Channel. One of these, No. L 352, was liberated on Blackpool Closed Ground on 13th November, 1905, and about six months later news of its capture at Courtown Bay, Co. Wexford, Ireland, reached me *via* a coastguard officer, the Irish Board of Agriculture and Technical Instruction, the English Board of Agriculture and Fisheries, and Dr. Jenkins, who formed the last link of this official chain. This fish, supposing it had made a straight course for Courtown (which it, most probably, did not) had travelled at least 130 miles in 6 months. Other two fish have been reported from the East Coast of Ireland, one from near Balbriggan, in Co. Meath, and another from Belfast Lough. In each case the brass label had disappeared, but the bone button and silver wire indicated that these fishes had been liberated on the East side of the Irish Sea. One probably came from Blackpool, and the other from Luce Bay. Finally, a Luce Bay fish was taken in a herring-net in Campbelltown Loch on the Argyllshire side of the Firth of Clyde. It is to be noted that all these fishes must have crossed water of at least 50 fathoms in depth, unless, indeed, the Campbelltown fish made a circuitous journey round the Lochs of the Clyde.

In the following tables I give the information relating to each fish returned. In the column "time in the sea" the number of months is indicated. In many cases full information was not obtained. The weight of the fish was not always ascertained, and sometimes the fish had been gutted and it is not possible accurately to allow for this.

TABLE II.—Particulars of all the Fish Returned.

Station.	No. of Label.	Size when liberated. inches.	Place where recovered.	Date when recovered.	Time in the Sea. months.	Size when recovered. inches.	Weight when recovered. grms.	Increase in size. inches.	How captured.
I. Luce Bay. 18th October, 1904. 50 plaice.	E6035	8	Chapel Rossen, Luce Bay	25/11/04	1	—	—	—	Gill net.
	E6040	8	Abreast of Powfoot, near Annan ...	10/1/05	3	8	72	—	Shrimp trawl.
	E6042	11¾	S. from Davaar Island, Campbelltown Loch.	26/8/05	10	12¼	270	1½	Herring net
II. Ramsey Bay. 19th October, 1904. 34 plaice.	E6054	12	8 miles S S.E. from Bahama Light Ship, 13 fathoms.	10/2/05	4	12	—	—	Steam trawler.
	E6055	12	Near Bahama Light Ship	14/2/05	4	12	208	—	Smack.
	E6069	9½	8 miles S. by W. from Bahama Light Ship.	31/12/04	2	—	—	—	Steam trawler.
	E6082	9	Off N.W. of I.O.M., near mouth of Leavens River.	30/6/05	7	10½	144+	1½	Line.

Station.	No. of Label.	Size when liberated. inches.	Place where recovered.	Date when recovered.	Time in the Sea. months.	Size when recovered. inches.	Weight when recovered. grms.	Increase in size. inches.	How captured.
III.	L9	$10\frac{1}{4}$	Red Wharf Bay, off Tableland, 13 fathoms.	1/12 04	1	$10\frac{1}{2}$	—	$\frac{1}{4}$	Smack.
1 mile N. from Puffin Island.	L10	$10\frac{3}{4}$	Red Wharf Bay, 4—7 fathoms.....	3/12/04	1	$10\frac{3}{4}$	—	—	Smack
12th November, 1904.	L12	10	Red Wharf Bay	19/11/04	1	10	—	—	Smack.
42 plaice.	L15	10	Red Wharf Bay	14/12/04	1	10	—	—	—
2 soles.	L36	$10\frac{1}{4}$	$1\frac{1}{2}$ miles off Red Wharf Bay between Moelfre and Tableland, 6 fathoms.	4/12/04	1	$10\frac{1}{2}$	—	$\frac{1}{4}$	Smack.
	L45	$11\frac{1}{4}$	Red Wharf Bay, 7 fathoms	17/11/04	1	$11\frac{1}{4}$	—	—	Smack.
	L19	$9\frac{1}{2}$	Greenfield, Mostyn Deep, Dee	20/12/04	1	$9\frac{1}{2}$	—	—	
	L32	$8\frac{3}{4}$	Carnarvon Bay	11/6/05	7	$9\frac{3}{4}$	142.5	1	Smack.
	L49	10	Near Ansdell Buoy, in Pinfold Channel, 8 feet.	15/2/05	3	10	160.5	—	2nd class trawler.
IV.	L53	$9\frac{1}{4}$	Red Wharf Bay. 4 fathoms	16/12/04	1	$9\frac{1}{2}$	—	$\frac{1}{4}$	Smack.
$1\frac{1}{2}$ miles N.W. from Great Ormes Head.	L72	$8\frac{3}{4}$	Red Wharf Bay	28/12/04	2	$8\frac{3}{4}$	—	—	
12th November, 1904.	L107	8	2 miles N.W. from Gt. Ormes Head, 16. fathoms.	18/8/05	9	$10\frac{1}{4}$	146	$2\frac{1}{4}$	Smack.
49 plaice 5 soles.	L68	$8\frac{1}{4}$	Greenfield, Mostyn Deep, Dee	31/12/04	2	$8\frac{1}{4}$	—	—	
	L90	$8\frac{1}{2}$	Off Kilan Head, Cardigan Bay. 11 fathoms.	18/4/05	5	$8\frac{1}{2}$	64	—	2nd class boat.
	L88	9	Newport Bay, 2 miles from land.....	18/8/05	9	$11\frac{1}{4}$	227	$2\frac{1}{4}$	Smack.

V. 2 miles N.W. by W. from Newcome Knoll Buoy, Mersey. 12th November, 1904. 78 plaice.	L118	8¼	Near Pinfold Buoy, in Gut Channel, Southport.	1/2/05	3	8¼	—	—	2nd class trawler.
	L144	9¼	Near Ansdell Buoy, Gut Channel, Southport, 2 fathoms.	1/12/04	1	9¼	—	—	2nd class trawler.
	L119	11	Red Wharf Bay, 5 fathoms	17/12/04	1	11½	244	½	Smack.
	L125	10¾	Between Table Land and Moelfre, Red Wharf Bay.	19/12/04	1	—	—	—	Smack.
	L131	11	Red Wharf Bay, abreast of Tableland, 7 fathoms.	10/9/05	10	12¼	347	1¼	Smack.
	L134	9¾	Red Wharf Bay, 4 fathoms	16/12/04	1	9¾	—	—	Smack.
	L139	8¾	Red Wharf Bay, 1½ miles from land, 7 fathoms.	22/8/05	9	10¼	225	1½	Smack.
	L152	8	Off Gt. Ormes Head, 17 fathoms	3/12/05	13	13¼	—	5¼	Smack.
	L138	9½	Salt Island, Holyhead Harbour	28/5/05	6	10¾	186	1¼	
	L132	10	Menai Straits, between Port Dinorwic and Carnarvon, 5 fathoms.	5/1/05	2	10¼	—	¼	
	L133	9¾	Rock Channel, Mersey, near No. 5 Buoy, 3 fathoms.	18/11/04	1	9¾	—	—	Shrimp trawler.
	L117	8¾	Below N.W. Buoy, 9 fathoms	5/8/05 ?	—	—	-	—	
	L146	9	Stake net at Leasowe	19/11/04	1	9	—	—	Stake net.
	L147	9	Below N.W. Buoy, 9 fathoms	5/8/05 ?	—	—	—	—	
	L161	8	Wallasey Shore on "tees"	18/11/04	1	8	–	—	"Tees."
	L162	7¾	Wallasey Shore in Stake net	18/11/04	1	7¾	—	—	Stake net

Station.	No. of Label.	Size when liberated. inches.	Place where recovered.	Date when recovered.	Time in the Sea. months.	Size when recovered. inches.	Weight when recovered. grms.	Increase in size. inches.	How captured.
	L124	12	3 miles S.E. from Bahama Light Ship. 10 fathoms.	25/1/05	3	—	—	—	Steam trawler.
	L166	11¾	12 miles E.S.E. from Maughold Head. 10 fathoms.	26/12/04	1	11¾	—	—	Steam trawler.
	L170	11	"Shoals, Morecambe Bay"	4/2/05	3	11	—	—	Steam trawler.
	L169	10½	Lune, Near No. 6. Buoy, 6 feet	2/12/04	3	10½	—	—	
	L158	8½	Carnarvon Bay, 20 fathoms	12/7/05	8	10¾	181	2¼	Smack.
VI. Blackpool Closed Ground. 13th November, 1904. 78 plaice, 1 flounder, 5 soles.	L100	8	Near Morecambe	21/11/04	1	8	—	—	2nd class trawler.
	L173	8½	Ulverston Channel, No. 2 Buoy	29/12/04	2	8½	—	—	Shrimp trawler.
	L179	9½	1 mile above Humphrey Head. Grange	19/11/04	1	9½	—	—	Stake nets.
	L184	8	Abbey Light, near Glasson Dock.....	26/11/04	1	8	—	—	Draught net.
	L190	9	Ulverston Channel, 10 feet	9/1/05	2	9	—	—	
	L198	8½	Probably near Morecambe	8/2/05	3	8½	81	¼	2nd class trawler.
	L301	9	3 miles W. from Morecambe Harbour. 4 fathoms.	3/1/05	2	9	—	—	2nd class trawler.
	L307	9¼	Probably near Morecambe	10 2 05	4	—	—	—	

L313	8½	3 miles W. from Morecambe, 3 fathoms	30/1/05	3	8½	96.5	—	2nd class trawler
L323	8¼	Ring Hole, Morecambe, 3 fathoms ...	13 12 04	1	8½	—	¼	2nd class trawler.
L330	8¼	2 miles opposite Morecambe, 8 fathoms	25 2 05	4	8¼	—	—	2nd class trawler.
L334	7½	Grange Channel, half way between ..... Grange and Morecambe.	30 11 04	3	7½		—	
L338	8¼	Off Humphrey Head, Grange, 3 faths.	1/11/04	1	8¼	—	—	Shrimper.
L342	8	2 miles W. from Morecambe Harbour, 3 fathoms.	15/12/04	1	8	—	—	2nd class trawler.
L343	9½	Lune, near No. 4 Buoy	10/1/05	2	9½	112	—	2nd class trawler.
L348 Flounder	12	Raby's baulk, Cockersands, Glasson	17/5/05	5	—	171	—	Hedge baulk.
L182	11¼	Gut Channel, Southport, 7 fathoms	27/12 04	1	11¼	—	—	2nd class trawler.
L318	10½	Jumbo Buoy	18/11/04	1	—	—	—	2nd class trawler
L320	8	Jumbo Buoy	23/5/05	7	8¾	—	¾	2nd class trawler.
L321	9¾	Ansdell Buoy, Pinfold Channel, Southport, 8 feet.	12/2/05	1	9¾		—	2nd class trawler.
L175	11¾	Colwyn Bay	2/3/05	4	12	—	¼	Smack.
L305	11	Orme's Head, bearing S.E., 7 miles distant.	8/12/04	1	11	210	—	Smack.
L331	9	Off Newcome Knoll Buoy, Mersey, 7 fathoms.	8/6/05	7	10	154	1	
L193	10¼	Red Wharf Bay, 8 fathoms	8/9/05	10	13	370	2¾	Smack.

Station.	No. of Label.	Size when liberated. inches.	Place where recovered.	Date when recovered.	Time in the Sea. months.	Size when recovered. inches.	Weight when recovered. grms.	Increase in size. inches.	How captured.
	L345	$8\frac{1}{4}$	Between Gt. Ormes Head and Puffin Island.	3/11/05	13	$11\frac{3}{4}$	$3\frac{1}{2}$		Smack.
	L311	$8\frac{1}{2}$	Puffin Island bearing S. 15 fathoms	12/7/05	8	10	168+	$1\frac{1}{2}$	Smack.
	L326	$8\frac{1}{2}$	Red Wharf Bay, 8 fathoms	8/9/05	10	12	300	$3\frac{1}{2}$	Smack.
	L333	$8\frac{1}{2}$	Benllach, Red Wharf Bay	13/2/05	3	$8\frac{1}{2}$	75	—	
	L339	$9\frac{1}{2}$	Red Wharf Bay, 8 fathoms	10/7/05	8	11	228	$1\frac{1}{2}$	Smack.
	L341	8	Between Puffin and Moelfroe Islands, 11 fathoms.	28/10/05	12	$10\frac{3}{4}$	—	$2\frac{3}{4}$	Smack.
	L344	$8\frac{1}{2}$	Off Liverpool Bar Lightship, 10 fathoms	27/6/05	8	11	242	$2\frac{1}{2}$	Smack.
	L346	$8\frac{3}{4}$	Welshman's Gut, Point of Ayre, Dee, 5 fathoms.	1/5/05	6	$9\frac{1}{4}$	98	$\frac{1}{2}$	
	L312	$9\frac{1}{4}$	Off Dawpool, Dee, 3 fathoms... ...	19/12/04	1	$9\frac{1}{4}$	96·5	—	2nd class trawler.
	L196	$11\frac{1}{2}$	Probably on "Shoals"	2/2/05	3	$11\frac{1}{2}$	128	—	
	L314	$11\frac{3}{4}$	8 miles W. by S. off Blackcombe, 16 fathoms.	27/11/04	1	—	—	—	Smack.
	L315	10	6 miles W.S.W. from Morecambe Bay Light Ship.	12/7/05	8	$10\frac{3}{4}$	—	$\frac{3}{4}$	Smack.
	L324	$8\frac{1}{2}$	2 miles S.E. from Morecambe Bay Light Ship.	9/6/05	7	$8\frac{3}{4}$	—	$\frac{1}{4}$	Smack.
	L196	$11\frac{1}{2}$	In box of plaice from Leicester	2/2/05	—	$11\frac{1}{2}$	—	—	
	L352	$8\frac{1}{2}$	Courtown Bay, Co. Wexford, Ireland	6/5/05	7	—	—	—	

VII. **Luce Bay.** **18th November, 1904.** **71 plaice,** **1 cod.**	L229	8	Solway, Annan, near No. 5 Buoy on Scotch side of Channel.	10/1/05	2	8	75	—	Shrimp trawler.
	L240	$8\frac{1}{4}$	Luce Bay, 7 fathoms	22/4/05	5	$8\frac{1}{4}$	77	—	Gill nets.
	L257	$9\frac{1}{2}$	Luce Bay, off Chapelrossen, 6 fathoms	25/1/05	2	$9\frac{1}{2}$	118.5	—	Gill nets.
	L259	9	Glenluce, Luce Bay	17/5/05	6	—	—	—	
	L263	$9\frac{1}{2}$	Luce Bay, off Chapelrossen	10/4/05	5	$10\frac{1}{8}$	154	$\frac{5}{8}$	Gill nets.
	L265	10	1 mile E. from Sandhead, 6 fathoms...	19/7/05	9	$12\frac{1}{2}$	229	$2\frac{1}{2}$	Gill nets
	L272	$10\frac{1}{4}$	Luce Bay, Chapelrossen, 4 fathoms ...	16/12/04	1	$10\frac{1}{4}$	—	—	Lines.
	L294	$10\frac{1}{2}$	200 yards off shore, 4 miles N. of Girvan, 3 fathoms	3/10/05	10	$12\frac{1}{4}$	225	$\frac{3}{4}$	Herring net.
VIII. **2½ miles W. off Liverpool Bar Light Ship.** **24th January, 1905.** **49 plaice.**	L201	$8\frac{1}{2}$	Greenfield, Dee, 5 feet	8/2/05	1	$8\frac{1}{2}$	83.5	—	
	L209	$8\frac{3}{4}$	1 mile from E. end of Morecambe Pier	22/3/05	2	$8\frac{3}{4}$	90	—	Stake net.
	L210	$8\frac{3}{4}$	No. 5 Buoy in Lune	11/2/05	1	$8\frac{3}{4}$	—	—	2nd class trawler.
	L212	9	Stake nets, 5 miles from Morecambe	2/4/05	2	$9\frac{1}{2}$	113	$\frac{1}{2}$	
	L366	$9\frac{1}{2}$	1 mile from E. end of Morecambe Pier	22/3/05	2	$9\frac{1}{2}$	+122	—	Stake net.
	L368	9	Lune, from No. 2 to No. 6 Buoys, 12-15 feet	11/2/05	1	9	—	—	2nd class trawler.
	L407	$7\frac{1}{2}$	4 miles from Bolton-le-Sands	21/3/05	2	$7\frac{3}{4}$	62	$\frac{1}{4}$	Stake net.
	L214	8	Trammel net midway between Southport and Lytham.	6/4/05	2	$8\frac{1}{4}$	77	$\frac{1}{4}$	Trammel net.

Station.	No. of Label.	Size when liberated. inches.	Place where recovered.	Date when recovered.	Time in the Sea. months.	Size when recovered. inches.	Weight when recovered. grms.	Increase in size. inches.	How captured.
	L217	8	Pinfold Buoy, Lytham	9/2/05	1	8	65.5	—	2nd class trawler.
	L218	8¼	1 mile S.W. from Southport Pier ...	9/5/05	4	8¾	98.5	½	Stake net.
	L359	8	Stake net, Horse Bank, Ribble	4/5/05	3	8½	—	½	Stake net.
	L360	8	Boghole, Southport	27/5/05	4	8¼	71	¼	2nd class trawler.
	L372	8½	Bar Buoy, Gut Channel, Southport ...	9/2/05	1	8½	—	—	2nd class trawler.
	L409	8¾	Probably near Southport	12/2/05	1	9	98	¼	Smack.
	L221	8½	Wallasey Shore, stake net	3/4/05	2	8¾	—	¼	Stake net.
	L223	8¼	Below N.W. Buoy, 9 fathoms	5/8/05(?)	—	—	—	—	
	L371	9	No. 9 Buoy in Crosby Channel, Mersey, inshore in 8 fathoms.	10/2/05	1	9¼	98	¼	
	L211	7¾	2½ miles W.S.W. from Workington Pier	6/7/05	7	9	86	1¼	2nd class trawler.
	L219	8	S.W. by W. from Morecambe Bay Ship 19 fathoms.	15/7/05	6	9½	—	1½	Smack.
	L364	8¾	5 miles W.S.W. from Morecambe Bay Light Ship, 16 fathoms.	19/7/05	6	—	—	—	Smack.
	L361	9¾	1 mile N. of New Quay, Cardigan Bay, 14 fathoms.	30/5/05	4	10½	—	¾	Smack.
	L403	9	Newport Bay, Newport Head, bearing S. 12—13 fathoms.	8/8/05	7	12	—	3	Smack.

IX. **10 miles W. from Carnarvon Bar Buoy.** **25th January, 1905.** **50 plaice.**	L417	7¼	Wallasey Shore	5/5/05	3	7½	—	¼	Stake net.
	L411	8½	2½ miles off Llanon, Cardigan Bay...	20/8/05	2	10	154	1½	Liverpool smack.
	L412	8	6 miles S.E. from Kilan Head, 12 faths.	31/5/05	4	8¾	90.8	¾	Southport 2nd class trawler
	L420	7¾	3½ miles off St. Tudwall Islands, 19 fathoms.	21/6/05	5	9½	108	1¾	Liverpool smack.
	L421	7½	Carnarvon Bay	9/6/05	5	8	—	½	
	L426	8¾	2 miles N.E. ½ N. from St. Tudwall's Light House, 3½ fathoms.	1/9/05	8	11¼	230	2½	
	L431	8½	Between Dinas and Kaemmaes Heads, 17 fathoms.	12/9/05	8	12¼	308	3¾	Liverpool smack.
	L436	8¼	6 miles S.E. from Kilan Head, 26 faths.	6/7/05	6	9¼	96.8	1	Carnarvon smack.
	L438	8¼	Near Cardigan Bay Light Ship	2/9/05	8	10¼	—	2	Milford smack
	L444	8	Off Patches Buoy, Aberystwyth	19/10/05	9	11⅝	255	3⅝	Liverpool smack.
	L452	7½	Carnarvon Bay, 18 fathoms	12/7/05	6	9¼	100+	1¾	Douglas smack
	L437	8¼	St. Bride's Bay, 4 miles from land	12/6/05	5	9	—	¾	Brixham smack.
X. **5 miles W. from Morecambe Bay Light Ship.** **17th March, 1905.** **74 plaice.**	L470	8¼	Barrow Channel	25/5/05	2	8¾	106.5	½	Stake net.
	L472	8¼	Roosebeck Scar	28/3/05	1	8¼	72	—	do.
	L481	9	Barrow Channel	5/5/05	2	9¼	112	¼	do.
	L482	9¾	Barrow Channel	30/4/05	1	—	—	—	do.
	L485	8½	Barrow Channel	29/5/05	2	8¾	—	¼	Fleetwood Police cutter

Station.	No. of Label.	Size when liberated. inches.	Place where recovered.	Date when recovered.	Time in the Sea. months.	Size when recovered. inches.	Weight when recovered. grms.	Increase in size. inches.	How captured.
	L485	$8\frac{3}{4}$	10 miles N.W. of Morecambe Bay Light Ship.	28/6/05	4	$8\frac{3}{4}$	—	—	Smack.
	L502	$10\frac{1}{4}$	Barrow Channel	17/5/05	2	11	232	$\frac{3}{4}$	Stake nets.
	L504	$7\frac{1}{2}$	Barrow Channel	17/5/05	2	$7\frac{3}{4}$	69.5	$\frac{1}{4}$	do.
	L505	$7\frac{3}{4}$	Barrow Channel	7/12/05	9	$10\frac{1}{4}$	183	$2\frac{1}{2}$	Fleetwood Police cutter.
	L507	8	Barrow Channel	23/5/05	2	8	74	—	Stake nets.
	L512	$8\frac{1}{4}$	Barrow Channel	25/5/05	2	$8\frac{3}{4}$	99.5	$\frac{1}{2}$	Stake nets.
	L515	9	Barrow Channel	23/5/05	2	$9\frac{1}{2}$	160	$\frac{1}{2}$	do.
	L516	8	Barrow Channel	23/5/05	2	$8\frac{3}{4}$	101	$\frac{3}{4}$	do.
	L517	8	Barrow Channel	25/5/05	2	9	126.5	1	do.
	L518	$8\frac{1}{4}$	Barrow Channel	24/5/05	2	—	—	—	do.
	L559	$9\frac{1}{2}$	Barrow Channel	2/6/05	2	$10\frac{3}{4}$	211.5	$1\frac{1}{4}$	do.
	L562	$7\frac{1}{2}$	Barrow Channel	29/5/05	2	8	—	$\frac{1}{2}$	Fleetwood Police cutter.
	L570	$7\frac{1}{2}$	Barrow Channel	1/6/05	2	$8\frac{1}{4}$	106	$\frac{3}{4}$	Stake net.
	L479	$8\frac{1}{4}$	Wallasey Shore	1/5/05	6	$8\frac{1}{4}$	—	—	
	L460	$8\frac{1}{2}$	Off Blackpool, 13 fathoms	18/7/05	6	$10\frac{1}{2}$	—	2	

L463	9½	8 miles S.E. from Bahama Light Ship. 10 fathoms.	26/3/05	1	9½	—	0	Steam trawler.
L469	7½	Probably near Morecambe Bay Light Ship.	20/9/05	6	—	—	—	Smack.
L483	9¼	Bahama Light Ship, bearing N.W. by W. 7 miles.	15/6/05	3	9¾	123	½	
L462	9	3 miles N.W. of Workington Pier ...	28/7/05	3	10⅜	—	1⅛	Smack.
L493	8½	10 miles N.W. from Whitehaven Harbour.	3/5/05	2	8½	—	—	Smack.
L503	7½	3½ miles N.W. from Whitehaven Pier	23/8/05	6	9	—	1½	
L499	8	15 miles W. from Barrow Steel Works	27/6/05	4	9	—	1	Smack.
L514	10	10 miles W.S.W. from Morecambe Bay Light Ship.	18/7/05	4	—	—	—	Smack.
L522	7½	14 miles S.E. from Maughold Head, 12 fathoms.	16/11/05	8	10½	3	—	Steam trawler.
L526	8½	Morecambe Bay Light Ship bearing E., 15 miles, 22 fathoms.	23/3/05	1	7¾	64.5	—	Smack.
L680	9¾	11 miles W. from Morecambe Bay Light Ship, 18 fathoms.	2/6/05	3	10½	182	¾	Smack.
L686	8	12 miles W. by. S from Morecambe Bay Light Ship, 22 fathoms.	5/6/05	3	8	—	—	Smack
L690	9¼	13 miles W.S.W. from Morecambe Bay Light Ship, 22 fathoms.	4/6/05	3	9¼	98	—	Smack.
L478	8	Holyhead Harbour, 6 fathoms.....	3/5/05	2	8	—	—	

Station.	No. of Label.	Size when liberated. inches.	Place where recovered.	Date when recovered.	Time in the Sea. months.	Size when recovered. inches.	Weight when recovered. grms.	Increase in size. inches.	How captured.
XI. **1¼ miles W. of Morecambe Bay Light Ship.** **29 May, 1905.** **44 plaice.**	L601	11	18 miles N. by W. from Morecambe Bay Light Ship.	15/7/05	2	—	—	—	Steam trawler.
	L604	8	5 miles S.S.W. from Morecambe Bay Light Ship, 15 fathoms.	1/9/05	3	9½	—	1½	Smack.
	L680	9¾	10-12 miles W. from Morecambe Bay Light Ship, 18 fathoms.	2/6/05	1	—	—	—	Smack.
	L684	7¼	S. of Morecambe Bay Light Ship, 15 fathoms.	19/10/05	5	8¾	—	1½	Smack.
	L686	8	12 miles W. by S. from M. B. L. Ship, 22 fathoms.	5/6/05	1	8	—	—	Smack.
	L690	9¼	13 miles W.S.W. of Morecambe Bay Light Ship, 22 fathoms.	4/6/05	1	9¼	—	—	Smack.
	L693	7½	Formby Channel, 5 fathoms	25/8 05	3	8	83	½	2nd class trawler.
	L607	8	Horse Channel	19/9/05	4	10¼	210	2¼	
XII. **1¼ miles S.W. of Chicken Light, I.O.M.** **31st May, 1905.** **11 plaice.**									
No fish returned from this station.									

XIII.	L631	10¼	Newport Head, S.W. 1½ miles, 18 fths.	11/8/05	2	—	—	—	Milford smack.
Off Kemmaes Head.	L639	10	Newport Head S.W. 1½ miles	11/8/05	2	—	—	—	Milford smack.
23rd June, 1905.	L649	11¼	Off Dinas Head, 22 fathoms	7/7/05	1	11½	—	¼	Steam trawler.
30 plaice.	L653	9½	Newport Bay, Newport Head, bearing S. 12-13 fathoms.	8/8/05	1	10	156	½	Brixham smack.
	L658	8½	4 miles from a line joining Dinas and Kenmaes Heads, half way across.	31/8/05	2	9	127	½	Liverpool smack.
XIV.	L524	10¾	Off Newcome Knoll, 10 fathoms	15/8/05	1	12	265	1¼	
2 miles W.S.W. from Liverpool Bar Light Ship.	L525	8½	Near North Buoy, 9 fathoms	9/8/05	1	9¼	—	¾	2nd class trawler.
6th July, 1905.	L527	8¼	Horse Channel, 9 fathoms.	9/8/05	4	11	262	2¾	2nd class trawler.
35 plaice.	L530	9	10 fathoms water off Hoylake	24/8/05	2	12⅓	362	3⅓	Smack.
1 dab.	L532	9½	Horse Channel, outside Fairway Buoy, 14 fathoms.	24/8/05	2	11½	280	2	2nd class trawler.
	L534	9¼	1 mile N. of Fairway in Horse Channel	14/8/05	1	11	240	1¾	2nd class trawler.
	L535	9¼	Newcome Knoll, 3—4 fathoms	12/7/05	1	9¼	—	—	2nd class trawler.
	L538	10¼	1 mile N.W. of Light Ship Buoy, Horse Channel.	22/8/05	2	11⅛	256	⅞	Smack.
	L533	9½	Off Moelfre Island, 12 fathoms	8/11/05	2	12½	280	3	Smack.

Station.	No. of Label.	Size when liberated. inches.	Place where recovered.	Date when recovered.	Time in the Sea. months.	Size when recovered. inches.	Weight when recovered. grms.	Increase in size. inches.	How captured.
	L548	$11\frac{1}{4}$	Horse Channel, 10 fathoms	10/8/05	1	$11\frac{3}{4}$	$9\frac{3}{4}$	$\frac{1}{2}$	2nd class trawler.
	L549	$8\frac{1}{2}$	Off Herbert's Patent Buoy	10/8/05	1	—	—	—	2nd class trawler.
	L550	$9\frac{3}{4}$	S. of Bar Light Ship	6/11/05	4	12	350	$2\frac{1}{4}$	2nd class trawler.
	L551	$9\frac{3}{4}$	2 miles S.E. from Liverpool Bar Light Ship, 7 fathoms.	25/7/05	1	$9\frac{3}{4}$	—	—	Smack.
	L552	$8\frac{3}{4}$	1 mile S.E. from Liverpool Bar Light Ship.	23/9/05	3	$12\frac{3}{4}$	—	4	2nd class trawler.
	L553	$9\frac{1}{2}$	Fairway Buoy, entrance to Hilbre Swash.	16/10/05	3	$11\frac{5}{8}$	302	$2\frac{1}{8}$	Smack.
	L556	9	Newcome Knoll, 9 fathoms.	17/8/05	1	$9\frac{3}{4}$	166	$\frac{3}{4}$	Smack.
XV. 2 miles W. from Morecambe Bay Light Ship. 11th July, 1905. 19 plaice.	L572	$11\frac{1}{4}$	8 miles S.W. by S. from Morecambe Bay Light Ship.	22/11/05	5	—	—	—	Smack.

XVI. **Near Bahama Light Ship.** **12th July, 1905.** **21 plaice,** **3 dabs,** **1 brill.**	L591 Dab.	9½	N.W. from Bahama Light Ship, 5-6 fathoms.	8/11/05	4	10½	—	1	Steam trawler.
	L664	11	12 to 14 miles S.E. from Maughold Head, 12 fathoms.	12/12/05	5	13¼	374	2¼	Smack.
XVII. **Blackpool Closed Ground.** **13th July, 1905.** **31 plaice.**	L812	8½	Morecambe Bay, near Silverdale	31/10/05	4	9	105	½	Stake net.
	L800	10	8 miles S.S.W. from Morecambe Bay Light Ship.	8/11/05	4	11¼	—	1¼	Smack.
	L808	8½	Outside Nelson Buoy, 9 fathoms ...	7/8/05	1	—	—	—	2nd class trawler.
	L826	7	Salthouse Bank, opposite Fairhaven Hotel, near Lytham.	/10/05	3	8⅛	90	1⅛	Stake net.
	L597	8	2 miles W. from Liverpool Bar in 9 fathoms.	21/9/05	1	8¾	114	¾	Smack.
XVIII. **3 miles N.W. from Nevin.** **20th July, 1905.** **6 plaice.** **5 ray.** **No fish returned from this station.**									

Station.	No. of Label.	Size when liberated. inches.	Place where recovered.	Date when recovered.	Time in the Sea. months.	Size when recovered. inches.	Weight when recovered. grms.	Increase in size. inches.	How captured.
XIX. **3 miles S.W. by W. from Aberystwyth.** **21st July, 1905.** **9 plaice.** **No fish returned from this station.**									
XX. **5 miles N.W. by W. from Aberystwyth.** **22nd July, 1905.** **11 plaice.** **No fish returned from this station.**									
XXI. **Luce Bay.** **13th Oct., 1905.** **20 plaice.**	L868	8	Off Sandhead, 3 feet	24/10/05	1	—	—	—	Gill net.
XXII. **2 miles N. from Pillar Buoy, entrance to Formby Channel.** **26th Oct., 1905.** **43 plaice.**	L910	8½	Rock Channel	31/10/05	1	—	—	—	2nd class trawler.
	L918	8½	Newcome Knoll Buoy	21/11/05	1	—	—	—	2nd class trawler.
	L920	9¼	Horse Channel	17/11/05	1	—	—	—	2nd class trawler.

NOTES ON THE TABLES.—The positions given for the recaptures of the fishes are those reported to me by the finders. Since a smack or steam trawler may in one haul sail over a considerable tract of sea-bottom the positions can only be approximations to the real spot where the fish was captured. Hence the depths do not always correspond to those given on the charts for the positions indicated. Two or three fishes, the numbers of which cannot be identified, were also returned.

Remarks on the different experiments.

Station I.—Luce Bay.

Strictly speaking, Luce Bay is not within our Lancashire and Western Fishery District, but as we have been interested in this fishing ground for the last few years we thought it a useful thing to "plant" some marked plaice there. There is very little fishing of any kind, and no trawling, in the neighbourhood of Luce Bay, and the chances of a successful result depended on offshore migration of the fishes, or migration into the Solway Firth. This offshore migration was indicated by one fish which crossed the North Channel and was found in Campbelltown Loch, and the Solway migration was shown by another fish which was found near Annan. Only one other fish was recaptured, and this was taken in the Bay itself.

Station II.—Ramsey Bay.

Only four fishes were found out of 34 liberated in this Bay. Three went offshore and one was found on the North-West Coast of the Isle of Man. Here again there is little inshore fishing, and in consequence of the Manx Fishery Laws all the territorial waters are closed against trawling.

Station III.—Off Puffin Island.

Unfortunately the aluminium labels were used for this experiment, and as the label itself appears to have been corroded away in a comparatively short time, leaving only the button and wire attached to the fish, it is probable that many of these fishes have been recaptured but have escaped notice. The migration of the fishes actually found are indicated on Chart II. by the red circles surmounted by a horizontal line. Most of the

fishes found were caught in Red Wharf Bay within the first four weeks. One, however, was taken in the Dee and one in Carnarvon Bay, having probably gone through the Menai Straits.

Station IV.—Off Great Orme's Head.

In this experiment the results are almost exactly the same as in Experiment III. Two fishes were found in the Dee. Two, however, made very extended migrations, and were found in Newport Bay, in the Milford Fishery District, and off New Quay Head, near the Southern extremity of our own area.

Station V.—Newcome Knoll.

This experiment is remarkable because of the extraordinary manner in which the fishes liberated have scattered. Within the first 12 weeks after liberation marked plaice from this station were found in Red Wharf Bay, Menai Straits, the Wallasey shore, the Ribble, and Morecambe Bay. Three also were recaught off the North-East Coast of the Isle of Man. Later on the other fish caught were taken in the waters round Holyhead, and these were probably those which had migrated to that area in the first three months.

Station VI.—Blackpool Closed Ground.

This is the most interesting of all the experiments made, and the results are, on the whole, consistent with each other. They are represented on Chart I. by the black circles. If note be made of the length of time elapsing between the liberation and recapture of the fish (this time is indicated by the small figures within the circles), then it is fairly easy to trace the migration paths of the fishes recaught. Out of 78 plaice liberated, 16 were found in the waters of Morecambe Bay, and two in the

Ribble, during the first 16 weeks. This shows, on the whole, a general migration inshore and in a Northerly direction *during the winter*. But again it will be seen that 11 fishes were found in Red Wharf Bay and Liverpool Bay generally at periods of from four to 13 months after liberation, and that two fishes actually crossed the Irish Channel and were found off the Irish coast. It is only reasonable to suppose that many more fish entered Morecambe Bay (and the Ribble) from Blackpool Closed Ground than were recaught, and that *in the Spring* following the experiment these fishes began to migrate out from the Bay (and the Ribble) and to proceed offshore and in a Southerly direction. If the times of recapture be noted, this course can be traced with some degree of probability. I have represented it on Chart I. by lines and arrows. The thick lines indicate the winter migration, generally inshore and to the North, and the thin lines the spring and summer migration, generally offshore and to the South.

The chart shows exceptional migrations. But we are dealing with creatures possessed of volition, and to some extent capricious in their movements. When one remembers this, and reflects on the multitude of influences acting on a marine fish so as to determine its movements and habits, it would be too much to expect that simple undeviating migration paths should be followed without exception.

Station VII.—Luce Bay.

For some reason or other the second Luce Bay experiment was more successful than the first. But few fishes were returned, and the only conclusion to be drawn is that the fish population of the Bay is an indigenous one, for most of those returned were caught in the area

where liberated. One, indeed, went to Girvan, in the Clyde: this was initially the largest of those recovered; and one went to the Solway, and conversely this initially was the smallest of those recovered.

Station VIII.—2½ Miles W. from Liverpool Bar Lightship.

Here again we meet with consistent results. Of the fish set free on this Station 16 went inshore, and in the main in a Northerly direction towards the bays and estuaries. Most of these were caught in the Ribble and in Morecambe Bay within the first 12 weeks. After this interval two were found in offshore waters and two far to the South in Cardigan Bay, while one had crossed the "head of the tide" and was recaptured off Workington in the Cumberland Sea Fishery District.

Station IX.—10 Miles W. from Carnarvon Bar Buoy.

Again we are comforted by finding that the results of the experiment are uniform. Of 50 plaice liberated in Carnarvon Bay 12 were found. Nine of these went South and eight were caught in Tremadoc and Cardigan Bays. One at least left the district and was caught in St. Bride's Bay, in the Milford Haven Fishery District, 20 weeks after liberation. The single inevitable exception to this general Southerly migration was observed by a fish which found its way into Liverpool Bay (probably through the Menai Straits) and was caught in a stake net on Wallasey shore. It is remarkable that so many fish from this and other experiments should have rounded the rocky, precipitous coast of the Carnarvon Peninsula.

Station X.—Morecambe Bay Lightship.

This also was a very remarkable experiment. At the time when it was made I was busy at Piel conducting the

Fishermen's Classes and could not go to sea except for a day at the week end between the beginning of March and the beginning of May. On March 16th, Mr. John Wright, the Chief Fishery Officer at Fleetwood, came over to Piel and trawled in Barrow Channel for plaice, which were brought into the Hatchery and marked there. The fish were then kept alive in the tanks for a day, and were put on board the "John Fell" and taken out to beyond the Morecambe Bay Lightship, where they were liberated. For about a week nothing was heard of these fishes, and then they began to come back into Barrow Channel again, and within the first two months 16 marked plaice from this experiment alone were caught in this area. It is not, as might appear, the case that this abundance of recaptures depends simply on excessive fishing, for practically all these fishes were caught by two or three men working stake nets. It is evident that there was a general inshore migration towards Morecambe Bay, and that most of the fishes participating entered the Channel. Two fish travelled North along the Cumberland coast, and crossing the head of the tide were caught in the Solway Firth. I think it probable that the fish, after leaving the Lightship ground, struck the Cumberland coast and most of them came South but that a few went North.

It will be seen from Chart I., where these results are represented by the blue circles, that quite a number of marked fish were caught on the ground round the Lightship. But it will also be seen that these fishes were mostly caught there three months after liberation, and taken together with the results of the Blackpool Experiment, this indicates that the fish, after finishing their first inshore migration and feeding for a time on the shallow water grounds, began to migrate outwards again.

The exceptions to these general conclusions are represented by two fish which went at once directly North and were caught near the Bahama Lightship, and by one which at once went South and was caught in Holyhead Harbour about seven weeks after liberation, having in that time travelled at least 55 miles.

Station XI.—Morecambe Bay Lightship.

It was thought advisable to repeat the above experiment, so in May 44 plaice were liberated near the same place but a little further to the West. None of these fish (which had also been caught in Barrow Channel by Mr. Wright) returned to that area, and in one month three of them were caught to the South-East of the place where liberated. Very few of these fishes have been returned, but such recaptures as have been reported show a general tendency of the fishes to travel to the South and East into shallower water. While trawling in Barrow Channel for these fishes, Mr. Wright caught two of those which he had already trawled there. These were measured and taken out to sea to be used in this experiment, and one of them has already been recaptured.

Station XII.—Off Chicken Rock, I.O.M.

At the end of each hatching season the plaice remaining in the tanks at Piel are turned back again into the sea. We thought it might be useful, however, to mark some of these fishes and liberate them in deep water. Accordingly 11 large mature fishes were taken out from Piel in the "John Fell" and marked and liberated in the deep water South-West of the Calf of Man. None of these fishes have been returned to us. But after a sojourn of two months in small tanks large plaice are not

possessed of great vitality, and I think it possible that the transportation and handling and the marking operation may have killed these plaice.

Station XIII.—Off Kemmaes Head.

Thirty plaice were liberated on this station, which is at the Southern extremity of the Lancashire and Western Sea Fishery District. Only five have been returned, and these were caught immediately to the South-West of the station.

Station XIV.—Near Liverpool Bar Lightship.

Hearing that plaice were plentiful on this area in July last we caught and marked 35 fishes. Up to the present all the fishes returned from this lot have been found in the immediate neighbourhood of the station, no migrations of any extent having taken place. The results are represented on Chart II. by the blue circles.

Station XV.—Near Morecambe Bay Lightship.

Nineteen plaice were liberated here, but only one has been returned, and this was caught near the station but about five miles S.W. by S.

Station XVI.—Near Bahama Lightship.

Twenty-one plaice, three dabs, and one brill were liberated here on July 7th. Only one plaice has been returned, but one of the three dabs set free was sent back on 8th November last. This is the only dab out of four marked which has been returned to me.

Station XVII.—Blackpool Closed Ground.

Thirty-one plaice were liberated on this station in July last, and five have been returned. With the exception of one fish (which went offshore) all these were recaught on the inshore waters North and South of the station.

The fish liberated on the three last stations were not all in a perfectly sound state. They were caught in the vicinities of the three stations and kept on board in the tanks for a short time only. When we caught them the surface of the sea, and the waters for some depths down, were swarming with the jelly-fish *Aurelia* so much so that the sea was literally carpeted in places with these creatures. When the net was hauled an enormous quantity were always included among the catch, and the fish caught were always very sickly. Even when great masses of seaweed or mud were taken, the fish caught never exhibited the same lack of vitality as was shown in these catches, and the result is probably due to the contact of the fishes with the poisonous stinging cells of the jelly-fishes. I think it quite probable that a large number of these fishes died some time after liberation.

Stations XVIII. to XX.—Nevin and Aberystwyth, Carnarvon and Cardigan Bays.

Thirty-one fish were liberated on these three stations, but none has been returned so far. Five of the fish marked were small rays, but the rest were plaice and in good condition when liberated. These poor results are due, I consider, to the fact that the amount of fishing on

the Welsh coasts is so very trifling, and that the fish have simply not had a chance of being caught. Most of the fishes liberated on the Welsh stations have been caught on the grounds round Kilan Head, in Tremadoc Bay, and on the trawling grounds extending from New Quay to Dinas Head. That the comparative lack of success attending these experiments is due to the absence of fishing on the part of the local Welsh population may be seen by considering the tables where I have given the port of registration of the vessels catching the fish (when ascertainable). In the case of the fish caught off Kilan Head the captors were Southport half-decked boats, and the fish caught in the waters South of Kemmaes Head were taken by Liverpool, Milford, or Brixham boats. In only one case was a marked fish taken by a Welsh boat—a Carnarvon smack. Even in the case of the Red Wharf Bay fishes, the captures were usually made by Hoylake vessels registered (for some reason or other) out of Douglas.

Station XXI.—Luce Bay.

On the occasion of trawling the Bay for spawning plaice for Piel, 20 plaice were marked and liberated. Only one has been reported to me, and this was caught on the shore of the Bay.

Station XXII.—Formby Channel.

Several attempts were made to mark a number of fish in October last, but on two occasions very rough weather was experienced and the experiments were abandoned. The last lot of plaice marked in 1905 were set free in Formby Channel on October 26th. It is, of course, far too soon to discuss the results of this experiment. Hitherto only six fishes have been returned. Three have

been caught in the neighbourhood of the station, and other three (not included in the tables) from Morecambe Bay.

Intensity of fishing.

It is customary, in investigations of this kind, to use the results for making deductions as to the intensity of fishing in the areas dealt with. If, say, 100 plaice are liberated and spread themselves over a comparatively wide area, and if within a certain period, say one year, 50 of these are recaptured, it may be argued that of all the plaice present on the same area 50 per cent. have been captured during the same year. Information to form such estimates of the intensity of fishing on the East side of the Irish Sea is afforded by the summary table. In the case of nine experiments the data are complete—a complete year having elapsed between the time when the fish were liberated and the time when the summary was drawn up. The last column gives the percentages recaptured, and the figures may mean that in the course of one year 6 per cent. of the plaice in Luce Bay and the adjacent waters were captured, 12 per cent. of those on the fishing grounds round the Isle of Man, and so on. Now we may leave the Luce Bay experiments out of consideration, and those made on Stations III. and IV. may also be ignored, since these two experiments were vitiated by the faulty nature of the labels employed. On the other hand, Experiments V., VI. and VII. may be considered together, since most of the fish liberated on the stations so numbered have apparently spread themselves over much the same area—the Irish Sea North of Holyhead, South of St. Bees Head, and East of the Isle of Man. Within this area about 80 plaice out of 180 have been recovered—a percentage of about 45. That is to say,

in this area fishermen have captured, in one year, about 45 per cent. of *all* the plaice present on the ground which were over eight inches in total length.

I think that too much may easily be made of this argument. It would be justifiable to make the percentage of marked plaice returned indicate the intensity of plaice fishing *if* the marked fish behave normally; *if*, when liberated, they spread themselves uniformly over wide areas. Then it may reasonably be contended that the proportion of marked fishes re-caught represents also the proportion of the unmarked fishes caught. I think that the marked fish behave normally, but it is the case that there is a certain amount of segregation in the distribution of the marked fishes. The figures indicating "intensity of fishing" are to be regarded only as approximate indications of the degree of exploitation of the local fishing grounds.

On the other hand, the results of the Luce Bay and the Welsh experiments indicate a much less intensity of fishing. In Luce Bay and the adjacent waters this is accounted for by the anti-trawling legislation of the Scottish Fishery Board. Plaice are only caught in this area by lines, trammels, and other forms of fishing, which are very ineffective when compared with trawling. But in the Carnarvon Bay experiment this is not the case. The low proportion of fish returned, 12 per cent., is due only to the fact that there is very little fishing indeed in Carnarvon and Cardigan Bays when compared with the Coasts of Lancashire, Cheshire, and that part of the North Welsh Coast exploited by Hoylake smacks. The same is to be said of the other Welsh experiments, for though the complete year has not yet elapsed it is apparent that nothing like the same proportion of fish as in the case of the Lancashire experiments will be returned.

These estimates agree generally with what we know, from other considerations, of the intensity of fishing on the East side of the Irish Sea. It is well known that there is a very great amount of fishing on the Lancashire Coast proper, that the Coasts of North Wales are not exploited to the same extent, and that the two great Welsh Bays are fished to a very much less extent again.

These estimates must be regarded as only approximate ones. It is no doubt the case that a certain number of the fish liberated in each experiment must die from injuries received during trawling which were not at first apparent. On the other hand, there is also no doubt that a certain proportion of marked plaice have been caught by fishing boats and have escaped notice and so have not been included in the above summary.

Influence of different kinds of fishing.

The tables give information as to the kind of vessel or fishing instrument by which most of the marked fishes were caught. This information was not always given, so that all the cases are not included. The figures are:—

Method of fishing.	No. of marked fish returned.
1st class sailing trawlers (smacks)	66
2nd class sailing trawlers (half-decked boats) ...	47
Stake-nets	25
Steam trawlers	10
Lines, "tees," trammels, hedge-baulks, "draught-nets"	6
Information not given	41
	195

This table gives one a rough idea of the relative importance of different methods of fishing in the area embraced by the experiments. It must be remembered,

in appraising the relative influence of sail and steam, that marked fish may have been overlooked especially aboard steam trawlers. On the other hand, it has to be remembered that steamers are excluded from the territorial waters in which the majority of the marked fish were recaptured. On the whole, the figures in the table agree fairly with practical experience of fishing methods in the district.

Rate of Growth of Plaice in the Irish Sea.

This is very variable, as might be expected. The growth of a fish depends on the amount of food present on the ground which it inhabits, and it is well known that different grounds vary greatly in this respect. The present experiments were not favourable for observations on the rate of growth. In order to study this to the greatest advantage, a large number of fish would have to be marked and liberated before the period of the year when growth begins. We did, indeed, set free 566 before the end of March, but of these the great majority captured were taken before the end of July, and only a comparatively small number after that time. In May, June and July we set free 227 plaice, but few of these have been recaptured. Conclusions as to the general rate of growth based on these are not reliable. Up to the end of July, however, our figures afford reliable indications as to the growth rate. These figures are:—

Average increase in length up to the middle of			January	0·04 inch.
Do.	do.	do.	February	0·04 ,,
Do.	do.	do.	March	0·07 ,,
Do.	do.	do.	April	0·2 ,,
Do.	do.	do.	May	0·42 ,,
Do.	do.	do.	June	0·86 ,,
Do.	do.	do.	July	1·5 ,,
Do.	do.	do.	August	1·95 ,,
Do.	do.	do.	September	2·62 ,,

These figures will be more easily understood by consulting the diagram below. In this the black columns represent the actual increase in length of the plaice captured from month to month.

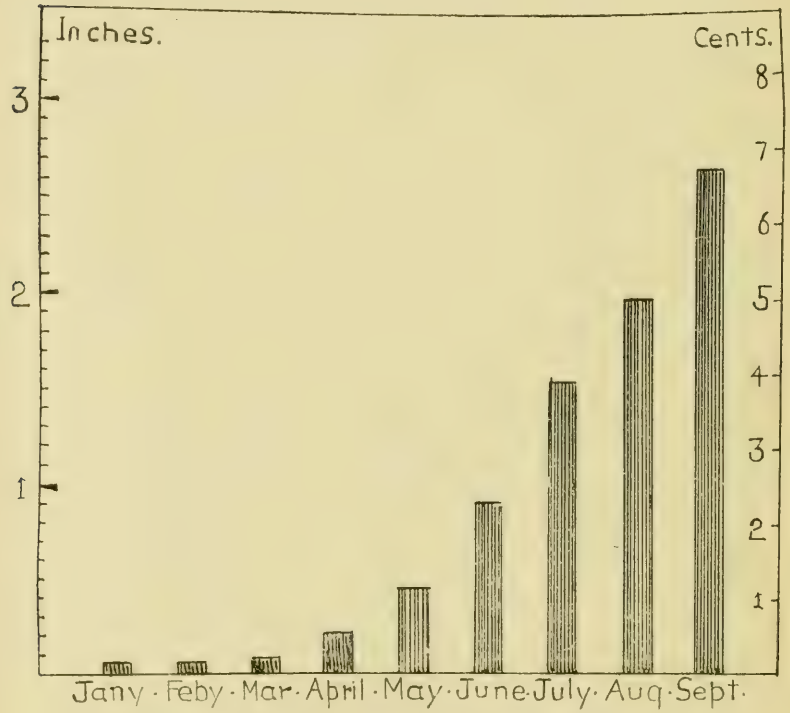


FIG. 10. Actual increase in growth of the plaice during the months January—September. The figures on the left hand indicate inches of growth, and those on the right centimetres.

It will be seen from the chart that the growth of the plaice is very slight during the months January, February and March; practically the fish does not grow at all during this period. Then from April to September the growth is very rapid, and it is only during this season of the year that growth really takes place. By the end of September the average increase in length of the fishes

liberated before the end of March was about $2\frac{2}{3}$ inches. I think, however, this number is too low. If we consider also the fishes liberated during the summer, and include them in the calculation of the growth rate, we get a curve which, however, is not represented in the diagram. This indicates that by the end of September the average increase in growth was just over three inches; and, moreover, the slope of the curve indicates that in September the fishes were not growing nearly so fast as in the two preceding months.

In a few cases exceptionally large increases in length have been observed. One fish, set free on the Mersey Deposit Ground on 12th November, 1904, and recaptured by a Hoylake smack off Great Orme's Head on 3rd December, 1905, about $12\frac{1}{2}$ months afterwards, had grown $5\frac{1}{4}$ inches. Perhaps a more extraordinary instance, however, is that of a plaice set free near the Liverpool Bar Lightship on 6th July, 1905, and recaptured by a second-class trawler on 23rd September, 1905, only a mile or two from the place where it was liberated. In 11 weeks this fish had added 4 inches to its stature. These, however, are quite exceptional cases.

The "Homing-theory."

It was suggested to me by A. Scott that the facts of Experiment X. lend some support to the theory (which has been more favoured in relation to fresh water than sea fish) that fishes tend to return to the places from which they are taken. At first sight this is very plausible. It is true that 17, or about 25 per cent., of the fishes caught in Barrow Channel and taken out to the Morecambe Bay Lightship returned again to Barrow Channel; and if we consider only the fishes which were

reported during the first eight weeks the supposition is still more plausible. Again, of the plaice caught in Red Wharf Bay and liberated off Puffin Island and Gt. Orme Head, a fair number did go back into the Bay. But I think that the theory (which is *a priori* improbable) is discounted by the other migrations observed. Thus the Newcome Knoll fish, which were caught in Red Wharf Bay, scattered everywhere, when they might more easily have returned into the Bay, and the Blackpool fish also caught in Red Wharf Bay went North, for the most part. It is more likely that there was a migration already in existence, in each of the cases of apparent "homing," into the areas into which the "homers" travelled, and that these simply obeyed the impulses which led to this migration.

Fish caught in intra- and extra- territorial waters.

It will be obvious from a glance at the charts that the greater number of fish returned have migrated along the shallow waters within the territorial limits. The line defining the seaward limit of the Lancashire and Western Sea Fishery District is indicated roughly on the charts, and it will be seen that, of the fish returned, the place of capture of which could be defined without doubt, by far the greater number have been caught within the territorial waters. Of 173 fish, the places of recapture of which are marked in the charts, 124 or over 71 per cent. were caught within the district, and 49 or over 28 per cent. were caught outside the limits of the latter. It must be remembered that some marked fish recaught by steam trawlers may have escaped identification, but I have reasons for concluding that comparatively few have been allowed to escape notice. It is also to be borne in mind that there is more fishing along the coast and within the

territorial waters than on the offshore grounds, and that there is a greater chance that a fish will be recaptured in the former area. However, it seems most probable that the migrations made by the majority of marketable plaice on this side of the Irish Sea are mainly along shore and in territorial waters.

Influence of size on migration paths.

Nevertheless a fair proportion have been recaptured from places well outside the territorial waters, and in some cases at considerable distances from the place of liberation. If the sizes of these fish be compared with those caught in the territorial waters, it will be seen that the sizes of those taken outside are usually greater than those caught inside the district. But the difference is not very striking, and is to be seen only when considering averages. The fish dealt with in these experiments have for the most part ranged from 8 to 12 inches in length, and though the very smallest of these do not migrate to a marked extent, nevertheless it is difficult to draw any distinction between plaice of different sizes within the limits indicated above. Other influences—the season, abundance of food, &c., operate more powerfully than the exact age of the fish.

General conclusions.

The experiments here described have so far been made on too small a scale to yield conclusions of a high degree of probability, and it is advisable that they be repeated on a larger scale before any inferences of a practical nature be made from their results.

The value of these conclusions obviously depends on whether or not a marked plaice behaves normally, that is, like an unmarked healthy plaice. Fishermen express two

views: (1) that the marking stimulates the fish to travel further than it would otherwise have done: and (2) that the marking makes them sluggish. I do not think that either of these views is correct; they are, indeed, only the usual kind of conjectures made by fishermen with regard to matters outside their experience. Nearly everything we have seen of the behaviour of marked plaice indicates that they behave normally. Marked plaice have never been caught by themselves. Where they have been caught in unusual numbers there have also been large catches of unmarked plaice made. In the case of Experiment XIV., for instance, an unusually large number of marked plaice were returned, and all, with one exception, from the locality where they were originally caught. But during all this time plaice were very abundant here and large catches were made by the fishing boats. The marked plaice, in fact, behaved just as the other fishes on this ground did.

Again, it is not uncommon to catch perfectly healthy plaice and other flat fishes which have suffered mutilation. I may also instance the case of a marked plaice re-caught a few weeks ago in Luce Bay, after 15 months from the date of liberation. This fish was in excellent condition, and the wound made by the mark had not become greater than at first. The fish had grown $3\frac{1}{2}$ inches.

In the meantime one may summarise the results as follows:—

1. The number of fish returned depends on the intensity of fishing in the area into which the fish have migrated, and gives a measure of the latter. Thus of the fish liberated on the Lancashire Stations, where fishing is actively carried on, from 25 to 50 per cent. have been returned within the year following liberation; while on the Welsh Stations, where there is very little fishing, the

highest percentage recovered was 25, and in three of the experiments no fish whatever have been sent back.

2. The average percentage of marked plaice returned from all the experiments is 23·2. This may be regarded as indicating the extent to which fishing goes on on the East side of the Irish Sea. It suggests about 25 per cent. of the plaice present on the fishing grounds at any time will be caught by fishermen before the expiry of one complete year.

3. The majority of the fish returned have been recaught by smacks. But it must be remembered that it is more likely that marked fishes would escape recognition if taken by a steam trawler.

4. The increase in size of the fishes recaught agrees well with previous estimates. Roughly speaking, this may be put down at three inches in the year; that is, for plaice between eight and 15 inches in length. This increase in growth takes place almost exclusively during the months May to September. During the other months of the year plaice do not grow at all.

The increase in weight is, of course, much more rapid than that in length. The weight of plaice of eight inches in length varies from 75 to 90 grams (from three to four ounces), while that of a plaice 11 to 11½ inches long may vary from 240 to 280 grams (9½ to 11½ ounces). That is, a plaice which in April is only one quarter of a pound in weight will, if allowed to remain in the sea, attain a weight of from one-half to three-quarters of a pound by the end of the following September. Marked plaice shew much the same relationships of weight and length as unmarked fishes.

5. Migration paths can, so far, only be roughly determined, and many more experiments will have to be made before the main facts of fish migration can be

rendered clear. In the meantime, the main migrations made by plaice on the Lancashire and Welsh Coasts *during the winter* are along the shore and within the territorial waters; the estuaries and bays are greatly frequented by the fish. We have observed a general Northerly tendency during the winter. In the summer, while the along-shore migration, within the territorial waters, still continues to some extent, an offshore and Southerly migration has been noticed. There are, of course, many exceptions to these general tendencies. Fish liberated within the waters of Liverpool Bay remain there for the most part. Only in two cases have fish liberated on the West Coast of England crossed the Irish Channel. Only three cases are recorded, so far, of fishes which have migrated out of the Irish Sea, and all of these are, most probably, fish which were set free in Luce Bay.

Explanation of the Charts.

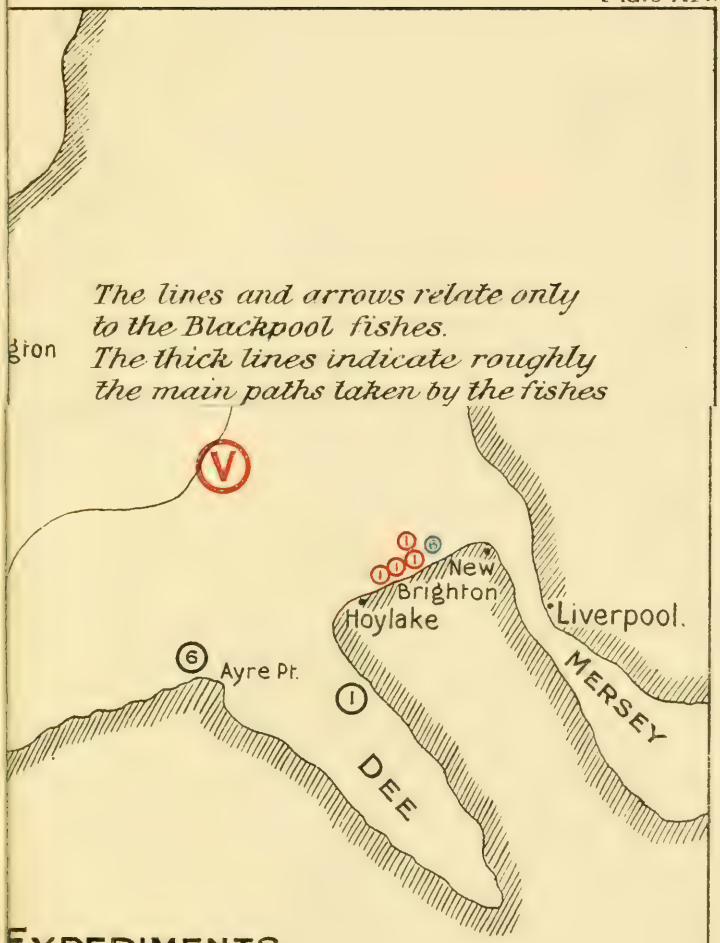
Plate XIV.

Shews the results of Experiments V., VI., X.

Plate XV.

Results of Experiments I.-III., IV., VII.-VIII., XI., XIV.

In all cases the large circles indicate the positions of the "stations" on which the marked fishes were liberated. Each of the smaller circles indicates the position where a marked fish has been re-caught. Obviously these latter positions can only be represented approximately on the charts. The figures inside the small circles represent the numbers of months (4-weekly periods) between liberation and recapture.



EXPERIMENTS.

come Knoll. RED.
kpool closed ground. BLACK.
les W. from Morecambe Bay Light-ship. BLUE.

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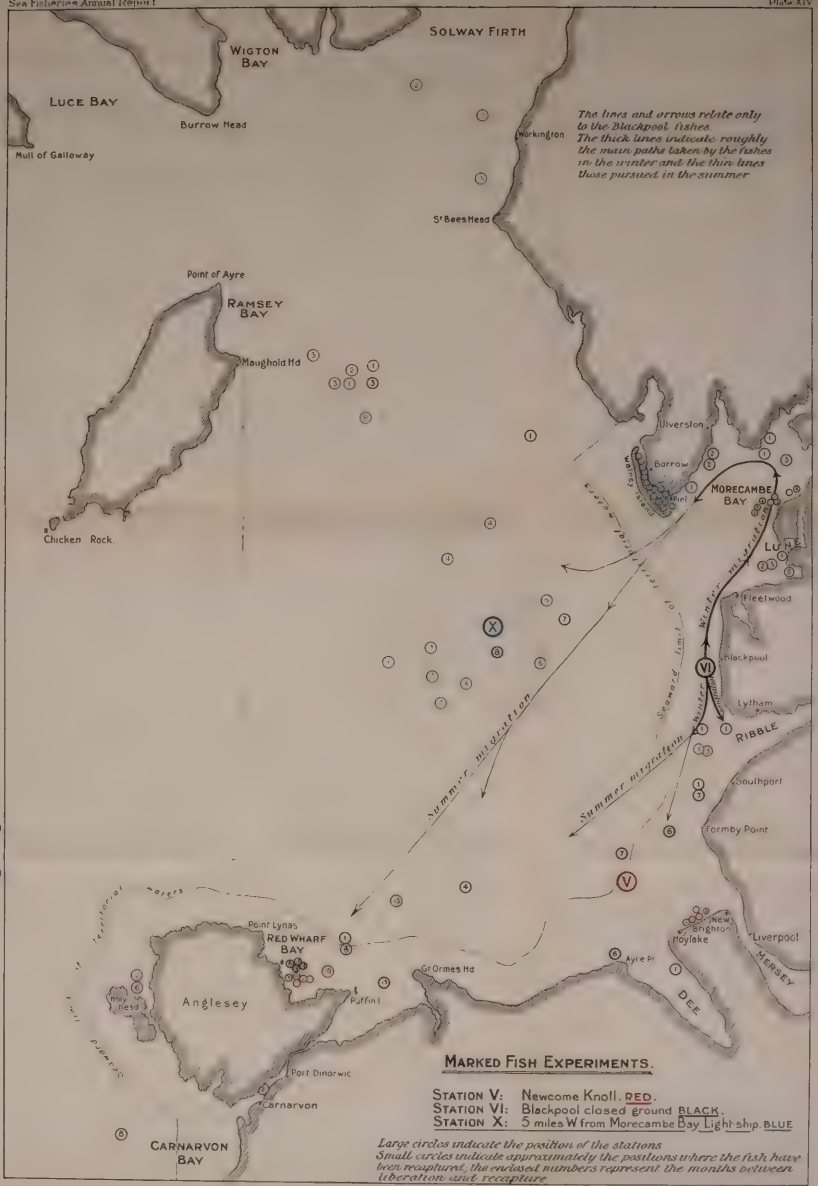
SOLWAY FIRTH
WIGTON BAY
LUCE BAY
Burrow Head
Mull of Galloway
Workington
St Bees Head
The lines and arrows relate only to the Blackpool fishes
The thick lines indicate roughly the main paths taken by the fishes in the winter and the thin lines those pursued in the summer
Point of Ayre
RAMSEY BAY
Maughold Hd
Chicken Rock
Ulverston
Barrow
Piel
MORECAMBE BAY
LUNE
Fleetwood
Blackpool
Lytham
RIBBLE
Southport
Formby Point
Winter migration
Summer migration
Seaward limit of
Summer distribution
Point Lynas
RED WHARF BAY
Anglesey
Penmon Pt
Puffin I
Gt Ormes Hd
Ayre Pt
New Brighton
Prince's Dock
Liverpool
MERSEY
DEE
Port Dinorwic
Carnarvon
CARNARVON BAY
MARKED FISH EXPERIMENTS.
STATION V: Newcome Knoll. RED.
STATION VI: Blackpool closed ground BLACK.
STATION X: 5 miles W from Morecambe Bay Light-ship. BLUE
Large circles indicate the position of the stations
Small circles indicate approximately the positions where the fish have been recaptured, the enclosed numbers represent the months between liberation and recapture

EXPERIMENTS.

ce Bay, ☐ Black & Red

Red

Black.

rpool Bar Light Ship, Black.

ecambe Bay Light Ship, Red

Liverpool Bar Light Ship, Blue

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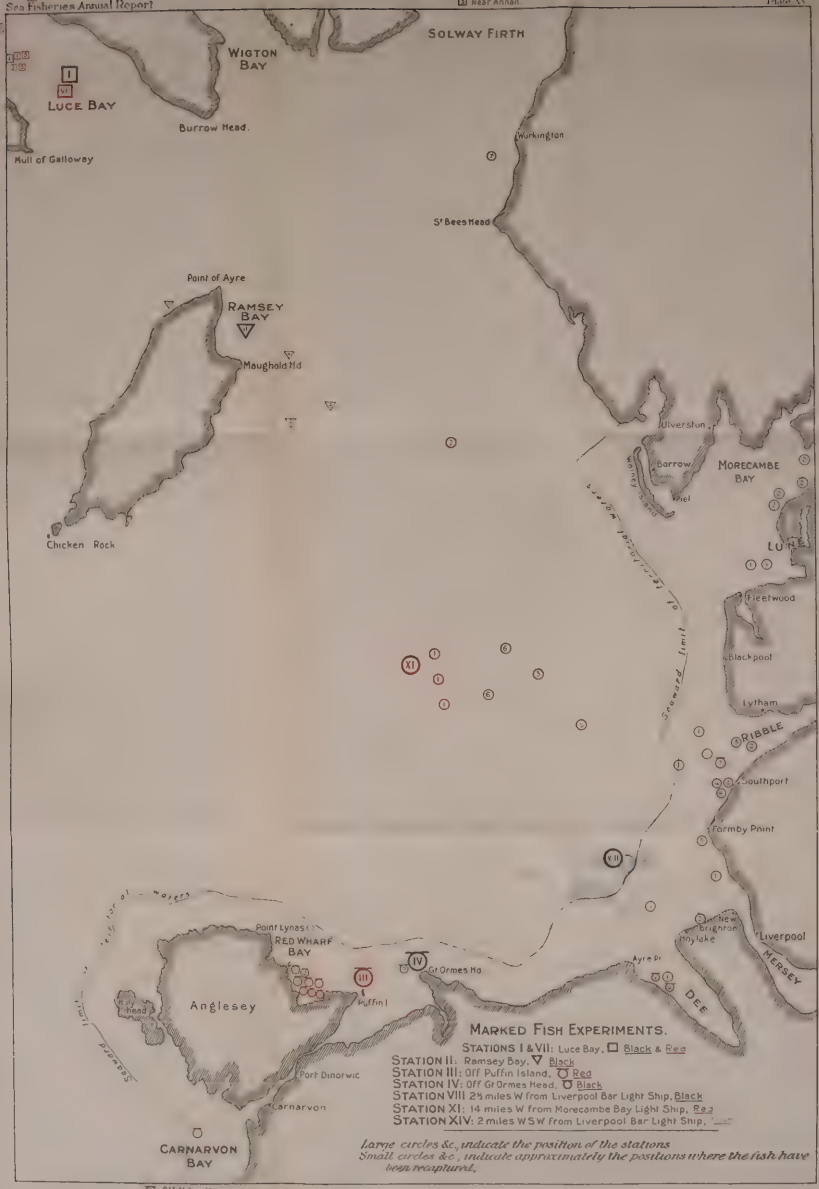

Marked Fish Experiments.

Stations I & VII: Luce Bay, □ Black & Red
Station II: Ramsey Bay, ▽ Black
Station III: Off Puffin Island, ○ Red
Station IV: Off Gt Ormes Head, ○ Black
Station VIII 2½ miles W from Liverpool Bar Light Ship, Black
Station XI: 14 miles W from Morecambe Bay Light Ship, Red
Station XIV: 2 miles W S W from Liverpool Bar Light Ship, —

Large circles &c., indicate the position of the stations
Small circles &c., indicate approximately the positions where the fish have been recaptured.

(5) Off Kilan Head
(6) Newport Bay
(7) Newport Bay
(8) New Quay

2553

INTERNAL PARASITES AND DISEASED CONDITIONS OF FISHES.

By Jas. Johnstone.

1. CESTODA.
2. TREMATODA.
3. FUNGI.
4. TUMOUR FROM SKIN OF DAB.

I am describing here a small collection of cestodes and trematodes made last summer from trawl fish caught by the s.s. "John Fell." As a rule the species collected were taken from skates and rays. The usual method of collection was to take the whole gut from the fish to be examined and place it in a dissecting dish containing fresh water. The gut was then slit up longitudinally and examined bit by bit. In a short time the fresh water causes the worms to relax and they can then be detached from the intestinal wall without injury to suckers or hooks. If they are kept in fresh water for about a quarter of an hour complete relaxation takes place before death, and in the case of cestodes bothria are expanded, while with trematodes the animals die without any trace of wrinkling. In the case of the latter animals it is always necessary to make stained preparations in order to determine the species and this is greatly facilitated by gently pressing the worm, while alive, between a slide and cover glass, or between two slides, according to its size. The whole is then put into a flat dish containing fresh water and in a short time the animal dies in a beautifully flat and thin condition. I have found that about 5 per cent. formalin makes the best general preservative for cestodes if it is desired to display the animals in

as natural a condition as possible, or to make general stained preparations of the proglottides. Before preserving it is, however, desirable to rinse the animal very gently in fresh water in order to get rid of the mucus and chyle with which it is surrounded. In the case of many species the strobila generally comes to pieces on being preserved and if the whole organism is to be studied it is necessary to preserve such worms, each in a separate tube.

I. CESTODA.

Bothriocephalidæ.

Bothriocephalus (= **Dibothrium**) **punctatus**, Rudolphi.—Fig. 11.

Hosts: *Rhombus maximus* and *R. laevis*; at all stations.

Every turbot and brill examined has so far proved to be the host of one or more of this cestode. Generally the brill harbours only two or three worms, but in the case of the turbot the number is much greater. One turbot 30½ inches in length, caught in Luce Bay in October, 1905, was greatly infested, and I counted over 60 *Dibothria* in the gut exclusive of several which had become detached. All were attached to the walls of the pyloric cæca.

Two distinct varieties of *Dibothrium punctatus* are to be noticed (see fig. 11, A and B), and it is hard to resist the impression that we are dealing here with two distinct species. The general morphology of the scolex and proglottides is, however, so similar in both cases that it is probable that we have to deal with varieties only, or at most physiological species, the difference being due to the different habitat. The differences between the two cestodes are (1) the length and thickness of the head and

the succeeding proglottides: and (2) the general appearance of the strobila on preservation. In the case of the two specimens figured the measurements are:–

A (from the turbot)–

Length of head: 3·5 mm.;

Length of strobila: 49 cm.;

Width of strobila at the widest part: 4 mm.

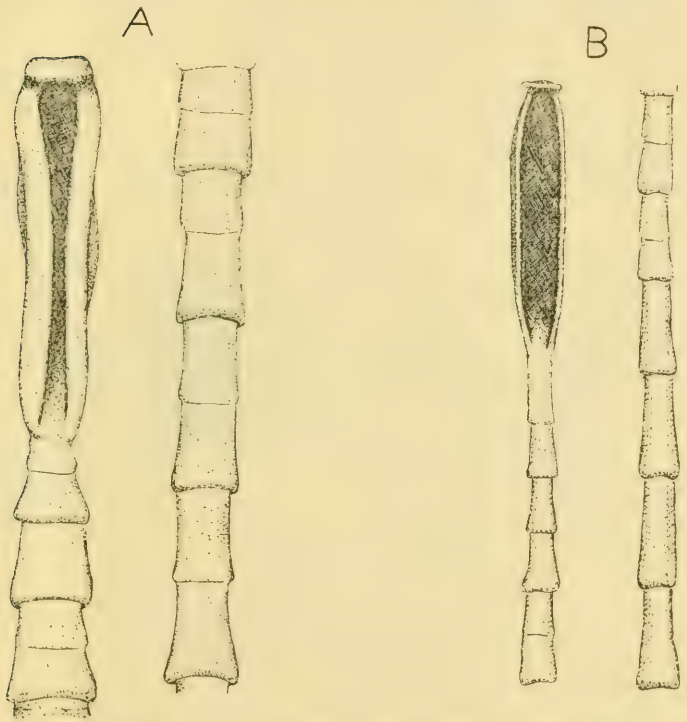

FIG. 11. *Bothriocephalus punctatus*, Rudolphi. A: from the turbot: B: from the brill. Mag. 22 dia.

B (from the brill)-

Length of head: 2·3 mm.;

Length of strobila: 69 cm.;

Width of strobila at the widest part: 6 mm.

On preservation by killing in water and pickling in five per cent. formalin, the whole strobila is more transparent and thinner in the turbot than in the brill, and in the latter case the edges of the proglottides are very usually more or less crenulated. These differences are very obvious and are generally constant. The smaller head of the cestode from the brill is, in particular, a very striking point of difference.

Tetraphyllidea.

Oncobothriidæ.

Oncobothrium uncinatum, Rud (Figs. 12).

Hosts: *Raia maculata* and *R. microcellata*, Cardigan Bay: and *R. clavata*, Bahama Bank.

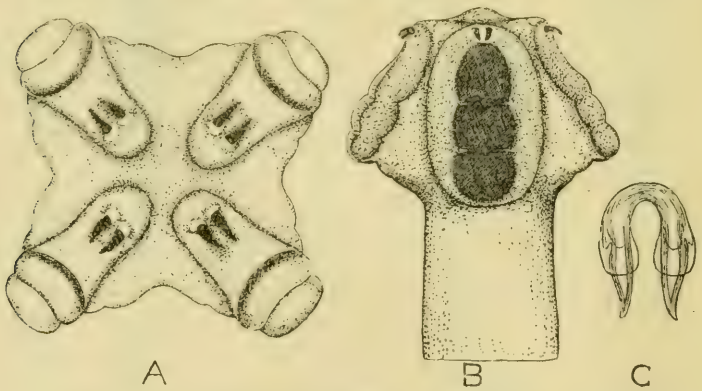

Fig. 12. *Oncobothrium uncinatum*, Rudolphi. A: the scolex seen from above, mag. 32 dia.: B: the scolex seen from the side, mag. 21 dia.: C: hooks.

This species has been recorded by van Beneden from the coasts of Belgium as a parasite of *Raia clavata*, and *Trygon pastinaca*, while Linton records it from the Wood's Hole region from *Trygon centrura*. According to van Beneden it is very rare. I have obtained five specimens altogether.

The measurements of the largest of these are:-

Greatest diameter of head: 1·75 mm.;
Total length of strobila: 10·7 cm.;
Width of widest proglottis: 3 mm.;
Length of widest proglottis: 1·7 mm.;

but this worm is obviously incomplete.

The shape of the head is very characteristic of this species but identification is made practically certain if the top of the scolex be shaved off and cleared so as to display the hooks. There is one pair of these on the margin of each bothrium and the two hooks of the pair are connected together at their bases.

Fig. 12 shows the scolex from the side and the same seen from the top.

Acanthobothrium coronatum, Rudolphi.—Fig. 13.

Hosts: *Raia clavata*, Carnarvon Bay, and *R. batis*, off-shore grounds.

Most of the specimens of this worm were very small, measuring from 5 mm. to 20 mm. One, however, was much larger, and I give the principal measurements as taken from this specimen.

Length of head: 1·18 mm.;
Greatest diameter of head: 1·16 mm.;
Length of head and neck: 3·5 mm.;
Diameter of hook apparatus at the apices: 0·24 mm.

This species is easily recognised by the general shape of the head and the presence of the three large accessory suckers above each bothrium. These accessory suckers are not easily observed in such a view of the head as is represented in fig. 13, but if the latter is propped up in a watch-glass so that one may look down on it from above their disposition can easily be seen.

P. J. van Beneden in diagnosing the genus says: "The four bothria are each armed with two hooks, united at their bases and bifurcated at the apices." I have not been able to see this union of the hooks. The extremities (fig. 13) are closely apposed and one seems to fit into the

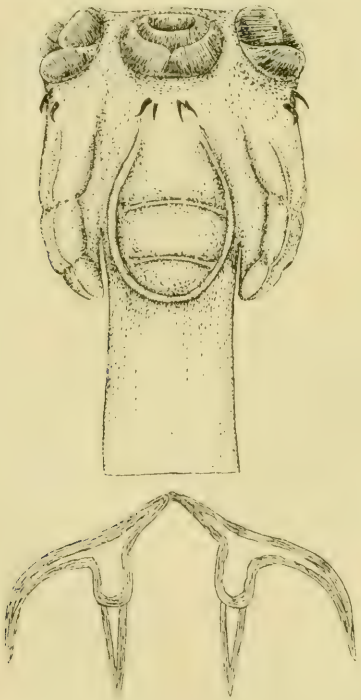

Fig. 13. *Acanthobothrium coronatum*, van Ben. Scolex mag. 22 dia., hooks mag. 200 dia.

other, forming a kind of ball and socket joint. There is apparently no fusion of the substance of these structures.

Calliobothrium verticillatum, Rudolphi.—Figs. 14.

Host: *Galeus vulgaris*, Cardigan Bay.

P. J. van Beneden recorded this species from *Galeus canis*, *Mustelus vulgaris*, and *Squatina angelus*; while

Linton found it in *Mustelus canis* in the Wood's Hole region.

This cestode is very small and not easily seen among the mass of food *debris* usually filling up the spiral valve of the hosts. In the part of the strobila following the scolex the diameter is often no greater than that of a human hair. The following measurements apply to the largest of four specimens found in the two fishes mentioned above:

Length of head: 0·34 mm.;
Greatest diameter of head: 0·32 mm.;
Length of hooks: 0·095 mm.;
Width of proglottides immediately succeeding head: 0·085 mm.:
Width of proglottides about anterior third of strobila: 0·16 mm.;
Width of proglottides about midway between head and extremity of strobila: 0·19 mm.:
Width of proglottides about posterior third of strobila: 0·2 mm.:
Total length of strobila: 50 mm.

In spite of its extreme tenuity this worm is easily recognized by the peculiar modification in shape of the proglottides, and by the characters of the head. Each bothrium is divided by two transverse costæ so as to form three loculi, of which the most anterior is the largest. The costæ are situated rather far back so that the two posterior loculi are very small. Fig. 14 is a view of the head showing one of the bothria in face, but when the head is rotated through 45° so that two bothria only are seen, and these in profile, the latter are then seen to project very considerably, giving the animal a most characteristic appearance. At the summit of each bothrium there are

three accessory suckers, the margins of which I have represented as seen from the side. These are, however, very inconspicuous, and their existence would hardly be suspected except on very careful study of the specimen.

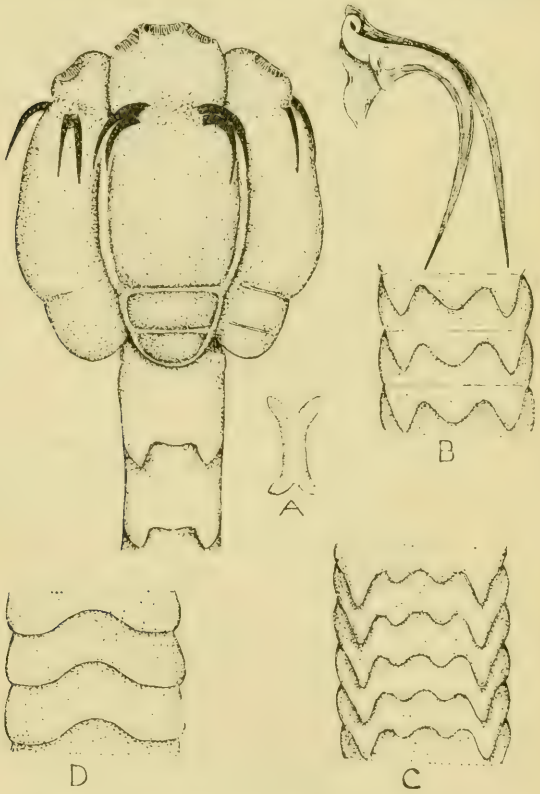

Fig. 14. *Calliobothrium verticillatum*, Rudolphi. Mag. 132 dia. hooks mag. 366 dia.

I have not seen them so distinctly shewn as is represented in van Beneden's fig. 3, pl. XII.* The hooks are very characteristic of the species. There are two pairs on the lateral and anterior margins of each bothrium, and each

* "Vers Cestoides."

pair is united at the bases. They project considerably from the margin of the head and are very conspicuous. The shapes of the proglottides vary from region to region of the strobila and give the worm a unique appearance. There is no neck and the proglottides immediately posterior to the head are each provided with four laciniate lobes or lappets. A section of the worm is given in fig. 14 A, and shows the situation of these lobes. A litle way further back (fig. 14 B) an additional rounded lobe appears at the middle of the posterior margin of each proglottis, and these median lobes characterise the region of the strobila about one-third of the distance between head and extremity. Further back than this (fig. 14 C) this median lobe sub-divides into two, and further back yet these subsidiary lobes disappear and the posterior margin of the proglottides shew only a blunt rounded prominence at each lateral and posterior corner. Towards the posterior extremity of the strobila the proglottides lengthen out greatly until they are about thrice as long as they are broad, and the terminal proglottis is always pointed. The whole strobila withstands preservation in formalin very well and does not break up on immersion in this fluid.

Phyllobothriidæ.

Phyllobothrium lactuca, van Beneden.—Fig. 15.

Hosts: *Raia clavata*, Carnarvon Bay; *R. circularis*, Beaumaris Bay; *R. batis*, off-shore grounds.

This worm, which is usually very commonly present in the intestines of various rays, is easily recognised by the extraordinary shape of the head and by the appearance and length of the strobila. P. J. van Beneden's figure of this species in the "Recherches sur les vers Cestoides" (also in Bronn, Taf. XLI., fig. 10), is drawn from a

specimen in which the bothria have undergone extreme contraction and the head has assumed a spherical appearance, presenting very little indication of the true shape of

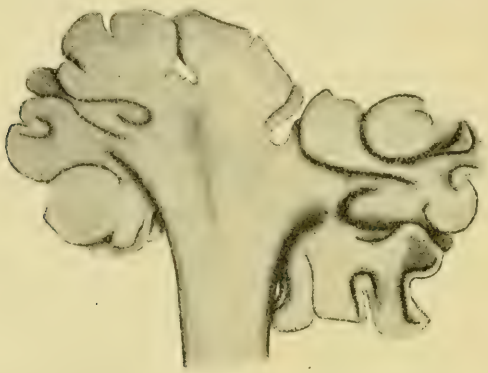

Fig. 15. *Phyllobothrium lactuca*, van Ben. Scolex seen from beneath. Mag. 18 dia.

the bothria. Fig. 15 is drawn from a specimen which was killed in fresh water and shows the bothria fully expanded. The head is seen from underneath, being bent over at right angles to the longitudinal axis of the strobila; and fig. 16 is a view of the same scolex seen

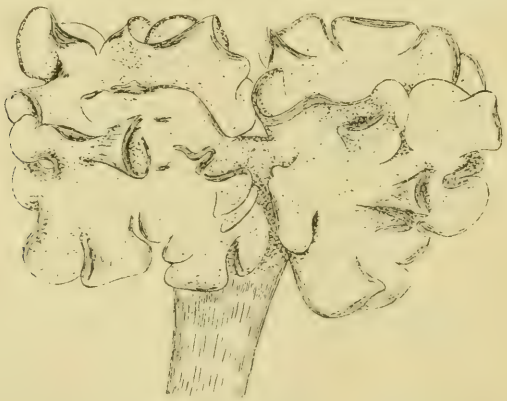

Fig. 16. *Phyllobothrium lactuca*, van Ben. Scolex seen from above. Mag. 18 dia.

from the top. There are four bothria present, though it is usually very difficult to observe the boundaries of each. The edges of these organs are deeply wrinkled and crenulated. Even when a number of these cestodes are killed in the same manner, the form of the scolices is often extremely variable. The term "lettuce-like," however, describes the general appearance very well.

The measurements of the specimen figured are:—

Greatest diameter of head: 3·5 mm.;

Length of strobila: 183 mm.;

Least width of proglottides (just behind the neck): 0·6 mm.

Greatest width of proglottides: 2 mm.;

Greatest length of a proglottis: 1·75 mm.

The terminal proglottis is always the longest: it generally tapers to a blunted posterior point.

Phyllobothrium thridax, van Beneden.—Fig. 17.

Hosts: *Raia clavata*, Carnarvon Bay and Bahama Bank.

I refer a number of smaller cestodes to this species principally because of the difference in the general appearance of the scolex and strobila. Neither in *Ph. lactuca* nor in *Ph. thridax* is there any myzorhynchus, and I have been unable to discover any trace of accessory suckers in the former species. In the worms identified as *Ph. thridax* there are, however, small accessory suckers on the anterior borders of the bothria as shewn in van Beneden's fig. 4, pl. 5 ("Vers Cestoides"). The appearance of the bothria is very variable, but there is never the highly complex folding which is to be observed in the scolex of *Ph. lactuca*: the bothria can generally be seen to be four in number, with comparatively simple outlines. The strobilæ in the specimens obtained were always

shorter and more delicate in appearance than in the case of *Ph. lactuca*. In the median proglottides the irregular alternating position of the penes on the margins of the segments can usually be made out.

The measurements of the specimen figured are:—

Greatest diameter of head: 2·0 mm.;
Length of strobila: 36 mm.;
Greatest width of a proglottis: 1·6 mm.

Fig. 17. *Phyllobothrium thridax*. Mag. 40 dia.

Crossobothrium laciniatum, Linton.—Fig. 18.

Host: *Raia batis*, off-shore grounds.

The genus *Crossobothrium* was founded by Linton* for the reception of a species having the following characters: "Body articulated, slender, flattened, subquadrate; neck short or none; bothria four, opposite, pedicelled, unarmed, each provided with one auxiliary acetabulum on the anterior border; faces of the bothria with a raised rim or border, which becomes more or less

* Commissioner's Rept. U.S. Commission of Fish and Fisheries, part xiv., Washington, 1889. Pp. 470-4, Pl. 3, figs. 4-18.

free, cut, or frilled as the worm grows weak, or when placed in fresh water or alcohol."

From this diagnosis it appears that *Crossobothrium* is closely related to *Phyllobothrium*, and indeed the cestode figured here resembles greatly *Ph. thridax*. The

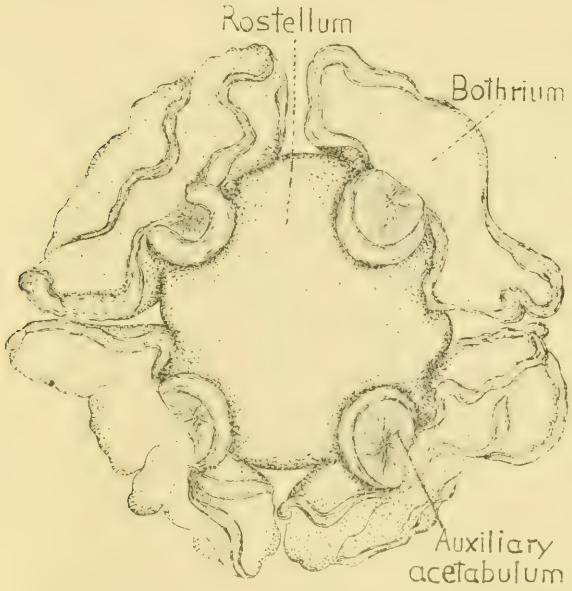

FIG. 18. *Crossobothrium laciniatum*, Linton. Scolex seen from above. Mag. 100 dia.

differences, however which Linton emphasises as constituting the distinctive features of the genus are (1) the bothria pedicelled here, instead of being sessile as in *Phyllobothrium*, and (2) the absence of a distinct neck.

I refer a worm obtained from the large intestine of *Raia batis* very doubtfully to this species. The specimen is indeed very different in appearance from *Ph. thridax*, but in dealing with such highly variable structures as the bothria of these cestodes too much

caution can hardly be exercised. In this specimen the bothria are placed on short but distinct pedicels round a large dome-shaped myzorhynchus. On looking down on the latter structure from above, the insertion of the bothria is well seen. The outlines of the latter structures are fairly simple. Each is bounded by a raised rim or border, which is most prominent on the anterior margins. This rim is very slightly cut into or folded. The bothria are set exactly opposite to each other. On the anterior margin of each, and, as seen from above, apparently lying on the myzorhynchus, is a large accessory sucker, or acetabulum. Anteriorly this acetabulum has a thickened rim: posteriorly this rim appears to be much thinner.

The single specimen obtained by me is a very young one, and it apparently possesses a distinct neck, thus differing in what appears to be an essential feature from the worm described by Linton. But the age of the specimen probably accounts for this difference. Linton's fig. 17 represents a young stage of *Crossobothrium laciniatum*, and in this specimen there is a distinct neck: that is, segmentation does not begin immediately behind the head as in mature worms, but at some little distance posteriorly.

I conclude then that this specimen is probably Linton's species, but may possibly be only a young stage of *Phyllobothrium thridax*, in which the preservation has influenced the form of the bothria so as to give the worm an appearance different from the typical one.

The measurements are:—

Diameter of head: 0·79 mm.;
Greatest width of strobila: 0·19 mm.;
Length of strobila: 8 mm.;
Greatest diameter of accessory suckers: 0·13 mm.

Echeneibothrium variabile, van Beneden.—Figs. 19, A, B.

Hosts: *Raia clavata*, Carnarvon Bay, Duddon Banks, Bahama Bank, and off-shore grounds: *R. batis*, off-shore grounds; *Galeus vulgaris*, New Quay. This is, perhaps, the commonest and most widely distributed cestode obtained during the past year.

The genus *Echeneibothrium* was founded by van Beneden to receive cestodes with the following characters:—The four bothria of the scolex carried each on a long and protractile pedicel; bothria extraordinarily variable in form; each distinguished by regular transverse folds along the entire length of the bothrium.

These folds resemble the transverse lamellæ of the adhesive sucking organ of the fish *Echencis*, a resemblance which suggested the generic name.

The most striking character of this species is its astonishing variability. Figs. 19 A, B represent the two most common varieties which I have observed. All these cestodes were preserved in the same way: that is, they were killed by immersion in fresh water for about a quarter of an hour, and then put into 4 per cent. formalin. The difference in the characters of both bothria and myzorhynchus is such as almost to lead one to suspect that the worms belonged to different species.

Variety A (Fig. 19 A) best answers to the characters given by van Beneden in his original diagnosis of the species. In these worms the myzorhynchus is long and slender and is provided with a small accessory sucker at its tip. In the figure it is almost concealed, owing to the necessity of so arranging the scolex as to get a good view of the most characteristic bothria. Each of the latter structures is thin and leaf-like, but the posterior extremities are rolled up and present a characteristic notching of the edges and backs. The

lamellar structure of the bothria is not shown well either in this or in any other specimen of the species that I have seen. Instead one finds that the face of each bothria is divided up into a number of separate loculi by means of one axial, and several transverse ridges. Only at the tip of one of the bothria are the transverse ridges continued across the whole face of the former. Five or six loculi on each side may be counted and there are also several in the broader, posterior, rolled-up part of the bothrium, but the number and shape of these latter cannot easily be seen.

FIG. 19. *Echeneibothrium variabile*, van Beneden. Varieties A and B. Mag. about 40 dia.

Variety B.

This variety, which is represented in fig. 19 B was a very common one. The myzorhynchus is always more rounded and club-like than in Var. A, and I have not observed any indications of a sucker at its tip. The bothria are thin and leaf-like, and are borne on comparatively long pedicels: their anterior extremities are more

tapering than in Var. A. As in the former case their posterior edges are rolled up and notched at the margins and backs. Each bothrium bears from seven to nine separate loculi which was distributed much as in Var. A. A central, and four transverse ridges divide up the face so as to form four loculi on each margin of the bothrium. One loculus is nearly always apical, as shewn in the figure. At the posterior edge two strong ridges, running out radially, separate the face of the bothrium into three cup-shaped loculi.

Seen from the side, as in the case of the bothrium at the top left-hand of fig. 19 B, each of the latter structures presents a very characteristic appearance when seen in profile.

Variety C.

The cestodes identified as Var. C of *Ech. variabile* differ so much from those already described that I hesitate to place them in this species. But it is more probable that they are only an extreme variety of the species than that they are specifically distinct from the worms figured as Vars. A and B. The appearance of the strobila is very like that of the others, and the anatomy of the proglottides, so far as studied, is not different. The scolex (fig. 20) is at first sight most dissimilar. The myzorhynchus is very large, and is either tabular or flatly dome-shaped. Its outline as seen from above is sometimes (as in the figure) roughly quadrangular with rounded angles, but more often it is circular. At times radial lines may be seen which appear to be folds dividing the upper surface of the structure into separate compartments. The bothria are placed on very short pedicels, or may be almost sessile. Each is small compared with those in Vars. A and B. It may be derived from such a bothrium as is shown in Var. B, by the complete rolling

up of the anterior tips. The posterior margin shows the characteristic notching of the edge and back, and the division of the face into the three deep cup-like loculi by two radial ridges.

P. J. van Beneden's figs. 3 and 9, pl. III., "Vers Cestoides," represent much the same condition as is represented in Var. A. Fig. 2, pl. III. of the same book shows the condition of Var. B. Variety C has been

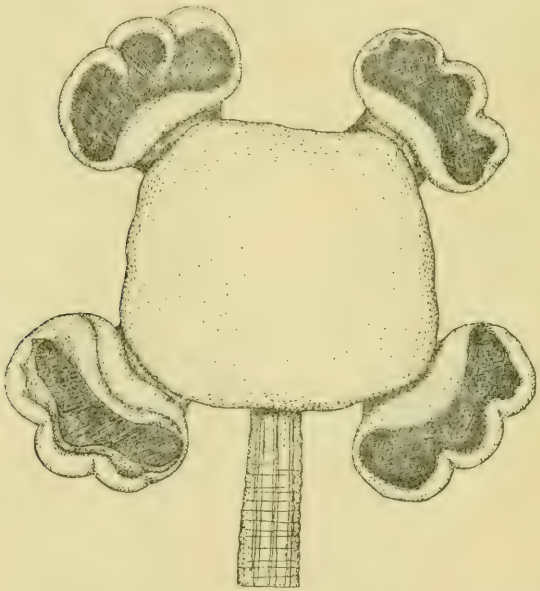

FIG. 20. *Echeneibothrium variabile*, van Ben. Var. C. Mag. 40 dia.

figured by Olsson,* whose fig. 15 is very similar to fig. 20. The variety is there described as "Forma singularis floribus Rosarum similis."

Such "varieties" as are spoken of here are to be regarded as conditions produced by the manner in which the animal has died. The effect of the killing in fresh

*Entozoa iakttagna hos skandinaviska hafsfiska. Acta Univ. Lundensis. Lunds. Univ. Aarskrift for 1866. Lund. 1866-7.

water, and perhaps also the subsequent preservation, must depend, to some extent at least, on the condition of nutrition of the worm before death, and this would be greatly influenced by the condition of the host, and, perhaps, also by the nature of the material on which the latter had been feeding.

Echeneibothrium, sp.—Fig. 21

A single specimen of a cestode belonging apparently to the above genus was taken from the large intestine of a *Raia batis* caught off the Calf of Man in July, 1905.

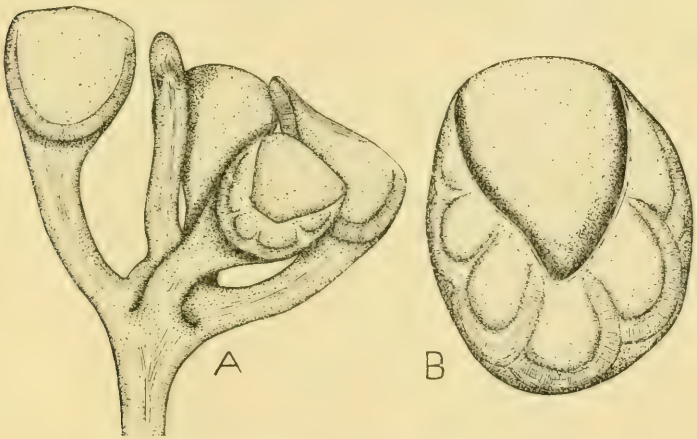

Fig. 21. *Echeneibothrium* sp. A: the scolex from the side; B: a single bothrium seen from the sucking face. Mag. about 40 dia.

I at first identified it as *Ech. dubium* van Beneden, but a more careful examination showed that it could not be this species. In *Ech. dubium* there are only about a score of proglottides and the last one is about one-third the total length of the strobila. In the worm described here the characters of the strobila and proglottides are rather those of *Ech. variabile*, to which species indeed the specimen probably belongs.

Fig. 21 is a general view of the scolex. The myzorhynchus is very long and slender and bears at its tip a "cephalic bulb." The four bothria are each borne on a long and highly mobile pedicel. In the figure one of the bothria is seen from above, and close to it, on the right hand, is one seen from the side; fig. 21 B is a view of one bothrium seen from above and should be compared with the right hand bothrium in fig. 21 A. The structure appears to be a kind of hollow bulb with a triangular opening on the top. Round this opening, but at some distance from its margin, is a raised rim from which a series of five or six radial ridges pass inwards towards the large central opening.

In this specimen the latter portion of the strobila is missing, and the characters of the proglottides actually present are of little value for the purposes of identification.

Anthobothrium auriculatum, Rudolphi.—Pl. xvi., Figs. 1, 2.

Four specimens of a cestode were obtained in 1905, which appear to be identical with the cestode described as above. Two of the specimens were obtained from *Raia clavata* caught on Duddon Banks, but I have no record of the host of the other two worms.

The measurements of the worm figured are:—

Greatest diameter of the head: 3 mm.;
Greatest diameter of one bothrium: 1·3 mm.;
Least diameter of one bothrium: 1 mm.;
Length of strobila: 86 mm.;
Width of proglottides behind the head: 0·48 mm.;
Length of proglottides behind the head: 0·04 mm.;
Width of terminal proglottis: 2 mm.;
Length of terminal proglottis: 2·5 mm.;
Diameter of largest ovum: 0·043 × 0·040 mm.

The Scolex.

Fig. 2 is a view of the scolex with the bothria turned to one side so as to expose their sucking faces. The myzorhynchus is very short and bears no terminal sucker. In all the specimens it is a mere protuberance on the anterior surface of the head. The bothria are four in number, arranged in a cruciform manner, carried on short but very evident pedicels. Each bothrium is oval in shape, and their longest diameters are at right angles to the axes of the pedicels. The sucking face of a bothrium is surrounded by a strong rim or tip which is indented at two places on each margin, and adjoining these indented parts of the rim there are two transverse septa which divide each bothrium up into three separate loculi. The cavities of these loculi are very deep.

The Neck.

This is very short. Segmentation almost immediately follows the part where the pedicels are inserted. The average distance apart of the segments is about 0·04 mm., and the edge of the strobila is thus finely and regularly serrated.

Anatomy of the proglottis: Fig. 1, Pl. XVI.

This corresponds very well with that of *Anthobothrium auriculatum* (Rudolphi), as described by Zschokke.* The chief difference is the position of the genital cloaca, which in my specimen is slightly further from the posterior margins of the proglottis than in Zschokke's figures. These openings alternate from side to side of the strobila in a very irregular fashion. The single genital cloaca contains both male and female orifices. The cirrus sac is oval in shape. The vas

* See Zschokke, Recherches Structure Anat. et Histol. des Cestodes. Geneve, 1888; p.p. 261 ex. seq. Pl. vii., Figs. 106-107.

deferens is greatly convoluted. The vagina is a nearly straight tube running transversely across the proglottis, near the posterior margin. The ovary is confined also to this posterior part of the segment, and consists of two lateral lobulated masses. The uterus appears to be a greatly convoluted tube, but the walls of this where in contact with each other appear to have broken down so that the organ is a large sac, occupying the middle of the proglottis. In the ripest segments the uterus, densely packed with eggs, occupies almost the whole volume of the proglottis, and only traces of the other organs can be seen at its periphery.

The testes are situated on either side of the uterus as two irregular bands. Immediately external to the testes are the vitellaria, which consist of small densely packed glands.

The anatomy of the proglottides in the specimens described here corresponds fairly well with that of *A. auriculatum*. The identification of my specimens with this cestode is, however rendered rather doubtful by some characters in the scolex. *Anthobothrium* appears to possess bothria which are unilocular, that is, are undivided by internal septa. But in the specimen figured here there are certainly two transverse septa, not, however, very conspicuous, and these cross each bothrium, dividing the cavity of the latter into three. This appears to be a character which hardly warrants the identification with the genus *Anthobothrium*. These cestodes are, however, so very mobile in life, that one must suppose that the exact shape of the scolex after death and preservation is due to the nature of the contraction, and that the precise form assumed may be very variable.

Tetrarhynchus erinaceus, van Beneden.—Fig. 22.

Hosts: *Raia clavata*, *R. maculata*, *R. circularis*, *R. microcellata* and *R. batis*.

Intermediate hosts: *Pleuronectes platessa*, *Trigla* spp., *Gadus morrhua*, *G. aeglefinus* and *Merluccius vulgaris*.

Fig. 22. Part of a proboscis of *Tetrarhynchus erinaceus*. Mag. about 440 dia.

This is one of the commonest tapeworms of Irish Sea fishes; it enjoys a very wide distribution both in its adult and pleurocercoid stages. *T. erinaceus* is always easily recognised by the extraordinary hooks. Fig. 22 is a view of a proboscis and shews the arrangement of the hooks on one side of the organ. The larger curved hooks, three of which can always be seen on one side, are about 0·05 mm. in length. Along one side of the proboscis is a series of long, comparatively straight hooks which are about 0·034 mm. long. The other hooks are short, straight or slightly curved and their average length is about 0·013 mm.

The other characters of the cestode need no description, as a glance at an everted proboscis is sufficient to distinguish the species.

Tetrarhynchus tetrabothrius, van Beneden.

Hosts: *Raia clavata* and *Acanthias vulgaris.*

This cestode can generally be distinguished by the presence of the four ear-shaped bothria and by the shape and arrangement of the hooks. On one side of the proboscis seven hooks can generally be seen. They are about 0·017 mm. in length, have expanded bases and sharply recurved apices.

II.—TREMATODA.

Distomum appendiculatum, Rudolphi.

Hosts: *Pleuronectes platessa, Pl. limanda,* New Brighton shore.

In the summer of 1904 Mr. G. Eccles procured for me a large number of small flukes $\frac{1}{2}$in. to 1in. long from the sandpools on the New Brighton shore. These were dissected by the fishermen attending the classes at Piel, in order to see the characteristic method of feeding on copepoda adopted by small pleuronectid fishes of this size. In quite a number of these tiny fishes a small appendiculate Distome was found which is *D. appendiculatum.* This trematode is probably far more widely distributed than any other endo-parasitic member of the group.

P. Olsson *(loc. cit.)* gives the following list of fishes in which the species is found:

Cottus scorpio,	Clupea harengus,
Salmo salar,	C. spratta,
S. fario,	Gadus morrhua,
Corregonus oxyrhynchus,	G. minutus,

G. virens,	Molva vulgaris,
G. melanostomus,	Pleuronectes limandoides,
G. merlangus,	Rhombus laevis,
G. pollachius,	Hippoglossus maximus,

Muræna anguilla.

This extensive list of hosts indicates that the immature form of the worm is to be found in some animal or animals which are very widely distributed, and Pratt* has described an immature trematode from copepods which is most probably the young of *D. appendiculatum.* In the small flat fish referred to in the present paper, copepods principally were found in nearly every specimen examined.

Distomum gulosum, Linton.†—Fig. 23 C.

Host: Mackerel, off Walney Island, July, 1905.

About half-a-dozen specimens of an appendiculate Distome were found by A. Scott in a mackerel dissected by him, and I refer these worms to the species described by Linton as *D. gulosum*, from the Butterfish, *Rhombus triacanthus*, of the Wood's Hole region. The principal characters made use of by Linton in his diagnosis are (1) the relative sizes of the oral and ventral suckers, and (2) the tubular form of the vitellaria.

The measurements of the specimens figured here are:-

Length: 10 mm.;
Diameter at ventral sucker: 1·1 mm.:
Diameter of oral sucker (transverse): 0·6 mm.:
Diameter of ventral sucker (transverse): 0·5 mm.:

* Zool. Jahrb., xi., 1898.

† Bull. U.S., Fish Comm., vol. 19, for 1899-1901, p. 454, Pl. 28, figs. 315-316.

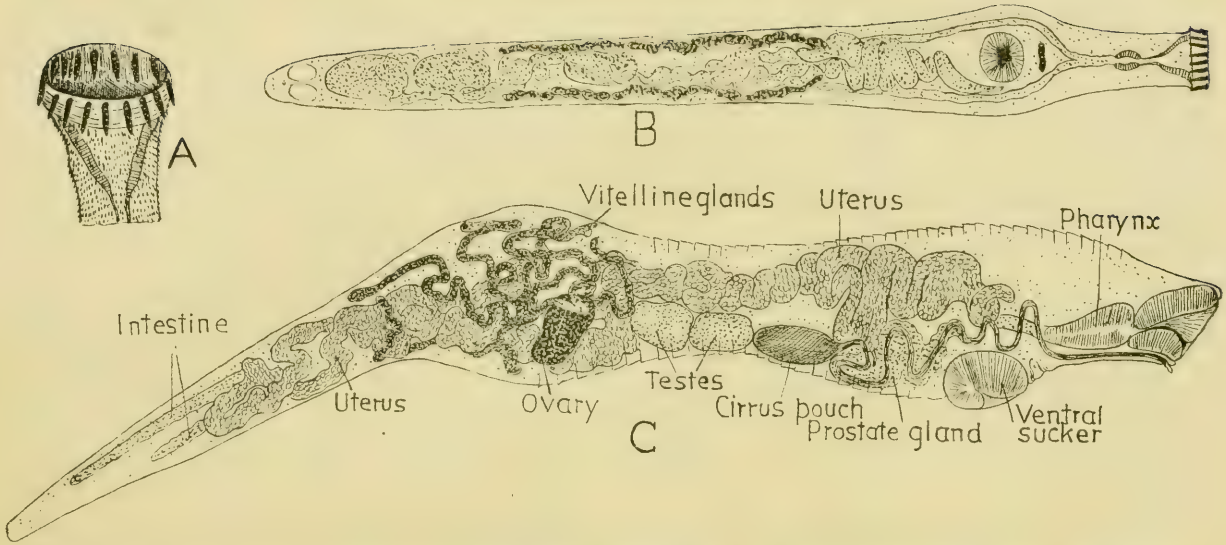

FIG. 23. A: oral sucker of *Echinostomum imbutiforme*. Mag. 46 dia. B: *Echinostomum imbutiforme*. Mag. 20 dia. C: *Distomum gulosum*. Mag. 14 dia.

Diameter of opening of ventral sucker: 0·24 mm.;

Distance apart of centres of suckers: 1·8 mm.;

Diameters of ova: 0·024 × 0·0135 mm.

The oral sucker is nearly round, but has two notches on its ventral lip; the ventral sucker is globular and rather smaller than the oral one. The pharynx is long and the intestine forks just anteriorly to the ventral sucker, and the rami extend down into the appendix. The latter is about one-third of the total length of the animal, but is retracted to a different degree in some of the specimens. The body when viewed in optical section appears to be provided with small spines, but these are only the edges of fine wrinkles which extend round the body. The skin is quite unarmed.

The genital aperture lies on the ventral border of the oral sucker, the cirrus pouch lies directly in front of the testes and is provided with a "prostate gland"; the testes are nearly globular, and are situated end to end at about the middle of the body. The ovary lies some distance behind the testes. The uterus is very voluminous and extends about half-way down into the appendix.

The vitellaria are very peculiar: there are about half-a-dozen contorted tubes situated immediately round the ovary. The exact number of these structures is, however, difficult to make out because of their tortuous courses.

Echinostomum imbutiforme, Molin.—Fig. 23 A.B.

Host: *Labrax lupus*, Morecambe Bay, July, 1905.

In 1859 Molin* described a *Distomum* from the

* *Nuovi Myzhelminta raccolti ed. esaminati.* Sitzungsb. k. akad Wien, Bd. 37, pp. 818-854. 1859.

intestine of *Labrax lupus*, with which the worm described here appears to be identical. Molin gives no figure, and I am unable to find one anywhere in the literature; the diagnosis, however, indicates that the worm figured here is most probably Molin's species.

The diagnosis is:—

"Corpus teres, antice truncatum, postice acuminatum, spinulis minimis densissime armatum; collum conicum, extremitate anteriori dilatatum; os terminale, amplissimum, imbutiforme, coronula sexdecim aculeorum majorum cinctum, apertura circulari; acetabulum ore minus, ad colli basim, sphæricum, apertura genitalis bilabiata, ante et ad acetabulum."

Measurements of the specimen figured:—

Length: 6·5 mm.;
Thickness at ventral sucker: 0·5 mm.:
Diameter of oral sucker: 0·39 mm.;
Diameter of ventral sucker: 0·33 mm.;
Distance apart of centres of the two suckers: 1·1 mm.;
Length of oral spines: 0·09 mm.

In the specimens described here all the characters summarised in Molin's diagnosis can be made out. The coronet of 16 to 17 long straight and stout spines surrounds the mouth, and are inserted on a prominent raised lip. The mouth itself is conical, passing into a short pharynx situated nearly halfway between the two suckers. A little way behind the pharynx the intestine forks, and between the fork and the anterior lip of the ventral sucker the genital aperture is situated. The latter is an elongated slit on the surface of a papilla; its longest diameter is transverse to the axis of the body.

The ventral sucker is spherical and is rather less in diameter than the mouth: it projects considerably from the general line of the body. The testes are large, oval bodies situated far back, near the pointed posterior end of the worm; the ovary is smaller than the testes, is oval in shape and is situated at about the posterior third of the body. The uterus is very voluminous, is crowded with ova, and obscures greatly the relationship of the vitellaria and their ducts. The latter glands are situated on either side of the body as two broad bands of glands, the edges of which bands are turned towards the observer in the view presented. At the posterior extremity are two small, clear vesicles, which are doubtless dilatations of the excretory duct or ducts.

All the body is covered very densely with small, straight spines; these are represented in fig. 23 A, which shows the mouth, coronet, and the beginning of the œsophagus.

Molin's species appears to be smaller than those which I have described, but I have no hesitation in regarding the Piel specimens as identical with the worm described by him.

III.—FUNGI.

I describe here an entomophthoran fungus, which is apparently situated near to the genus *Conidiobolus*, but the exact identity of which is in the circumstances indeterminable. This organism occurred in the viscera: the liver, kidney, and mesenteries of plaice (*Pleuronectes platessa*) living in the open-air spawning pond at the Port Erin Biological Station, and has been associated with a serious mortality among these fishes. The description and figures of this fungus given here are based on the

examination of sections of preserved parts of the livers and kidney taken from several fishes which were examined by Mr. Chadwick, the Curator of the Biological Station. In the absence of fresh material, and of cultures of the organism, it is impossible to refer the fungus, with certainty, to any known species.

All the fishes which died had wounds on the surface of the body. In one preserved specimen, a fish about 14in. long, there are three large lesions on the blind side, one on the head and the other on the body and tail. Each is a large shallow abrasion with inflamed edges and some pus on the surface, but no indication of a fungus. There is a somewhat similar lesion on the ocular side. In a much smaller fish there is an annular lesion of the skin on the ocular side. The skin has disappeared, forming a ring-shaped, clean wound, also with no indication of the presence of a fungus. In neither of these fishes was the liver or kidney infested with the fungus. This also appears to be the case with a number of fish which died both in the spawning pond and in the storage tank. But the appearance of the lesions on the fish which died in the pond and the livers of which were infected was identical with that I have described. It is very reasonable to suppose that the fungus is the cause of death, and that the superficial lesions are to be associated with the presence of the parasite, but there is no direct proof of this; and the death of fish in aquaria from such wounds contracted in captivity, and due to imperfect nutrition and not to the effects of any parasitic organisms, is far from uncommon.

With regard to the occurrence and incidence of the epidemic associated with the organism, I quote from a letter from Mr. H. C. Chadwick:—

"My acquaintance with the disease in the plaice

began on June 22nd, when two of our fish were found dead in the pond, one at the surface and the other on the bottom. The former was somewhat decomposed, and appeared to have been dead some time. The liver of both was densely crowded throughout with the rounded whitish cysts, of which I sent you specimens, and there were a few scattered about in the intestinal mesentery. The condition of the water in the pond had given me some anxiety for some time before the above-mentioned date, and, as it became worse, it was decided to drain the pond. This was done on July 3rd and 4th, and resulted in the discovery of a considerable number of dead and dying fish. Many of the former were so much decomposed, that examination of the viscera was impossible, but a few were in better condition, and the liver of every one was more or less infected with the parasite. The same remark applies to the dying ones. In most cases the infection was complete, but there were several in which only part of the liver was visibly infected. Many of these fish had open sores or abrasions on the top of the head, like those of the specimens I sent you on October 10th, and all were much infested with a species of Lepeophtheirus.*

"What I have called dying fish were certainly sickly. They swam about languidly, but I saw no evidence of giddiness, or lack of co-ordination in their movements. Some of them struggled gamely when handled, but their general behaviour was not like that of healthy fish. All the apparently healthy fish were transferred to the lower storage tank on July 5th, and were kept there, with as frequent change of water as possible until August 7th. In spite of this, the water in the storage tank rapidly assumed the dirty brownish

* *Lepeophtheirus pectoralis* (Müller).

appearance of that in the pond before July 3rd, and it smelled offensively. The water was run off several times, and on each occasion dead and dying fish were found. Slight infection of the liver was observed in several during the early part of the time, but it was less and less obvious as time went on. I find that 17 died during that period. After the fish were returned to the pond, three were found dead on August 14th and the liver of one of them was found to be slightly infected. The second had a dozen worms,* of the same species as those I sent you some time ago, coiled up in a mass in the liver, which was highly congested, while the liver of the third appeared to be quite healthy. Another fish was found dead on August 21st, with the liver very badly infested. On September 20th the bottom of the pond was again examined, and nine dead and 14 sick fish were found. On this occasion no trace of the parasite was seen, but every fish had the open sores on the top of the head, and at the base of the tail on the unpigmented side. The one I sent to you on October 10th was one of 17 sickly ones found that day, but all the viscera of six, taken at random, appeared to be perfectly healthy. Every one had the external abrasions."

To the naked eye a portion of infected liver or kidney appears to contain small white globular bodies varying in size from 0·25 to 1 mm. In some cases, these are very sparsely scattered through the tissue, but in other specimens they are densely crowded together, and seem to hang together. Fig. 3, pl. XVI., represents a section through one of these masses. It will be seen that we have not to do here with a cyst, but simply with the mycelium and conidiophores of a fungus, the whole

* Nematode worms, with some plerocercoid larvæ of the cestode *Tetrarhynchus erinaceus*, van Beneden.

forming a little rounded mass penetrating through the tissues of the organ, which in the case represented is the kidney.

The mycelium is comparatively simple, and the hyphæ themselves are about 0·005 mm. in thickness. They are non-septate and are filled up with a homogeneous, lightly staining substance. The conidia in which these hyphæ terminate are oval bodies, very variable in size, but, on the average, about 0·08 by 0·04 mm. in diameter.

Apparently there are two kinds of conidium. One kind (fig. 6, pl. XVI.) stains more deeply than the other, in the ground substance and the cell inclusions. Scattered irregularly over the section are a number of small, rounded homogeneous granules. The other kind of conidium stains more lightly and the ground substance is more nearly homogeneous, while granules, as described above, are not apparent..

Here and there in the sections are to be seen structures which are apparently resting spores. These are represented in figs. 7, 8. Each is a rounded body measuring from 0·05 mm. to rather less in diameter. It consists of the spore itself surrounded by one or more distinct capsules. The substance of the spore usually contains the small granules, to be seen in the conidia. Fig. 4 represents such a resting spore beginning to germinate and showing the beginning of a hypha.

I think there is little doubt that the organism is to be referred to a genus of Entomophthorineæ; and is to be placed near to the genus *Conidiobolus*.* But, in the absence of material for setting up pure cultures, it is not possible to say more. The fungi of this group are either

* I am indebted to Prof. Harvey Gibson for assistance in this identification.

saprophytic or parasitic. *Conidiobolus* is parasitic on higher plants, but may live saprophytically in nutrient media, and apparently the spores may persist unharmed in salt water. Our fungus, which is not necessarily the above genus, and, indeed, may belong to an undescribed form, is probably one which, as is typical in the group, inhabits some insect. Insect life was very abundant in the spawning pond in which the fish were living. Thus the Port Erin Report of 1905, pp. 10-11, "As was the case during the hatching season of 1904, our spawning pond proved a death trap to myriads of insects, especially Diptera and Coleoptera, which seriously hampered the work of egg-collecting." Over thirty species of Coleoptera alone were identified by Dr. Bailey, of Port Erin, who adds that all were local species, probably caught up from the adjacent land by the wind and deposited on the surface of the pond. I understand that the practice was to depend on the growth of algæ to keep the water well oxygenated, and not to change it frequently. This practice no doubt would favour the infection of the fish by the fungus, assuming, as is probable, that the latter originally inhabited some insect. In this case the death of numbers of insects on the surface of the pond and the liberation of great quantities of resting spores must have infected the water, and the lack of frequent change of the latter must have increased the chances of the infection of the fish.

IV. On a Tumour in the Skin of the Dab (*Pleuronectes limanda*).

While trawling in Luce Bay in November, 1904, several unusually large dabs were caught, and while weighing and measuring these fishes several hard nodules

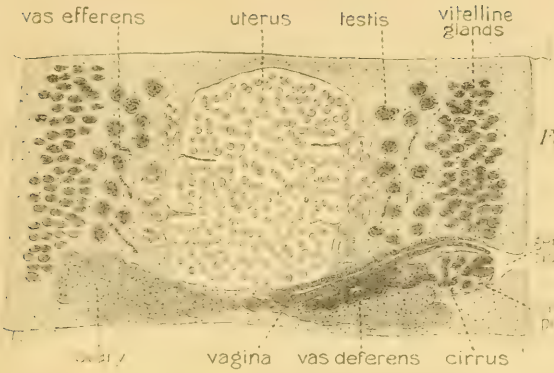

Fig. 1.

Fig. 8.

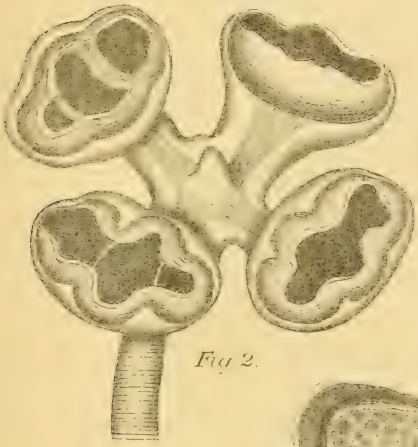

Fig. 2.

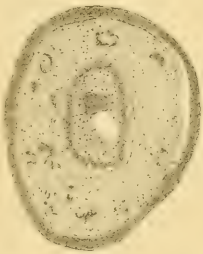

Fig. 10.

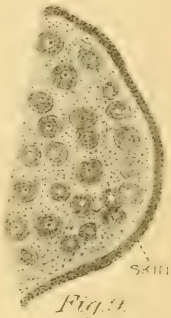

Fig. 9.

Fig. 4.

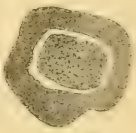

Fig. 7.

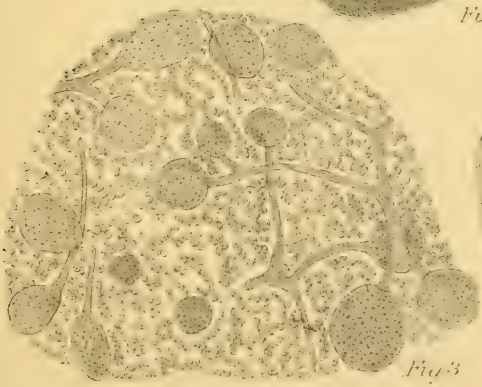

Fig. 3.

Fig. 5.

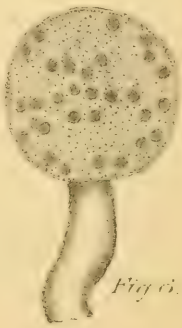

Fig. 6.

J. Johnstone, del.

S.B. lith.

Figs. 1 & 2. ANTHOBOTHRIUM AURICULATUM.
Figs. 3-8. FUNGUS IN PLAICE. Figs. 9 & 10. TUMOUR IN DAB.

were felt underneath the skin. Two of these nodules were situated close to the lateral line on the ocular side of the fish. Each was a little rounded mass about 3·5 mm. in diameter and about one mm. above the general surface of the skin. Just behind the anus was another tumour which, however, was rather larger and more irregular in shape than those on the side of the fish. It was situated on the posterior and lateral lips of the anus.

Fig. 9, pl. XVI., represents a section of the latter tumour in a longitudinal plane. The skin over the structure is quite normal. Directly underneath the skin is a great number of egg-like structures, each from 0·1 to 0·16 mm. in diameter. Each (fig. 10) is surrounded by a thick, apparently structureless, capsule. Within this the cell protoplasm is finely granular, and stains densely. Round the periphery of this cell (for the whole structure is obviously a single cell) are a number of inclusions, consisting of densely staining substance of apparently quite irregular form. The cell substance is usually contracted away from the capsule at various points. The nucleus is large, and is bounded by a kind of shell—not a membrane, but a thick layer, which in section presents a kind of scalloped appearance. The nucleus is often vacuolated. Within it is a single large, densely staining nucleolus.

Explanation of the Plate.

Plate XVI.

Fig. 1.—Anthobothrium auriculatum. Section of a proglottis. × 70.
,, 2.— Do. do. The scolex. × 17.
,, 3.—Fungus in kidney of plaice. Section of the kidney. × about 100.
,, 4.—Fungus in Plaice, germinating spore. × 600.
,, 5-6.— Do. conidia. × 600.
,, 7-8.— Do. resting spores. × 600.
,, 9.—Tumour from dab. Section. × 24.
,, 10.—One body from the tumour. × 220.

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ICHTHYOLOGICAL NOTES.

By Jas. Johnstone.

1. *Raia microcellata*, Montagu.
2. *Raia fullonica*, Linn.
3. *Solea lascaris*, (Risso).
4. *Dentex vulgaris*, Cuv.
5. *Raia clavata*, showing arrested development of pectoral fins.
6. *Pleuronectes flesus*, showing arrested metamorphosis.

1. Painted Ray—*Raia microcellata*, Montagu.

This ray does not appear to have been recorded for the Irish Sea area. On May 25, 1905, one male specimen, 16 inches broad, was trawled by the "John Fell" off Llanrhystyd, in Cardigan Bay, in about two fathoms of water. On 21st June, 1905, another male specimen, 20 inches broad, was obtained in Tremadoc Bay.

2. Fuller's Ray—*Raia fullonica*, Linn.

This ray has frequently been sent to us in baskets of ray bought at Fleetwood, but so far we have been unable to ascertain whether or not these fishes had been caught in the Irish Sea area. All doubt, however, was removed on the 26th May, 1905, when one specimen was taken by the "John Fell" in Carnarvon Bay. The fish was 14 inches in breadth.

Both *Raia fullonica* and *R. microcellata* appear to be much more common on the South Coast of England than in the Irish Sea.

3. The Sand Sole—*Solea lascaris* (Risso).

One specimen of this interesting sole was taken in Cardigan Bay, about two miles off Llanon, in about 12 fathoms, and on clean sandy ground. This specimen was $10\frac{1}{2}$ inches in total length, and was taken in the same

catch with 42 common soles. Several specimens were afterwards taken in Cardigan Bay. The colour of the specimen in life was dark brown with numerous small black spots and blotches.

The sand sole does not appear to be at all common in the Irish Sea on the East side, but there is little doubt that it is often overlooked. It is common in the Bristol Channel, and Mr. Holt informs me that it is commonly sold by Irish fishmongers who obtain their supplies from the seas between England and Ireland. It is nevertheless a Southern form, extending as far south as Madeira, and into the Mediterranean as far as the coast of Italy. The British Islands appear to be the extreme Northern limit of its distribution.

4. *Dentex vulgaris*, Cuv.

Five small fishes, which were taken by the "John Fell" in the trawl net, off Gimlet Rock, Pwllheli, I identify as the above species.* This is the first occasion on which this species has been taken in the Irish Sea, and only five previous records of the existence of the fish in British waters are known to me. *Dentex* occurs commonly in the Mediterranean and neighbouring parts of the Atlantic, but the British Islands appear to represent the Northern limits of its distribution, and specimens in our waters are to be regarded as occasional wanderers. The eggs of *Dentex* appear to be pelagic,† and it is much more likely that these should have been carried up into the Irish Sea by what appears to have been an exceptional northerly drift of Atlantic water during the last year, than that the adult fishes should have spawned in our area.

* I have to thank Mr. E. W. L. Holt for kind assistance in this identification.

† Holt, Ann. Mus. Marseille, v. 4. 1899.

All the specimens are small ones, being from $1\frac{1}{2}$ to 2 inches in length. The adult fish itself may attain a weight of 70 lbs.

The body is stout and slightly laterally compressed. The following measurements of this immature stage may be useful for purposes of comparison with the adult:*

Depth of body: $3\frac{1}{2}$ times in total length.

Greatest thickness of body: nearly $2\frac{1}{4}$ in total length.

Length of head: $3\frac{3}{4}$ in total length.

Depth of caudal peduncle: $3\frac{1}{2}$ times in length of head.

Diameter of eye: $3\frac{1}{3}$ in length of head.

Distance of anterior margin of the eye from the snout: $\frac{1}{4}$ of length of head.

Radial formula: D. XI. — 12; A. III. — 9.

Mr. Holt points out that the scale-formula is not so restricted as in his diagnosis of the adult. The transverse formula is $\frac{6-8}{14-18}$, and the longitudinal one about 60.

The teeth in both jaws are conical. In the upper jaw there are two canines on either side, with four smaller teeth in the symphysial space between the canines. In the lower jaw there are three teeth on each side which are longer than the rest.

In one specimen dissected there were four large pyloric cæca.

There are about six transverse bands on each side of the body.

5. Ray showing arrested development of the pectoral fins.

An immature specimen of *Raia clavata*, caught off Blackpool by the "John Fell" in September, 1905, shows in an interesting manner an arrested development of the "wings" or pectoral fins. Fig. 24 represents this speci-

* Holt and Byrne Report Sea and Inland Fisheries for Ireland for 1902-3, Pt. ii., 1905, pp. 156-161, Pl. xxvii.

men, which is a small ray measuring 4½ inches across the wings. On either side of the head is a deep notch which causes the pectoral fins to stand well out from the body. The dorsal side of the specimen is figured, but I have indicated the position of the gill openings by dotted lines. The median line of symmetry is disturbed, so that the

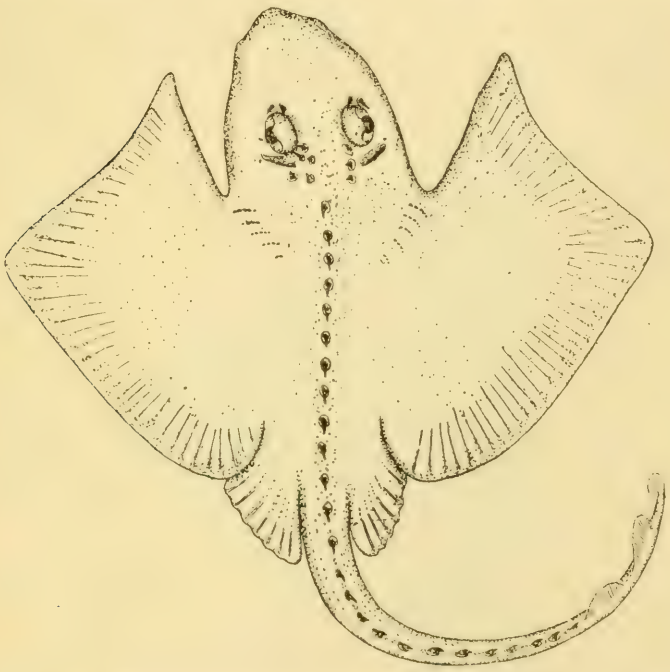

FIG. 24. *Raia clavata*, showing arrested development of the pectoral fins. Reduced.

head of the fish is bent to the left side by about ½ inch. So far as can be seen without dissection, the external borders of the notches are formed by the propterygia, and the malformation is evidently due to the assumption, during development, by the latter skeletal structures, of a position which is much more nearly related to the

primitive position of the Elasmobranch pectoral fin structures than the latter normally occupy in skates or rays *

The fish was alive, and apparently in good health when caught.

6. Flounder (*Pleuronectes flesus*) **showing arrested metamorphosis.**

A flounder caught in a stake net near Piel, Barrow-in-Furness, and sent to me some time ago, exhibits

Fig. 25. Flounder showing arrested metamorphosis. Nat. size.

several characters worthy of record. The fish was pigmented on both sides, and it was this bicolouration—the most perfect I have seen—which caught the attention

* A similar malformation is recorded by R. H. Traquair, Ann. Scottish Nat, Hist. Jan. 1902, pp. 29-30, 1 fig. in text.

of the fisherman. The fish, however, is noteworthy in other respects. Fig. 25 is a view from the right side, and indicates the characters in question. The left eye does not occupy the normal position, but is very distinctly on the (secondary) dorsal margin of the head, and, indeed, is easily visible from the "blind" side of the specimen. The right eye occupies the usual position. The anterior extremity of the dorsal fin is the most interesting character exhibited by the specimen. It was first suggested by Traquair that the forward extension of the dorsal fin in the median, or pseudomesial, dorsal line, irrespective of the asymmetry of the head, took place *after* this asymmetry, due to the translocation of the eye, was completed; and that the fin, though apparently arising from the head region, does not really belong to that region at all. In the specimen before us this hypothesis is verified, so far as the facts go. The eye not having crossed the pseudomesial line of the head, it is obvious that the forward extension of the dorsal fin to its normal position, with the anterior extremity just over the middle of the eye, cannot take place. But we find that, though the arrested shifting of the eye has prevented this forward extension of the fin, the latter has still grown, and now arches over the eye so that its anterior extremity is nearly in the position it would have occupied had the eye attained its definitive position.

REPORT TO THE CHAIRMAN OF THE SCIENTIFIC SUB-COMMITTEE ON THE EXAMINATION OF THE LLANFAIRFECHAN MUSSEL BED.

By Jas. Johnstone.

Some time ago Dr. Jenkins suggested to me that it would be desirable to make an examination *in situ*, and a further bacteriological analysis of the mussels from the Llanfairfechan shore. The mussel bed there has very little commercial importance, but it is alleged to be seriously polluted, and circumstances arose which made it advisable to examine it in detail. Accordingly, Dr. Jenkins and I visited the locality in question on the afternoon of May 18th and collected a sample for analysis.

Strictly speaking, there is no mussel bed at Llanfairfechan. The shellfish, however grow on the piles supporting a sewer-pipe, and have frequently been gathered and sent to the markets. The case of this mussel supply has previously attracted some attention, and was referred to in the proceedings of the Royal Commission on Sewage Disposal (Rept. 4, Vol. 2 [Cd. 1884], 1904, Question 16325).

All the sewage from the village of Llanfairfechan is conveyed out to sea through a 9 inch iron sewer pipe, which runs out over the sands in a direction nearly N.N.W. from the patch of stones in front of the village. The pipe is supported on wooden piles driven into the sand at regular intervals. It is about 1,500 yards in length and terminates very near the low water mark of high spring tides. A pumping station is connected with it, but there is no intercepting tank, and the sewage, which is quite untreated, flows continuously through the pipe and discharges on to the sands. About six months (we were informed) before we visited the locality a block

had occurred in the lower third of the sewer and, as it was impossible to clear the pipe, the latter had been cut; it was, however, still found impossible to remove the block, and a further cut was made in the pipe about 500 to 600 yards from the outfall. The crude sewage was, therefore, flowing from this latter break in the pipe at the time when we made our visit.

The ground round the pipe for the greater part of the length of the latter consists of hard clean sand, which affords no holding for the mussels. But the vertical and horizontal wooden piles supporting the pipe are covered with a thick growth of the shellfish, and here and there the shellfish were attached to the pipe itself. The mussels are mostly large, well-nourished animals with fairly clean shells. They were generally well over the gauge size, and, apart from the question of their contamination, appeared very suitable for food or bait.

The sample for analysis was collected by taking one mussel at regular intervals from the vertical piles on the Eastern side of the pipe all the way up from the outfall. Those which were collected from the piles in the vicinity of the break in the pipe were kept apart from the others and examined separately. The primary inoculations were made on the morning of the 19th. The method of analysis was that previously adopted in similar cases, and consisted in inoculating about 0·1 to 0·25 cc. of the contents of the stomach of each animal on separate plates of neutral-red, bile-salt, lactose agar: and in further testing the colonies formed on this medium for *Bacillus coli communis* by their reactions on various sugar media. In every case inoculations were also made to determine the presence or absence of the spores of an anaërobic bacillus, presumably Klein's *B. enteritidis sporogenes.* The results were as follows:—

RESULTS OF PRIMARY CULTURES ON NEUTRAL-RED AGAR.

Mussel.		Number of "Colon-like" Colonies.
Mussels from near the break in the sewer pipe.	1	1
	2	About 98
	3	0
	4	76 with several diffuse patches.
	5	60
Mussels from below the break in the sewer pipe.	6	1
	7	0
	8	One diffuse patch.
	9	1 with a diffuse patch.
	10	1 " "

Primary cultures were also made from the stomach contents in litmus milk under anaërobic conditions with the following results:—

PRIMARY ANAEROBIC CULTURES IN LITMUS MILK.

Mussel.	Enteritidis reaction.	Mussel.	Enteritidis reaction.
1	+	6	+
2	+	7	No reaction.
3	No reaction.	8	+
4	+	9	+
5	+	10	+

The results of the tertiary cultures on the various sugar media showed that *Bacillus coli communis* was present in mussels 2, 4, 9 and 10, and probably in all the

others with the exceptions of mussels 3 and 7, which were sterile both to this microbe and to the microbe usually identified as *B. enteritidis sporogenes.*

A further analysis by Houston's method of decimal dilutions was also made. Five mussels selected at random from all those collected were pounded up in a sterile mortar with sterile water and three primary cultures were made, both in neutral-red agar and in litmus milk incubated anaërobically. The results were:—

	No. of "Colon-like" Colonies.	Enteritidis reaction.
A: in 1 cc. (= $\frac{1}{100}$th part of a mussel)	26	+
B: in 1 cc. (= $\frac{1}{1000}$th ,, ,,	4	Milk decolorised but not clotted.
C: in 1 cc. (= $\frac{1}{10000}$th ,, ,,	1	No reaction.

B. coli was therefore present in 1-1000th part of a mussel in small numbers, but absent in 1-10000th part of a mussel. *B. enteritidis sporogenes* was present in 1-100th part of a mussel, but doubtfully present in 1-1000th part, and certainly absent in 1-10000th part.

Conclusions.

It will be seen, then, that *Bacillus coli* was isolated from the majority of the mussels examined. The presence of this microbe indicates the contamination by faecal matters of the shellfish in which it is found. But unhappily this organism must now be regarded as present

almost everywhere in shellfish bedded on our coasts, and its significance lies not so much in its mere presence as in its relative abundance. It will be seen from the results stated above that *B. coli* was very abundant in several of the mussels examined: these were they that were collected from the piles in the neighbourhood of the break in the pipe. Two mussels were quite sterile, and in one or two others the microbe was present in very small quantity; these latter shellfish were collected from the piles some considerable distance from the break in the pipe. Only in one or two of the mussels examined was the degree of pollution at all excessive.

It is probable that the faulty condition of the sewer pipe is the cause of the greater part of the pollution of the mussels. The eddies caused by the tide round the piles have excavated a shallow gutter directly beneath the sewer pipe. As the tide lays bare the sands, this gutter becomes filled with a mixture of sea-water and sewage flowing from the break in the pipe. Then when the tide begins to flow, some of this water becomes washed up against the mussels on the piles, and the former become polluted. If the sewer pipe were in proper repair, so that all the discharge flowed from its extremity, and still more if there were an intercepting tank at the pumping station and the sewage were only liberated on the ebb tide, I think that the pollution of the mussels would be very slight, and would be due only to the slight amount of general pollution of the sea caused by the sewage from the towns at the entrance to the Menai Straits.

NOTE ON THE OLIGODYNAMIC ACTION OF COPPER UPON CERTAIN ORGANISMS.

By W. A. Herdman.

In connection with the investigations upon copper in certain oysters and upon the pollution of certain oysters by sewage, and so possibly by disease germs, which were discussed fully in these Reports a few years ago, it may be of interest to put on record now the recent remarkable results that have been obtained in America, and elsewhere, in destroying intestinal bacteria by means of exceedingly minute traces of metallic copper.

The botanist C. von Nägeli seems first to have observed, some time in the eighties, that even the copper dissolved by distilled water during its passage through the copper still might have a toxic effect upon certain plants. He then experimented with water in which copper coins had been placed, and determined, for example, that one part of copper in about a thousand million parts of water is poisonous to some species of the water plant *Spirogyra*. Other investigators, both in Germany and the United States, have since extended the experiment to the action of copper upon bacteria and upon protozoa. They used copper foil in the water, and found that *Bacillus typhi* was especially sensitive, and that at a temperature of 35° to 40° C. the toxic effect was manifested in one hour. Pharmacologists as well as biologists have recognised the importance of these facts, and their possible application to the treatment of disease. Copper, while being exceedingly toxic to micro-organisms and certain parasites, is comparatively harmless to man. Professor Cushing (1899) says:—"Copper thus seems to have a very

powerful poisonous action on certain living forms and to be harmless to others, and the subject deserves further investigation. It is possible that it may prove to act prejudicially to some human parasites, and it is certainly less dangerous to man than many other remedies used as parasiticides and disinfectants."

Kraemer, in a recent paper,* commenting on this says:—"While various explanations might be offered to show why such extremely minute quantities of copper in solution are sufficient to kill unicellular and filamentous algae, bacteria and unicellular animal organisms, and yet not affect multicellular plants and animals, whose cells are as delicate in structure as those of the unicellular organisms, it seems that this is in a measure due to the fact that in the latter the entire individual is comprised of a single cell, which performs all the vegetative as well as reproductive functions, and being entirely surrounded by the copper solution all the life processes are affected, there being no way for the organism to distribute the solution to other cells, and thus by a dilution minimise the toxic action of the copper. Or if some of the cells in the multicellular organism are destroyed or injured by exposure to the solution, others are formed to take their place from the more or less deep-seated meristematic cells. It is true that the idiosyncrasies in these organisms should also be borne in mind, some of them being more resistent than others."

It has been shown, however, by Locke† that the poisonous action of minute traces of copper is not confined to unicellular organisms. Merely placing strips of quite clean metallic copper in water in which tadpoles are kept

* Proc. Amer. Philosoph. Soc. vol. xlix., No. 179, p. 51, April, 1905, where full references to the literature of the subject will be found.

† Journ. of Physiology, 1895, vol. 18, p. 319.

leads in a few hours to the death of the tadpoles. This observation has been confirmed by Ringer,† and more recently by Roaf and Whitley,‡ who have also shown that a trace of colloidal silver in suspension leads rapidly to a fatal result, while colloidal platinum under like conditions is quite harmless.

It has been suggested to me by Professor B. Moore that possibly the cause of the poisonous action in some organisms and immunity in others, may be due to those organisms which are poisoned throwing out excretory substances which dissolve copper and form soluble poisonous compounds which are absorbed, and so lead to the toxic effects.

The matter has also been discussed recently as one which may be of importance in killing algae and pathogenic organisms in water supplies. Dr. G. Moore, of Washington, found that one part in fifty millions was sufficient to kill off fresh-water algæ in water-cress beds, and that 1 in 100,000 would kill cholera and typhoid organisms in 4 to 5 hours. Rideal and Baines (1904) found that 24 hours in a copper vessel was sufficient to free the water from typhoid and colon bacilli. Bassett-Smith,* as the result of a number of experiments, states that "*Bacillus typhosus* is more easily killed than others of the coli group, being destroyed in 12 hours with the 1 in 10,000 dilution" [sulphate of copper]. He also finds that "Zinc, or iron coated with zinc, though less rapid in its action than copper, yet after 24 to 48 hours appears to free the water from typhoid organisms, and is the most

† Ibid., 1897, vol. 22, p. xiv. (Physiol. Soc. Proc.)

‡ Communicated by the authors (Biochemical Department, University of Liverpool)—the paper not being yet published.

* *Journ. of Preventive Medicine*, July, 1905.

valuable storage tank for all purposes that we possess." Finally, Kraemar has, during the last year, carried out a series of most elaborate and interesting experiments in the Philadelphia College of Pharmacy, "with a view of testing the efficiency of metallic copper for destroying typhoid and colon bacilli in water." He writes as follows:

"From the experiments thus far conducted, as well as the results obtained by other writers, the following conclusions may be drawn:

"1. Certain intestinal bacteria like colon and typhoid are completely destroyed by placing clean copper foil in water containing them, or by adding the organisms to water previously in contact with copper foil.

"2. The toxicity of water in which either copper coins or copper foil has been added is probably due to a solution of some salt of copper, as first suggested by Nägeli.

"3. The copper is probably in the form of a crystalloid rather than that of a colloid, as it has the property of permeating the cell walls and organised cell contents of both animals and plants, thereby producing the toxic effects.

"4. While the effects produced by the oligodynamic action of copper are apparently different from those of true chemical poisons, the difference is probably in degree only, and not in kind.

"5. Certain lower organisms, including both plants and animals, possess a specific sensitiveness to minute quantities of copper, and it has been shown that they are not restored on transferring them to water free from oligodynamic properties.

"6. Oligodynamic solutions of copper are

obtained by adding either copper coins, copper foil, or salts of copper to water: when copper foil is used sufficient copper is dissolved by the distilled water in one to five minutes to kill the typhoid organisms within two hours.

"7. A solution of copper may lose its toxicity by the precipitation of the copper as an insoluble salt or compound, by its absorption by organic substances, or by absorption by insoluble substances.

"8. The oligodynamic action of the copper is dependent upon temperature, as first pointed out by Israel and Klingmann.

"9. The effects of oligodynamic copper in the purification of drinking water are in a quantitative sense much like those of filtration, only the organisms removed, like *B. typhi* and *B. coli*, are completely destroyed."

Now if these results can be extended to the case of marine shell-fish, it may be argued that if the typhoid organism is killed in two hours by distilled water in which copper foil has been placed for five minutes, a comparatively simple measure of washing ought to be sufficient to render contaminated oysters innocuous. The importance of such a result is obvious. It may be asked why, considering the rather large amount of copper that may be present in the tissues of the oyster, should the copper foil be necessary. It is known, however, to be the case that in the normal oyster the copper of the blood is united with a proteid to form an organic compound, haemocyanin, in such a way as to be unable to exercise its toxic properties. It is probable that that is also the case in these abnormal green oysters which Professor Boyce and I investigated* some years ago, and where we

* On a green Leucocytosis in Oysters. Proc. Royal Society, vol. lxii., p. 30 (1897).

found copper stored up in greatly increased quantity in the numerous leucocytes which characterise this diseased condition; so that probably these "copper" oysters even cannot be trusted to free themselves from pathogenic organisms through the action of their own copper.

In dealing with such a case as that of the oyster, however, it must be noted that there are two further conditions which may effect the successful application of the above-mentioned methods. In the first place the pathogenic organisms are not necessarily free in the water, but may be in or upon the living tissues of the mollusc so as, possibly, to be protected from the toxic action of the copper. Secondly, the washing of the living oyster must be carried on in sea-water: there is apparently a difference in some of the experiments between distilled water and tap-water, and what further complications may be introduced by the salts in the medium surrounding the oyster has still to be determined. In conjunction with Professor B. Moore, of the Department of Biochemistry, we propose to investigate the whole question of this oligodynamic action of copper and other metals upon the organisms in shell-fish—with special reference to oyster culture.

SEA-FISH HATCHING AT PORT ERIN IN 1905.

By W. A. Herdman.

As the Reports of the Isle of Man Fisheries Board have only a limited circulation and are probably unknown to members of the Lancashire and Western Committee, it may be found convenient to have recorded here the portion of the last report which deals with sea-fisheries work in 1905. It occurs in the "Report from the Hon. Director," as Appendix I. to the First* Annual Report of the Fisheries Board.

The Report is made to Tynwald Court, and was drawn up in June, 1905, and signed on July 5th. The Report contains the following sentences:

"The Board entered into negotiations with the Lancashire and Western Sea Fisheries Joint Committee, with a view to obtaining the assistance of the Committee's s.s. "John Fell" in policing the territorial waters of the Isle of Man, and, having made a preliminary arrangement with the Committee, applied for and obtained from the Tynwald Court a grant of £50 for the purpose of carrying out such arrangement.

"The agreement is now in operation, and Dr. J. Travis Jenkins, Superintendent of Fisheries to the Joint Committee, and Capt. Wignall, of the s.s. "John Fell," have been appointed Fishery Officers under the provisions of the Sea Fisheries Act, 1894."

The Appendix on the Sea-fish Hatchery and Aquarium at Port Erin runs as follows:—

* The three previous reports were made by a Committee appointed by Tynwald Court—this Committee and others being now replaced by the "Fisheries Board."

"Report from the Hon. Director for the year 1904-5.

(Drawn up June, 1905.)

"Last year, I considered that I was able to give a satisfactory report to the Sea-fish Hatchery Committee when I recorded the production and liberation of about a million young plaice as the result of the first complete year of working with the necessary equipment. This year I am able to report that over five millions of young plaice have been set free in Manx waters. This gratifying result is due primarily to the considerable increase in our stock of spawners, effected partly by the kind co-operation of the Lancashire and Western Sea-Fisheries Joint Committee, and partly by our own fishing operations off Port Erin. The notable advance is due also in part to improvement in the hatching mechanism and to increased experience and skill on the part of our curator (Mr. Chadwick) and his assistant (Mr. T. N. Cregeen), whereby some wastage that occurred in the previous year has been wholly avoided, and the inevitable loss in working very greatly reduced. It is hoped that our stock of spawners will be still further added to during the present summer, and that the output next year will be correspondingly increased.

"A good deal of detail that was printed last year for the information of the Hatchery Committee need not be repeated. The condition and continued success of the Aquarium has been very satisfactory.

"The stock of adult plaice which furnished the eggs hatched during the past season consisted of (1) 99 out of the 105 fish with which the season of 1904 was begun; (2) 110 fish brought from Luce Bay by the s.s. "John Fell," on 19th November, 1904; and (3) 118 fish caught in two trammel nets, efficiently worked by the assistant

curator (Mr. T. N. Cregeen) during July, August, and September, 1904; making a total of 327. All the fish were placed in the spawning pond as soon as possible after capture, and no difficulty was experienced in keeping them in a healthy condition throughout the year. They were fed daily upon mussels, with the addition of lug-worms as often as the latter were procurable. The worms are dug, for the most part, by the assistant, at Port St. Mary; but the mussels have to be obtained from Lancashire, and about one cwt. per week is required to keep the fish in good condition.

"The state of the pond has been quite satisfactory. It was emptied and examined carefully in September, 1904, and again at the conclusion of the present spawning season, in May, 1905.

"The hatching apparatus was carefully overhauled and put into working order during the latter part of January, and was in continuous operation, without mishap of any kind, from 14th February to 13th May. The improvements in the structure of the tanks and boxes alluded to in last report have now been effected, and have resulted in a great saving of eggs during this season.

"The first fertilized eggs of the plaice were found in the pond on 14th February, 17 days earlier than last year: and on the 17th there were 12,500 incubating in the boxes. The daily yield of eggs gradually increased, until the maximum was reached on 3rd April, when 313,600 were collected. After this date the numbers ranged from about 224,000 to over 100,000 daily, until 25th April, when a marked diminution was observed, and the last batch of the season, numbering 45,000, was placed in the boxes on 1st May.

"The method of estimating the number of eggs was essentially the same as that of last year. Ten dips with

a measure of known capacity were taken from each day's collection, and the number of eggs in each dip carefully counted. The average of the ten countings was then divided by the number of cubic centimetres in the measure in order to obtain the average number of eggs per c.c. This figure was then multiplied by the number of cubic centimetres of water in the hatching box in order to obtain the total number of eggs.

"The larvæ were taken to sea in a fishing-boat by the assistant, and were liberated at various points either on the east or on the west side of the southern end of the Island, at distances of from 1 to 5 miles from land.

"The numbers of larvæ in this manner set free during the season were as follows:—

March	3	14,000
,,	11	72,000
,,	18	28,500
,,	20	28,500
,,	25	79,000
,,	30	285,000
April	1	254,500
,,	8	661,000
,,	10	40,000
,,	11	224,000
,,	13	415,000
,,	15	240,000
,,	18	296,000
,,	20	548,000
,,	25	392,000
,,	28	346,000
,,	29	325,000
May	4	279,500
,,	5	106,500
,,	6	96,000
,,	10	241,500
,,	11	33,500
,,	14	92,000
	Total	5,097,500

"At the close of the hatching season, in May, the pond was drained to within 18 inches of the bottom, and all adult plaice found in the smaller western portion were transferred to the larger portion nearest the hatchery, in preparation for the reception of a stock of adult soles.

"During this operation, it was discovered that eight of the adult fish had died since the pond was last drained, at the end of September, 1904, leaving a total of 319 healthy fish. It was also found that a large number of the young fish hatched during the season of 1904, which had been left to undergo their metamorphosis in the pond, were still present, and evidently thriving. Thirty-one of these were taken at random, and were found, on measurement, to range from $2\frac{1}{2}$ to $5\frac{1}{2}$ inches in length; but, while the pond was being re-filled, a few others of the same generation were seen which were certainly larger than the largest measured.

"It is evident from these observations (1) that the artificially hatched fry are perfectly healthy, and capable of continued life and growth; and (2) that the young fish which have undergone their metamorphosis in the pond have found there healthy conditions and abundance of their natural food.

"In accordance with an intention of extending, so far as is possible, the hatching operations to other suitable fish, steps have been taken to commence, on an experimental scale, with the black, or true English, sole (*Solea vulgaris*), which spawns rather later in the summer than the plaice. Forty-six adult soles were brought by the s.s. "John Fell" on May 31st, and are now confined in the western portion of the pond. A number of these are spawners, and although it is now getting late in the season, it is hoped that sufficient fertilized eggs for our purpose may still be obtained. It is proposed, unless some

unforeseen difficulty occurs, to increase this stock, and to devote more attention to the hatching and rearing of the sole during next season.

"It is a pleasure to report to the Board that Mr. Chadwick, the curator; Mr. T. N. Cregeen, the assistant; and the boy, Willie Christian, have been most energetic and efficient in their several spheres of work; and I should like to add that Mr. Chadwick and I feel much indebted to the secretary to the Board, Mr. R. Okell, F.L.S., for his valuable help and for the large amount of attention he gives to the affairs of the institution.

I have now to add that during last summer, after the above Report had been issued, a curious epidemic,* caused by a fungus which invades the liver and kidneys, attacked the fish in the pond, and resulted in considerable mortality of both plaice and soles. The fish that survived were set free, as it was thought best under the circumstances to clear out the pond completely, and start this season with a fresh stock of fish free from infection.

"(Signed) W. A. Herdman."

* Described by Mr. Johnstone in another part of this Report.

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