REPORT FOR 1897

ON THE

LANCASHIRE SEA-FISHERIES LABORATORY

AT

UNIVERSITY COLLEGE, 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, and Mr. JAMES JOHNSTONE.

WITH AN APPENDIX

GUIDE TO FISHERIES EXHIBITION, AT LIVERPOOL.

LIVERPOOL:

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1898

REPORT on the INVESTIGATIONS carried on in 1897 in connection with the LANCASHIRE SEA-FISHERIES LABORATORY at University College, 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, Resident Fisheries Assistant at Piel, and Mr. JAMES JOHNSTONE, Fisheries Assistant at Liverpool.

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INTRODUCTION.

DURING the earlier part of the year a good deal of Mr. Scott's time was occupied in helping Mr. Dawson and myself in preparing for the course of Sea-Fisheries lectures, which was delivered in January, February, and March in Liverpool. After that Mr. Scott was sent to make some hatching experiments at Piel, and then had to suddenly leave all the usual laboratory work and devote most of his time to the preparation of the rather elaborate exhibit which the Lancashire Sea-Fisheries Committee sent to the Jubilee Exhibition at the Imperial Institute, and which will be found fully described further on in this Report. During this busy time one of the College Laboratory lads, Mr. Tom Mercer, had to be drafted into

the fisheries work to help Mr. Scott and myself. It was soon found that we could usefully employ the whole of Mercer's time in this way, and later in the year he was definitely taken over into the Committee's service. During most of the summer and autumn he worked under Mr. Scott in arranging the Fisheries Exhibition in Liverpool, and since October he has acted as attendant in charge of that exhibition, and in doing any other work required in connection with the collections, and helping generally in the Fisheries Laboratory.

Mr. Scott went into residence at the Piel Hatchery on December 1st, and his place in the Liverpool Fisheries Laboratory has been filled by the appointment of Mr. James Johnstone, from the Royal College of Science, South Kensington, who entered upon his duties early in the present month (January, 1898).

The course of Sea-Fisheries lectures delivered in Liverpool last spring by Mr. Dawson, Mr. Ascroft, Mr. Scott, Mr. Thompson, Professor Boyce, and myself went off successfully, and attracted a good deal of interest. Alderman Grindley attended the last lecture, and at the conclusion of the course spoke in the name of the Lancashire Sea-Fisheries Committee. The hope was expressed by some of the audience and by the Press that the course would be repeated in other parts of the district, and that further lectures would be given in Liverpool. Our Exhibition and Fisheries Collections at the College now give us means of illustrating fishery courses, or of arranging demonstrations on fishery subjects, such as can exist in very few, if any, other centres in the country.

In January 1896, at the end of the Introduction to the Report for 1895, in urging the formation of the Fisheries Museum, which we now have, I pointed out that such collections, showing the work we were doing and the

results we had arrived at, formed "the practical evidence that Fisheries Experts from abroad especially desire to see when they come for information in regard to local fisheries and the conditions under which they are carried on." A year after that, last February, I am glad to say we had a visit from Dr. P. P. C. Hoek, Fisheries Scientific Adviser in Holland, who was sent by his government to confer with Prof. Boyce and myself as to our work on diseased conditions of Oysters, and to see our specimens and methods of investigation. Dr. Hoek stayed for some time working in our laboratories, and was pleased to express the opinion that he had thereby been saved a good deal of valuable time by getting as rapidly as possible into touch with the details of our work, so as to be able to carry on investigations in Holland on similar lines. We have also had an interesting visit from Dr. Johan Hjort, Scientific Adviser on Fisheries to the Norwegian government. We have had some correspondence with Dr. Hjort since, and the Committee has been able to help him in his work by sending him a shank trawl such as we think will be best suited for the local conditions off the south coast of Norway, where, at depths of over 60 fathoms Dr. Hjort has found considerable quanties of *Pandalus borealis*, a large prawn, which he thinks might be profitably fished.

During the summer I went to America, and took the opportunity of seeing all I could of various kinds of Fisheries Institutions, and of talking to fisheries authorities both in Canada and the United States. I visited hatcheries on the east coast of Canada, saw the enormous numbers of salmon in the rivers of British Columbia on the west coast, and also met Prof. Prince, the Commissioner of Fisheries for the Dominion, as well as other Canadian scientific men.

In the States I visited the head-quarters of the Fish Commission at Washington, and had the advantage of discussing their operations with a number of members of the staff. I then went to the celebrated hatchery at Wood's Holl, where I spent a couple of days with the Superintendent of the Hatchery, with the Collector (Mr. Vinal Edwards), and the Captain of the "Grampus," learning all I could of the details of their work, both as to sea-fish eggs and as to lobsters. Lastly, I went to Gloucester, the chief centre of the fishing industries of the American coast, and said to be the greatest fishing port in the world. There is a sea-fish hatchery here also, belonging to the Fish Commission, which has just recently been enlarged in order to increase the output. At both these hatcheries I saw the working of the McDonald hatching jar for lobster eggs, which we propose to try experimentally at Piel. It was interesting to learn at Gloucester that when the Fish Commission proposed lately to remove the hatchery from there to another part of the coast, the fishermen objected to the removal from their midst of what they regarded as a valuable institution.

Many of the details of information which I was able to learn on this tour of inspection will, I have no doubt, be of use in our local operations, and some of these points will be alluded to later on in this Report.

The chief additional matters I have to report upon this year are :—

1st.—A scheme which we started a year ago for the simultaneous observation of the "plankton," or floating fish food, &c., in the sea round our district, taken weekly throughout the year, at half a dozen stations. We are continuing the observations this year on an improved plan.

2nd.—The experimental sea-fish hatching carried on last Easter by Mr. Scott at Piel and by myself at Port Erin; and in that connection the possibility of effecting some union for fishery purposes with the local authorities at the Isle of Man. I have pointed out in previous Reports the community of interests in the case of the Lancashire and the Manx sea areas. A Commission is now sitting, under the chairmanship of the Bishop of Sodor and Man, to consider and report upon the insular industries, and the first industry they are dealing with is the fisheries. This seems, then, to be an opportunity—which would be welcomed, I believe, by those concerned in the Isle of Man—for carrying out some joint arrangement whereby young fish should be equally and efficiently protected on both shores, shell-fish and lobster culture be encouraged and regulated, and sea-fish hatcheries be established.

3rd.—The continuation of the work by Prof. Boyce and myself upon diseased conditions in Oysters and other shell-fish (see below, p. 26). It is interesting in this connection to note that the whole of my last year's account of this subject, amounting to about twenty pages of our Fisheries Laboratory Report, has been translated and printed by the French Fisheries authorities in the "Bulletin des Pêches Maritimes" for August, p. 273, under the title of "Recherches sur les Huitres."

In addition to the work recorded in this Report, during the year several samples of sewage and other effluents discharging from pipes into our estuaries have been examined by my assistants, and I have given my opinion to the Committee as to whether or not, under all the circumstances, these discharges could be considered as injurious to the fisheries of the neighbourhood.

I have also prepared, at the request of the Chairman, an outline scheme of work to be undertaken at Piel (see below, p. 9.), and a Memorandum on Technical Instruction for Fishermen, from which I quote the following opinion:—

"Instead of sending lecturers to various parts of the district, it would be better to bring parties of selected men from the different fishing centres to Liverpool to hear some fishery lectures in the University, where there are facilities for effective illustration, and to be shown matters practically in the Fisheries Laboratory and in the Museum. I should recommend, also, that these same men should be sent afterwards in the same way to our Marine Hatchery at Piel *during the hatching season.*"

It has been suggested that a useful addition to our investigation during the last two years of the currents of the Irish Sea by means of drift bottles would be the liberation of large numbers of drift bottles at the spots where we find fish spawn. We propose to use empty wine bottles weighted with sand so as to float submerged, with our usual post-card attached to the inner end of the cork. The bottles are now being prepared, and will be set free from the steamer during the spawning season.

I append to this Report:—

(A.) A note on the Shad, by Mr. R. L. Ascroft.

(B.) A guide to the very successful Sea-Fisheries Exhibition at University College, which was opened by Mr. John Fell on October 29th.

W. A. Herdman.

January, 1898.

The Hatchery and Laboratory at Piel.

At the end of last year's Report, brief reference was made to the establishment of a Sea-Fish Hatchery and Station for experimental work at Roa Island, known to the post-office as Piel, in the Barrow Channel, and about five miles from Barrow. Piel is now connected with the mainland by a railway embankment, and there are several trains in the day, each way, from Barrow. The "Villa Marina" (appropriate name) has been secured by lease from the Furness Railway Co., by the Sea-Fisheries Committee, and has been modified and adapted to the new purposes—fisheries investigation and experiment—under the direction of the Scientific Sub-Committee. Two rooms and a passage on the ground floor have been thrown together to form a large, well-lighted laboratory, 36 by over 20 feet, capable of affording comfortable working space for six students or investigators. The former lifeboat house, measuring 44 by over 16 feet, has been connected with a room opening from the kitchen, and has been fitted up with aquaria and hatching tanks. It will be referred to in future as the tank-house: it is well lighted by both side windows and sky-lights.

The rest of the house gives plenty of accommodation both for additional laboratories, if needed in the future, and for residential requirements. In addition to the kitchens and pantries, there are two public rooms, the dining-room and the library, a photographic dark-room, and three or four bed-rooms for the working naturalists. Two rooms upstairs have been handed over to the resident Scientific Assistant, Mr. Andrew Scott, and two to the resident bailiff, Mr. H. Richardson. Other rooms remain unfurnished, available for such purposes as may seem best as requirements develop.

The laboratory has 8 windows, on its N., E., and S. sides, and is fitted with both fixed and movable work tables, with wall shelving, cupboards, sets of drawers, sinks, gas, and both fresh and sea water. It is not proposed to have any fixed tanks in the laboratory. Small movable aquaria can be accommodated, but larger ones are confined to the tank-house. Apparatus and reagents are provided.

The tank-house has two large storage cisterns in the loft, capable of containing over 5,000 gallons of sea water. These are filled by a supply pipe from a 3-horse power Crossley gas engine and pump, which draws the water from a carefully chosen spot on the beach. Pumping can be carried on for about 4 hours during an ordinary tide, and the pumps are capable of supplying 2,500 gallons per hour. From the cisterns the water is led to the filter, where it passes upwards through 3 folds of thick blanket, and then to the concrete and plate-glass wall tanks, of which there are four, measuring respectively 11 by 3 by 3 feet, 7½ by 3 by 6 feet, 4 by 3 by 3 feet, and 3½ by 3 by 1½ feet.

There are also several floor tanks of concrete, of large size, which will be suitable for Lobsters and other shell-fish. The wooden hatching tanks were made in Liverpool, and are exactly like those described and figured in our last Report. They measure each 5 by 2½ by 1½ feet. These, and the various smaller wooden tanks and glass aquaria are movable. We have also several of the American McDonald hatching jars, which will be used for Lobster eggs.

Sometime ago, at the request of the Scientific Sub-Committee, I prepared a statement of the work which I proposed should be carried on at Piel. This was adopted by the Committee, and I now reprint it here in order that it may be placed on permanent record.

"MEMORANDUM sent to the Chairman of the Lancashire Sea-Fisheries Committee, for the use of the Scientific Sub-Committee, by Prof. W. A. Herdman, in October, 1897, on an

"OUTLINE SCHEME OF WORK FOR THE PIEL SEA-FISH HATCHERY.

"I think that the Institution at Piel, although it may serve several useful purposes, ought to be regarded as primarily for the hatching of sea-fish and Lobster eggs, and for experiments upon the further rearing of young sea-fish and upon the life history of shell-fish. That is, the ECONOMIC work ought to be regarded as of first-rate importance, and nothing else ought to be allowed to interfere with it. Mr. Scott ought to be instructed to give his whole attention to making the hatching and rearing a success. In my visit to America this summer, I made a careful study of the methods of the United States Fish Commission, at their two celebrated Hatcheries, at Woods Holl and at Gloucester. In each case the Institution is under the charge of a resident "Superintendent," who gives his whole time and attention to making the hatching and rearing a practical success. These men try to perfect every little detail of the cheese cloth in the hatching boxes, of the jets of water, of the cleansing of the boxes, the removal of dead ova, of the distribution of the fry, and so on—the little details upon which the economic results depend. Research and teaching are left entirely in other hands, and are carried on for the most part in other Institutions, such as the Biological Laboratory at Woods Holl and the Central Institution in Washington.

"I would propose, however, that the Piel Hatchery be

used secondarily, and so as not to interfere with the primary object, for two other purposes, viz. :—

"1st—For teaching the *practical details* of hatching and rearing to selected fishermen from different parts of the district, who might be brought in small parties at the proper season and have their expenses paid. A visit to Piel would probably be much more instructive after one had heard a lecture or two on the eggs, reproduction, fertilization, and development of fishes; and, as all others matters connected with the fisheries can be much more efficiently and conveniently taught at University College, Liverpool, where there are the laboratories and collections, it would be better for such fishermen to visit Piel after attending a course at Liverpool. The Piel Institution ought also to be available for the instruction in practical hatching of an occasional young man who is training himself with the view of filling some fishery post, such as superintendent of a district, or Scientific Fisheries Assistant in charge of a hatchery. Such a man ought first to go, as a student, through a regular course of zoology at a University laboratory, and then a prolonged visit to Piel during a hatching season, ought to be of the greatest benefit to him.

"2nd.—The other object which I should like to see fostered at Piel, so far as is compatible with the hatching work, is the encouragement of research by independent biologists, such as the members of the Liverpool Biological Society. Our knowledge of fishery matters owes much to the investigations of such men in the past, and I hope will owe still more in the future. I do not doubt that any small expense the Committee may be put to in giving facilities to professional zoologists for pursuing their investigations at Piel will be well-spent money, and will bring in a good return in the form of increased

knowledge in regard to the conditions of marine life in our district.

"I should deprecate, however, the extension of any such facilities to students from our Colleges. There are plenty of *teaching* marine institutions already round our coasts to satisfy the demand, and at these institutions the students require and receive a great deal of attention, which we could not give them at Piel. Our Committee and our Institution have nothing to gain from such students, who would occupy work places much better reserved for professional or amateur zoologists conducting serious investigations.

"To sum up. For the reasons given above I should recommend:—

"1st—That Mr. Scott be instructed to devote all his attention to the hatching and rearing, and to allied practical investigations.

"2nd—That parties of fishermen be brought from time to time to have practical sea-fish hatching and rearing demonstrated to them.

"3rd—That any young men in training as fisheries experts be encouraged to come and study operations at Piel, after being through a zoological course at some University.

"4th—That no other teaching, either of fishermen or of ordinary science students, be attempted at Piel, but be left to other institutions, such as the College laboratories, which are fitted for that purpose, and where it can be done better, and without interfering with more important economic work.

"5th—That all possible encouragement be given to competent zoologists to come and pursue their investigations at Piel, free of charge.

"Further, as to the details of the economic work to be

undertaken at Piel, I feel that these must develop according to local circumstances and as opportunities arise, but I may put down as a general programme :—

"The hatching of ordinary food fish, such as Cod, Haddock, Whiting, Plaice and the allied flat fish.

"The development and after-rearing of such young fish as are hatched.

"The cultivation of the food of fish, especially of young fish.

"The hatching of Lobsters' eggs both in shallow tanks and in McDonald jars.

"The rearing of young Lobsters, and the stocking of of suitable spots on the scars.

"The investigation of the feeding and breeding and the life history in general of shell-fish, and especially of the Mussel and the Cockle.

"The laying down of Oysters, and various other experimental attempts to improve our local shell-fish cultivation, and re-stock the beds.

"There are various other more theoretical and general items of work, such as the codifying of the statistics obtained in the district, enquires into the distribution and migration of fishes throughout the year, and so on, which will probably be better done at the Liverpool Laboratory, where large libraries are at hand, and where other scientific opinion is available for consultation; but possibly Mr. Scott might be able to help in that work also at times of the year when he is not very fully engaged with his more special economic operations. Similarly the Assistant at the Liverpool Laboratory will be able to help Mr. Scott when there is a press of work at Piel.

"This programme of work for Mr. Scott ought to be regarded as rather elastic, and susceptible of modification or extension as needs may arise from time to time.

October, 1897. (*Signed*) "W. A. HERDMAN.'

Sea-Fisheries Exhibition.

As the Sea-Fisheries Committee desired that Lancashire should be represented in the Yachting and Fisheries Exhibition held at the Imperial Institute last summer, Mr. Dawson and I, with the assistance of Mr. Scott, arranged, during the spring, an exhibit which should illustrate both the administrative and the scientific sides of the Committee's work. As it was clearly important that the exhibit should be available for use locally in different parts of Lancashire, three light but substantial pitch pine museum cases, so constructed that they could readily be taken to pieces and packed up for transit by rail, were made for us by Mr. R. Garner, the Superintendent of the Wood-working Department of University College. These three cases (labelled A to C) showed, as arranged at the Imperial Institute, in April :—

A. Examples of the results obtained from the scientific work in the Fisheries Laboratory.

B. Samples of the scientific papers and reports and the statistics and other statements as to the fisheries published by the Committee, and of photographs, drawings, and lithographic plates illustrating the fishery work of this district.

C. Specimens of fish taken with various nets, samples of meshes, models of nets and various other fishery implements, gauges, and other illustrations of the work of the Administrative Department.

These three cases together cover all the varied activities of the Committee's work. In addition our exhibit included samples of nets and trawls, maps, charts, regulations and notices, models of boats, &c., &c.

The Lancashire exhibit was not at all well placed at the Imperial Institute. In place of being beside the

other scientific exhibits—such as that of the Marine Biological Association—in the large north gallery, it was in a small badly lighted annexe; but several scientific men and others (such as the editor of the "Fish Trades Gazette") remarked publicly upon the interesting and important nature of the Lancashire Exhibit.

At the close of the London Exhibition the cases and their contents were brought back to Liverpool, and, with the sanction of the Committee and the permission of the authorities of University College, Mr. Scott and I arranged, during the autumn, a small but representative Sea-Fisheries Exhibition, of which the London Exhibit formed the nucleus, in the College Museum of Zoology. This exhibition was formally opened by the Chairman of the Lancashire Sea-Fisheries Committee in the presence of a representative audience on October 29th. An address was delivered by Mr. Fell upon "Some Aspects of the Work of Sea-Fisheries Committees, and speeches were made by the Principal of University College, the Chairman of the Technical Instruction Committee of the Liverpool City Council, and others. The exhibit was then opened to the public during the next few weeks on certain hours and days. At the end of three weeks I was able to report to the November Meeting of the Committee that over 1000 persons had visited the exhibition, and when we finally closed it at the end of the year, the total number of visitors was 1,550. On several days set demonstrations or explanations of the collection were given to a party of Board School teachers, to a group of fishermen from Hoylake, and to a company of children.

The museum, the nature of its contents, and the speeches at the opening of the exhibition were very fully and favourably reported by the Liverpool Press, and there is reason to believe that not only was the exhibition of

interest to many people in Liverpool and the neighbourhood, but that it led to a more general diffusion of useful information as to the objects of our Sea-Fisheries Committee and as to its methods of work. It is only in this way, and by courses of public lectures, that we can hope to secure a wider knowledge and appreciation of fisheries work, of the object of regulations, and the value of scientific investigation. The Catalogue of the Sea-Fisheries Exhibition, as arranged in Liverpool, is appended to this report.

"Plankton" Investigation.

One of the most important determining factors in the distribution and movements of fish is clearly their food. In past reports we have given a considerable amount of information of the same kind as has been given elsewhere by other fishery investigators, as to the more or less fixed food derived from the sea bottom in the case of most of our common edible fishes. We are now making a more systematic study than has yet been done in this district of the floating and drifting fish food found in the surface and deeper layers of water throughout the sea, and which is coming to be called "plankton." Much of the plankton consists of microscopic plants and animals which are, throughout their life, in a free condition. But another important constituent is the enormous quantity of eggs, embryos, and larval stages of many animals which, in the adult condition, are to be found on the sea bottom. These young stages are most of them only to be found at certain times of the year, and consequently the plankton differs considerably, both in nature and amount, according to the season, and also, to some extent, according to the weather. As the plankton is liable to be moved about from place to place by tidal and other currents, by pre-

vailing winds and by exceptional gales, it is evident that its condition in our area of the Irish Sea must be affected somewhat, from time to time, by that of the west coast of Scotland, of the Irish coasts, and of the Atlantic. As the plankton is a very important element of the food of many of our fishes in their younger stages and of some even when full grown, it can scarcely be doubted that a detailed knowledge of the condition and movements of the plankton throughout the year will give us important information as to the distribution of fish.

For the last ten years the Liverpool Marine Biological Committee have been paying more or less attention to the plankton during their numerous dredging expeditions in the Irish Sea, and in the Eleventh Report of that Committee, just published, a summary is given of the chief observations which have been made up to the present.*

A year ago, with the help of Mr. Andrew Scott, I organised a scheme for the weekly collection of surface plankton throughout 1897 at six stations in our district. The localities were Port Erin (I. of Man), New Brighton (near Liverpool), Lytham and mouth of Ribble (coast of Lancashire), Piel (Barrow Channel), and from the Fisheries steamer, at sea, wherever she happened to be. The collections were taken, preserved, and sent to the Laboratory at Liverpool, where they were measured by Mr. Scott and then examined in detail. The scheme was started towards the end of January, and was kept up as regularly as possible—perfect regularity is not possible, first, on account of the weather, and secondly, because the bailiffs who take the gatherings are liable to

* Prof. M'Intosh had carried out similar investigations for the Scottish Fishery Board in 1888 (see Seventh Ann. Rep. Fish. Bd., Scot., p. 259, 1889). More recently Messrs. Bourne, Bles, Garstang, and others at Plymouth have recorded the variations in the plankton at different times of the year.

be called off occasionally to other duties. During the first fourteen weeks the number of gatherings received out of the possible six were—5, 6, 4, 3, 4, 2, 3, 4, 4, 3, 3, 5, 3, 4.

These gatherings, which have been worked up fully, bring the record up to the end of April. The rest of the collection, which is now in process of being examined, consists of some sixty tubes, giving an average of nearly two a week for the remainder of the year. Taking these statistics, along with the many previous less complete records that we have, extending back for ten or twelve years, there are some prominent features of the collections, looking at them week by week and month by month, that arrest attention—the abundance of *Sagitta* in January and February; the comparative scarcity of Copepoda early in the year; the abundance of diatoms, such as *Biddulphia*, *Coscinodiscus*, *Rhizosolenia*, and *Chætoceros*, in February and early spring; the appearance of Nauplei and then other larval forms in February and March; the comparative scarcity of plankton all round in February and March (except when gelatinous Algæ sometimes swarm in the latter month); its increase in April, and especially the increased abundance of pelagic Coelenterates and of Copepoda in early summer; the appearance of fish eggs and embryos and larval fish in abundance about Easter; the disappearance of Nauplei and other larvæ as summer goes on, and the great increase in Medusæ and Ctenophora; the quantities of *Oikopleura* which appear in the height of the summer; the abundance of Dinoflagellates in late summer and autumn; the great relative abundance of life in general during July, August, and September; and lastly, the rapid diminution in the amount and variety of plankton during the last few months of the year.

There are, on the other hand, some organisms, such as the Algæ *Halosphæra* and *Tetraspora*, the Infusorian *Noctiluca*, and the Copepod *Anomalocera*, which seem to vary greatly in their abundance from year to year; but probably when we have a more complete knowledge of the plankton of the North Atlantic, and of the relations existing between physical conditions and the distribution of organisms, we shall be able to assign rational causes for these curious irregularities in the floating population of our seas. To give an example of such irregular distribution, one of our very few records of *Noctiluca* during the year is "off the Morecambe Bay Light Vessel," on June 28th, when it is said there were "miles of this material." The gathering consists entirely of *Noctiluca*. It was taken during a heavy thunderstorm.

It is interesting, in this connection, to note that of all the tow-net gatherings which I took this summer in crossing the Atlantic twice, between Liverpool and Quebec, once at the beginning of August, and again at the end of September, those from the sea around the Isle of Man, between Liverpool bar and the north of Ireland, were the richest in species. The lists of organisms observed in the gatherings in question, are given in full in a paper which has been recently published by Mr. Thompson, Mr. Scott, and myself.*:—

We have arranged that during 1898 plankton gatherings will be taken weekly at the same six localities as in 1897, but a little further out to sea to avoid the disturbing influences of the shore.

Experimental Sea-Fish Hatching.

During the last spawning season we continued our experiments, commenced the previous year, on the hatch-

* Trans. L'pool. Biol. Soc., vol. XII., p. 33.

ing of edible sea-fish in our local waters. Mr. Scott carried on the work in the boat-house at Piel, in order to test the water of the Barrow Channel, while I repeated the experience of the previous Easter at Port Erin in the south-end of the Isle of Man.

About the middle of April the Sea-Fisheries steamer, "John Fell," came to Port Erin under the direction of Mr. R. A. Dawson, for the purpose of searching for spawning fish. On Saturday, April 17th, we trawled mature fish of various kinds both flat and round, but did not succeed in getting both males and females of the same species in the ripe condition, and consequently no eggs were fertilized. On Monday, April 19th, we were more fortunate, and obtained to the north-west of Port Erin Lemon Soles and "Witches" spawning, and were able to fertilize the eggs. We also found spawning Megrims *(Arnoglossus laterna)*, and, as an experiment, we fertilized the eggs with the milt of a ripe Cod. As a result large numbers of the following embryos were started on their development in the Aquarium on the afternoon of the 19th:—

In tank I.—Lemon Soles *(Pleuronectes microcephalus)*.
In tank II.—"Witches" *(Pleuronectes cynoglossus)*.
In tank III.—Ova of Megrim fertilized by milt of Cod.

The arrangement of the hatching tanks, and the apparatus for the circulation of the water was described and illustrated in last year's Report.* The water during the hatching kept at a specific gravity of from ·26 to ·27 and at a temperature of from 46° to 47° Fahr. The cross between the Megrim (a flat fish) and the Cod only developed for from three to four days, and then all the embryos became abnormal and distorted, and died.

* See also Trans. Biol. Soc., vol XI., p. 67 and Pls. I.—IV.

On April 26th the Witches began to move inside the egg covering, on the 27th the Lemon Soles were wriggling, and on the 28th both hatched out, eight and a half days after fertilization of the eggs.

Mr. Scott went to Piel at the beginning of March for a couple of months in order to test the water there by seeing how the keeping of various marine animals and the hatching of spawn compared with our experiences at Port Erin. I give further on (p. 29) Mr. Scott's report to me upon his work at Piel, from which it is obvious that, although some measure of success was obtained in temporary premises under "make-shift" arrangements, the work was greatly hampered by the large amount of sediment in the water. We hope that the storage tanks and filter, which have now been established at the Piel Hatchery, will remove this difficulty, and will render the water more like that at the south-end of the Isle of Man, where no filtering is necessary.

We hope, then, in the present season, with a continuous supply of water, the larger tanks, filter, and more efficient apparatus altogether, to conduct the hatching work more successfully, and to deal with much greater quantities of eggs. When, however, the little fish is hatched out, only half the work—and that probably by far the easier part—is done. I think it most important that we should make all possible attempts to rear the fry through their larval and post-larval stages, as far as possible, before setting them free in the sea. For this purpose other tanks, besides the hatching ones, will be necessary; and shallow ponds in the open air, or enclosed areas of the sea shore, would be a great advantage. The most suitable food, whether natural—such as diatoms, copepoda, and the like—or artificial, for each stage, will have to be ascer-

tained, and, if necessary, reared and kept in ponds for the purpose.

It is interesting to notice that Mr. Harald Dannevig has been experimenting with the fry of plaice in this manner at the Dunbar Hatchery of the Fishery Board for Scotland (see Fifteenth Report, p. 175, 1897), and has succeeded in rearing them through their post-larval stages until they had undergone their transformation into little plaice and settled on the bottom.

In the Eleventh Annual Report (for 1896) of the Sea-Fisheries Inspectors for England and Wales, Mr. C. E. Fryer makes some interesting observations upon the results obtained by the artificial hatching of sea fish, especially in the hatcheries of Newfoundland and the United States. Upon some of these reports, and Mr. Fryer's comments, I desire to make some further remarks. According to the Director of the Hatchery near Arendal, in Norway, about 300,000,000 Cod can be hatched for an expenditure of about £600, that is at the rate of a million for £2, or something over 2,000 young fish at the cost of one penny—a very moderate cost if even a few only of the fish grow to maturity, or if, by increasing the swarms of young fry, which must be eaten by their natural enemies, they so enable some of the (perhaps stronger) naturally hatched fish to escape destruction.

Mr. Fryer's comments upon the figures which he quotes in connection with the hatcheries of Newfoundland and the United States, rather give the impression that he is disappointed at the absence of more definite results, and that he feels that an absence of increase, or even a decrease in the fisheries, is not compatible with the claim that the addition of millions of artificially hatched fry to the sea must be a benefit to the local fisheries. But it is, perhaps, unreasonable to expect, as the Commissioner of

Fisheries in Newfoundland remarks in his Report for 1895, a great increase of fish after such a short trial of artificial hatching. A Cod fish requires four years to reach maturity. A vast number of the young Cod fish planted must perish from natural causes, and only a small percentage can be expected to grow up and form marketable fish.

The increase to a fishery can, therefore, only be gradual, and time is required to determine the value of this important experiment. I may add that it may well be that a fishery which is not increasing is still greatly benefited by the results of artificial hatching. On the other hand, I think it quite as unreasonable to attribute any marked increase of fish in a district entirely to the hatching operations, unless it can be definitely proved that the young fish caught are the produce of the hatchery. I agree with Mr. Fryer that, in the case of the reported increase of Cod in the neighbourhood of Dildo during 1895 (and again in 1896), it is at least as reasonable to attribute the early catch of the fish to natural conditions, such as the increased temperature of the water, as to claim it as a result of the artificial hatching of a few million of Cod eggs at that place in 1890 and 1891. The careful observations of the Fish Commission have established the fact that the Gulf Stream fluctuates considerably from time to time in its extension towards Newfoundland in the north, and we now know that the tile fish *(Lopholatilus chamæleonticeps)* is influenced in its distribution on the east coast of North America by the condition of the Gulf Stream. The Cod, and other fishes, are probably also affected in a somewhat similar manner. But all this is absolutely no argument against artificial hatching. Natural circumstances will be sometimes with us and sometimes against us, and when they are with us they

will probably be more powerful than anything that man can do; but whether under favourable or adverse circumstances man's little effort should also be made to restore the balance of nature by returning to the sea some proportion of what he takes from it.

This is likewise true of Lobster hatching, and it is important to note that the greater number of the eggs from which young Lobsters are hatched in American hatcheries are taken from parent Lobsters which are on their way to the tinning factories; and, therefore, it may fairly be claimed that millions of embryo Lobsters are saved from certain destruction, and given a chance at least of prolonged life and of reaching adult size.

There are a couple of Mr. Fryer's general observations in regard to which I would make a remark, because I believe he has pointed out difficulties in the artificial operations which it is important to guard against. He remarks that "the tendency under the artificial conditions of a hatchery is towards an increased temperature, which hastens development of both ova and embryo, and causes them to anticipate the natural period for hatching, regardless of the general climatic conditions of the season." Well, this must be prevented, and it is not difficult in early spring—the usual hatching season—to keep the water in the tanks as cool as that in the sea. In the height of summer it is different, but at that time the sea itself is probably sufficiently warm to prevent there being any ill results from a few days anticipation of the period at which the hatching would take place in nature.

Mr. Fryer says further:—"Then—as to the circumstance under which the young fry are 'planted'—while they would be hatched naturally in deep open water, of a high density and comparatively low temperature, they are almost of necessity liberated in shallow water, of

relatively low density and high temperature." I fail to see the necessity, and I feel it very important that fry should not be liberated in such unsuitable waters. We must endeavour to plant them in the localities where they are naturally found, and in the condition under which they are naturally deposited and developed, so that they may grow and be distributed in the pelagic waters in the ordinary course of nature, and find their way gradually into the shallow water nurseries. It will be easy, for example, in our own district to carry this out by running the boxes of fry on the steamer out into deep water over the natural spawning grounds before setting them free. I hope, however, that before long we shall have taken the further step and be attempting to rear some of the newly hatched fry to later stages within enclosed areas.

The Fishery Board for Scotland, in their "General Statement" (see Fourteenth Annual Report, 1896, p. 10) as to the utility of Sea-Fish Hatching, say: — "The artificial propagation of the food fishes on a large scale may now be regarded as having passed beyond the sphere of experiment, and taken its place as a department of practical pisciculture," &c. I do not go quite so far as that, but would regard the operations as being still in the experimental stage, although I consider the experiment as being of very great importance, and one it is the duty of fishery authorities to test thoroughly, and I agree rather with their further remark from the same page of the Report:—"It is, however, of importance that the economic results of marine pisciculture should be as speedily as possible ascertained. Its utility as a means of benefiting the sea fisheries depends upon the extent to which it is likely to increase the abundance of the fishes propagated."

Marine biologists and fisheries authorities everywhere

must be anxious to see some definite scientific experiment carried out which would gauge the extent of the results of artificial hatching in a given area, but such an experiment is, from the nature of things, most difficult to devise and to keep free from disturbing elements. It is not difficult, perhaps, to define the conditions of the experiment in words, but it is very difficult to carry them out satisfactorily in nature. What is wanted is a fjord or circumscribed sea area of which the fish population is approximately known, or in regard to which, at least, we have reliable statistics extending over a number of years, so that we know what an average catch, under given conditions, ought to consist of. To this area the hatched fry must be added, and the fishing must be regulated, and exact records of both processes kept. The experiment must run for at least five or six years—better ten—so as to allow time for the growth of the fish and to eliminate any possible climatic disturbances during a few of the years. It would be important, as a control experiment, to have a second similar area, close at hand, under similar physical conditions and in which the same amount of fishing is carried on, but to which no fry are added.

Dr. C. G. Joh. Petersen, of the Danish Biological Station, in his last Annual Report (VI., 1897) upon the conditions of plaice population in the Limfjord, expresses his conviction that there is an abundant supply, or in his own word, an "over-population," of young plaice produced naturally in the German sea, and that the difficulty to be met lies, not in a scarcity of fry, but in securing that the young fish, having passed through all the dangers of early life, shall be spared from capture until they have reached the age at which their marketable value is greatest. He recommends, therefore, a system of artificial transplantation to suitable grounds, such as some parts of the

Limfjord, of undersized plaice, and he considers that this might lead to a great increase in the value of the plaice fisheries.

This superabundance of young plaice may possibly be present in some special localities, but I doubt whether it is at all general, and I do not see how, in the face of natural enemies and of fishing operations, we can speak of an over-population anywhere until it has been proved that there are more young fish than the ground and the food will support. I do not think that there is any evidence that anywhere in our district have we any young fish to spare. But still Dr. Petersen's observations are full of interest, and I think we might benefit by his suggestion in one particular. In view of the destruction of young fish effected in some of our nurseries by the Shrimp trawlers, it might be well to carry out transplantation experiments, such as those he proposes for Denmark, and remove some millions of young plaice and other immature fish from grounds where a large proportion of them are doomed to destruction, to other localities of a suitable nature where they can feed and grow in peace. The institution of "sanctuaries" amongst our fish nurseries is eminently desirable.

Oyster Investigation.

The investigations on the bacteriology and various diseased conditions of Oysters and other shell-fish, and on their possible connection with public health questions, are still being carried on by Prof. Boyce, Dr. Kohn, and myself. In July we communicated a paper to the Royal Society, giving an account of the presence of relatively large quantities of copper in certain green leucocytes found in a diseased condition of the American Oyster as bedded on our coasts. The Oysters suffering from this

leucocytosis are always more or less green, but must not be confounded with ordinary green-gilled Oysters, where the colour is due to a totally distinct cause. Later in the summer, at the Toronto meeting of the British Association, we gave a further account of our investigations up to date, and from that report I quote the following account of the micro-chemical part of the work * :—

"The following are our details of the histo-chemical investigation of the pigment. The green pigment is insoluble in boiling alcohol, ether, chloroform, xylol, and other fat solvents; it is soluble in dilute acids and alkalies. The addition of potassic ferrocyanide to sections containing the green colouring matter, or to the leucocytes themselves, gives a red reaction, indicating the presence of copper; but the reaction can be most readily obtained by the addition of a small quantity of ·5 per cent. hydrochloric acid to the potassic ferrocyanide. Ammonium-hydrogen sulphide gives also an immediate reaction with the green pigment. Ammonia strikes a beautiful blue wherever there is a green. It was then found that pure hæmatoxylin is an extremely delicate test, giving an immediate blue reaction in exceedingly dilute solution. Previous treatment of the green colouring matter by 3 per cent. nitric acid in alcohol prevented these reactions, and subsequent treatment with acidulated potassic ferrocyanide resulted in a very faint general prussian blue colouration of the tissue generally. We concluded that there was *no inorganic iron* present in the leucocytes, that the leucocytes which form the green patches contain a considerable quantity of copper, and that, just as in the case of iron, as shown by Professor Macallum, pure hæmatoxylin is a most delicate test, but that great care must be taken to

* For further details on some points see Proceedings of Royal Society, vol. LXII., p. 30, 1897.

ascertain by other reagents which of the metals is present. Very numerous tests were made with the blood obtained from white Oysters, and micro-chemical reactions revealed in some instances faint traces of copper. Hæmocyanin has been described in the blood of Molluscs and apparently in the blood of the Oyster. We have examined numerous samples of blood taken from the white Oyster, but have failed to get any blue colouration on exposure to air. In the green Oysters a very faint blue colour has been noticed in some cases on exposing the blood to air."

I quote the following conclusion from the Royal Society paper:—

"Our results demonstrated the presence of copper in comparatively large quantity in the green leucocytes, chiefly in the American Oyster, but also in the "natives" from Falmouth and other localities. We have shown that the colour was in proportion to the amount of copper present, and that the colourless leucocytes contained only traces of that metal. The deposition of the copper in this large quantity appears to us to represent a degenerative condition. It was accompanied by a most striking increase of leucocytes, which tended to distend the vessels and to collect in clumps, phenomena which are abnormal in our experience in the Oyster. The presence of the copper in the leucocytes in these cases might be compared to that of the iron which is met with, in man, in some of the leucocytes in cases of old hæmorrhages, pernicious anæmia, or in other cases where iron is set free. We are not prepared to state whether copper in the food can bring about this condition, but certainly we have abundant evidence to show that it can occur where no copper mines or other evident sources of copper are present.

"We are inclined to suggest that the increase in copper may be due to a disturbed metabolism, whereby the

normal copper of the hæmocyanin, which is probably passing through the body in minute amounts, ceases to be removed, and so becomes stored up in certain cells."

Preliminary Experiments at Piel.

Mr. Scott gives me the following report upon his work, at the Piel Hatchery, during March and April, 1897 :—

"In accordance with instructions received from the Scientific Sub-Committee, through Prof. Herdman, I went to Piel on March 2nd, for the purpose of carrying out the various experiments suggested in order to test the suitability of the water there for fish hatching, and for the study of the development and life histories of economic marine animals in general. I remained there, with the exception of a fortnight when I was recalled to Liverpool to assist in the preparations for the Fisheries Exhibition, for practically two months.

"The experiments were carried out in the old Life-Boat house, which had been fitted up as a temporary laboratory and tank house, and the apparatus used was a set of three tanks, exactly similar to the ones used in the experiments at Port Erin last year (see Report for 1896, p. 12) ; a few smaller tanks and glass aquaria were also employed from time to time. Owing to the structure of the place, the lifting apparatus, described in our last Report, could not be used for circulating the water, so we had to put up a store tank capable of holding about 200 gallons, which the bailiffs filled up as required; from this tank the water was siphoned off into the uppermost of the three tanks and allowed to circulate by gravitation throughout the system. The apparatus was put into working order with the least possible delay, and everything made ready for the reception of the fertilized eggs.

"An accident to the steamer, rendering it unfit for sea,

prevented it from being placed at our disposal to obtain the required fertilized eggs, but through arrangements made with Mr. Leadbetter, of Fleetwood, a member of the Committee, I was permitted to visit the fishing grounds in the sailing trawler 'Harriet.' Accompanied by one of the bailiffs from Piel, we left that place early on the morning of the 10th March, having previously arranged to meet the 'Harriet' outside the harbour not later than 6 a.m. A heavy sea was running outside, and no sign of the vessel could be seen, so it was decided to run to Fleetwood, and on arrival there we found that she had not gone out owing to the storm. By this time, however, the weather showed signs of improvement, and the captain arranged to sail that same afternoon. During the time we were waiting at Fleetwood we visited the fish market, and had a look at the condition of the fish landed from the trawlers that morning, and found that the majority of them had been nearly mature when captured.

"On putting out to sea the captain of the 'Harriet' decided to try the off-shore fishing grounds lying in line with St. Bees Head and the north end of the Isle of Man, whence most of the fish were being taken. The first hauls were unproductive of spawning fish, and it was not till midnight of the 11th March that we were successful in our search. In this haul spawning Cod and Haddock were found, the eggs were quite mature, and no difficulty was found in 'stripping' the fish and afterwards fertilizing them. After fertilization, the embryos were placed in clean buckets filled with fresh sea-water, and everything made ready for running into Piel Harbour at daylight. Unfortunately, however, during the night a heavy sea broke on board, carrying away the buckets from their fastenings, and sweeping the contents overboard. In the next haul mature Haddock were again found, the eggs of

which were again successfully fertilized, and this partially replaced the lost lot, but it was noticed that this second set were not quite so mature as the previous ones, and the eggs did not run so freely from the parent fish. During the succeeding haul the entire net was carried away, and there being no spare one on board, we had, therefore, to return to Piel with only a small quantity of fertilized eggs as the result of two days' fishing.

"The police boat was awaiting our arrival outside the harbour, but the sea was too rough to board, so the 'Harriet' had to bring us inside. Once inside the harbour, the embryos were conveyed ashore and transferred to the tanks without further loss of time, the dead ones being first carefully removed. The embryos floated quite freely upon the surface of the water, and development followed its natural course, as could be seen by frequently examining the embryos under the microscope.

"Probably owing to the eggs not being quite mature when obtained, and to injuries received subsequent to fertilization, a considerable daily mortality took place amongst the embryos, and at the end of nearly 200 hours after fertilization, all had died and sunk to the bottom of the tanks.

"During the whole time that the embryos were under observation, the temperature and specific gravity of the water was taken daily. The temperature varied from 5·8° C. to 6° C., and the specific gravity from ·23 to ·24. Although we were not fortunate in having the embryos hatch out at this stage of the experiment, it was clearly demonstrated that the specific gravity of the Piel water was sufficiently high to keep the eggs afloat.

"At this point I had to return to Liverpool, but Mr. Wright, chief bailiff, was left in charge of the place with instructions to endeavour to obtain more fertilized eggs at

the first opportunity. In this he was successful, for on boarding a trawler fishing on the off-shore grounds on April 1st, mature Cod and Haddock were found, and the eggs fertilized; these were conveyed to the tanks in the manner already described, so that when I returned on April 9th, the embryos had been in the tanks for eight days, and development had proceeded so far that the larval fishes were clearly visible through the egg membranes. Considerable mortality had taken place amongst the embryos, and that continued to the end.

"The embryos began to hatch out on the eleventh day after fertilization, and the last of them hatched out the following day. The larvæ gradually dwindled in number from day to day till at the end of seven days only one remained alive; the survivor was lost next day through being carried away by the vessel accidentally overflowing. Before my arrival the tanks had overflowed, the one into the other, thus mixing the embryos so that it is difficult to say now whether the larvæ of both Cod and Haddock were hatched.

"This second experiment shows that it is possible to hatch out the embryos in the tanks supplied with sea water from the channel, and to keep the larvæ alive for several days after hatching. Further experiments are necessary in order to ascertain for how long a period the larvæ can be kept alive by feeding them with 'plankton' collected in our tow-nets.

"For the greater part of the time that the hatching experiment was in operation, the water was used just as it was taken from the channel, and during all that period the weather was very unsettled, the sea washing up the mud and making the water, on some days, quite turbid; the fine mud consequently got in amongst the embryos, and, no doubt, had a bad effect upon them by adhering to

the outside of the egg membranes, and thus increasing their specific gravity beyond the point capable of floating in the water. On several occasions when the supposed dead embryos were examined, it was found that they were alive, and, on the removal of the coating of fine mud, the embryos again floated freely on the surface of the water.

"Towards the close of the hatching experiment, the water was passed through an ordinary flannel jelly bag before being allowed to enter the tanks, and by this means it was found possible to entirely remove the suspended matter, the water passing into the various vessels in a perfectly transparent condition; but, owing to the lateness of the season, and the arrival of workmen to make the necessary alterations for converting the premises into our present hatchery and laboratory, no further hatching could be tried with the filtered water.

"Besides the fish hatching experiments now described, other investigations were carried on as well, and these included visits made from time to time to the various shell-fish beds in the neighbourhood, for the purpose of examining their condition and collecting samples for working at in the laboratory and for testing the water in the tanks. We had, therefore, many economic marine animals living satisfactorily in the tanks during the two months; these consisted of various kinds of fishes, including small Soles, Plaice, and Dabs; shell-fish, including Mussels and Cockles, and also a couple of Oysters found living in the vicinity; Crustacea, including Shrimps, Lobsters, and Crabs, and other invertebrates which, although not directly valuable, are yet indirectly so, from the part they play as the food of other marine animals. Many of the Shrimps were egg-bearing females, and the more mature ones were taken from amongst the others and kept in separate vessels; so on several occasions we

had batches of newly hatched Shrimps in our glass jars, which were kept alive until the temporary laboratory had to be dismantled. One of the Shrimps on completion of the hatching out of the larvæ, cast its shell; both the shell and the animal were preserved, and are now in the Fisheries Collection at Liverpool.

"Early in February the bailiffs noticed that the rough ground between tide marks eastwards from Foulney was covered with young Mussels, and after my arrival I visited the various places pointed out, and found that everything was covered with the young shell-fish, the sizes of which varied from one-sixteenth of an inch to one-quarter of an inch. Whether these young Mussels are the result of the previous summer's spawning or not is at present difficult to say, as the rate of growth of this shell-fish depends a great deal upon its surroundings, food supply, &c., matters which can only be found out after lengthened investigation of any particular bed. Although numerous samples collected from the different Mussel beds in the neighbourhood were examined, no spawning shell-fish were found. The Cockle beds were also examined for spawning Cockles, but none could be discovered.

"Now that the Piel Marine Laboratory is completed and in working order, a close examination of the various shell-fish beds in the neighbourhood will be kept up throughout the year: (1) by weekly examinations of the shell-fish themselves for approaching maturity and time of spawning, and (2) by frequent tow-nettings in the vicinity of the beds for the free swimming larvæ.

"During the spring tides of March Mr. Richardson, one of the bailiffs, secured a 'berried' Lobster, which had been taken on the scar referred to in last year's Report, and brought it to the laboratory, where it was

placed in a tank and remained alive till after the place was dismantled. When the workmen arrived the tank containing the Lobster was transferred to the boat-house, formerly used by the Customs officials and now by the bailiffs as a storeroom and workshop. Later on in the spring another 'berried' Lobster was found by Mr. Wright, and placed in a second tank alongside the other. The Lobsters remained alive till well on in the summer, when one accidentally died, and the other was then placed in our wooden 'Lobster tank' on the shore. On being examined there from time to time, it was found that the 'berries' were gradually disappearing from the swimmerets, and eventually they had all gone. Probably the embryos hatched out and passed away into the open channel. With the better accommodation we now have, and the more suitable appliances in our new tank-room, it is expected that successful hatching of Lobsters will fall to be recorded in due course. It is so far satisfactory to find berried Lobsters in our own immediate neighbourhood, and the frequent occurrence of young ones, ranging from four inches upwards, points out the probable close proximity of a small Lobster rearing ground somewhere in the channel, which future investigations may yet bring to light. The Lobster tank on the shore still continues to prove satisfactory, notwithstanding frequent silting up, and several of the Lobsters have cast their shells during the past year.

"The Mussel Bouchot so far has not fulfilled our expectations, and this is probably due in large measure to the strong tides which sweep over the ground in its neighbourhood, so that very few of the original Mussels now remain upon it. In the spring of the past year a considerable number of young Mussels were observed amongst the material composing the Bouchot, and on several occasions

pieces of old stakes thickly covered with Mussels, of all sizes, were removed from the scars and fixed in the structure, but in a very short time all had disappeared. A further trial will, however, be given it during the present year, and, as soon as possible, it is intended to re-stock it."

Notes on the Shad.

(By Mr. R. L. Ascroft.)

This fish, whose scientific name is "*Clupea alosa*," belongs (as that appelation imports) to the Herring tribe. It is found in the Mediterranean and along the Atlantic and North Sea coasts of Europe, as far as Jutland. In this country it is plentiful in the Severn, and I have taken several on the Lancashire coast in a mackerel baulk at Formby. The Shad must have been numerous on the Lancashire coast, for in a lease of lands lying between the Ribble and the Mersey, one of the conditions of the lease was that one thousand Shad be delivered to the lessor by the lessee during the Shad season (Sceadda dagen), and, at the present time, all bright, silvery small fish caught in the Shrimp nets in the Lancashire district are called Shad by the fishermen.

Like the Herring, it is a migratory fish, but it continues its migration up the rivers for a short distance above the tidal waters to spawn. It enters the rivers in Holland from the middle of March to the middle of June, and proceeds up the rivers. In the Severn it is rarely seen above Worcester. The eggs, which are heavier than water, are laid by the female when in company of a male. The pair swim at night at or near the surface of the

water, and make a great noise (termed by the fishermen in the Potomac "washing"). The eggs sink to the bottom and are not adherent. The average number of eggs in an ovary is about 25,000, in some instances reaching 60,000. The diameter of the egg when laid is 1·5 mm., and it has the peculiarity that it rapidly absorbs water, reaching a diameter of 4·25 to 4·60 mm. In three to six days the young larvæ appear, having a length of 4·25 mm. They are provided with a yolksac of a diameter of 1·6 mm. Unlike the young salmon, although carrying as large a burden, they are, as soon as hatched, quick, active little fish.

The larvæ, after leaving the egg, grow very rapidly, arriving in September at a length of 100 mm., or four inches. They then proceed to the sea, and nothing is known of them after that until their return to spawn. When entering the rivers from March to June inclusive, they have arrived at lengths of from 57 cm. to 62·5 cm., average 60 cm., and weigh from 2·3 to 3·0 kilos.

In Germany and Holland a belief exists among the fishermen that the Shad are attracted by musical sounds, and they attach to their nets a number of small bells (klokijes) to attract the fish. [The above account is taken principally from the "Mededeelingen over Visscherij," for the months of April, May, and June, in which is an article by Dr. P. P. C. Hoek, Scientific Adviser in Fisheries to the Dutch government, entitled "De elft op onze rivieren," "The Shad up our rivers."]

It is most desirable to increase the Shad in our waters. There are ways in which it can be done. We might get live fish from the Severn, keep them until ripe, then strip them and hatch the eggs. I do not doubt but that ripe fish might be stripped at Cologne (Koln) on the Rhine,

and the eggs be sent over. Or the attempt might be made to obtain eggs or fry from Washington, D.C., of the American Shad *(Clupea sapidissima)*. There have been very successful plantings of the fry of this Shad in the Pacific, and they are now spread over a line of coast 3,000 miles long.—ROBERT LAMB ASCROFT.

NOTE.—The Appendix which follows was printed in October, 1897, as a Guide to our Fisheries Exhibition. The Catalogue of the permanent Fisheries Collection in University College, Liverpool, was printed as an Appendix to the last of these Annual Reports.

APPENDIX.

GUIDE TO THE
FISHERIES EXHIBITION,

Open during November and December, in the

ZOOLOGICAL MUSEUM

AT

UNIVERSITY COLLEGE, LIVERPOOL,

Arranged to illustrate the

FISHING INDUSTRIES AND THE

APPLICATION OF SCIENCE TO AQUICULTURE.

THE Exhibition is in three Rooms—the MAIN HALL of the Museum, the FISHERIES ROOM, and the GALLERY.

The MAIN HALL contains, in the centre of the floor, the three cases which were prepared for the London Jubilee Exhibition, and which are described fully below; while round the walls are those parts of the College Zoological Collection which have a bearing on fisheries.

In some of the wall cases and on tables are samples of nets and models of fishing implements.

The GALLERY round the Main Hall contains the collections of Marine Lower Animals from Liverpool Bay and the neighbouring parts of the Irish Sea. These form, directly or indirectly, the food supply of our fishes.

The Fisheries Room (Ground Floor) contains the permanent collection illustrating various branches of Aquiculture, and the Scientific Investigation of the Fisheries. A detailed catalogue of this Collection is printed separately.

MAIN HALL.

The Cases round the wall contain Back-boned Animals, arranged in Zoological order, commencing with Fishes to the left of the door and passing on to Amphibia, Reptiles, Birds and Mammals. Some of the land animals have been removed to give greater prominence to the marine forms. A group of the skeletons of Marine Animals (Whales and Seals) will be found on one of the tables, to the left of the door.

In the centre of the floor are three museum cases arranged to illustrate the varied work undertaken by the Lancashire Sea-Fisheries Committee. This Committee consists of 64 members, 36 elected by the constituencies and 28 appointed by the Board of Trade. The Chairman is Mr. John Fell, J.P., Ulverston, the Deputy Chairman Alderman E. Grindley, Liverpool, the Clerk Mr. H. C. Hulton, J.P., and the Deputy Clerk Mr. J. P. Muspratt. The Superintendent, Mr. R. A. Dawson, has under him the captain and crew of the Fisheries steamer "John Fell," and others, forming a staff of 13 bailiffs. The Honorary Director of the Scientific work, Professor Herdman, has under him as Fisheries Assistant Mr. Andrew Scott and as laboratory attendant Thomas Mercer. The Fisheries Laboratory is in the Zoological Department of University College, Liverpool, and the Marine Station and Hatchery (not yet completed) is at Piel, the most favourable position on the Lancashire coast for the purpose.

CASE A contains specimens of fish, shell-fish, fish-food, fish-spawn, etc., in illustration of some of the scientific investigations made in the fisheries laboratory. The exhibits in the case are :—

1. A series of the food fishes of our district, with the more important food matters of each, according to the observations in our laboratory. The fishes are arranged on the lowest shelf, on one side of the case, and their foods on the shelf above. The series is as follows :—

Fish.		Food.
Gurnard ...	...	Crustacea.
Cod ...	...	Crustacea.
Haddock ...	...	Mollusca and Echinoderms.
Whiting ...	...	Fishes.
Plaice ...	...	Mollusca and Annelids.
Lemon Sole	...	Annelids.
Dab ...	...	Annelids, Mollusca, etc.
Flounder ...	...	Annelids, Mollusca, etc.
Sole ...	...	Annelids.
Skate ...	...	Crustacea, etc.

2. A series of useful and useless fishes which compete with one another by eating the same food. Three pairs of such fish have been chosen for exhibition, and in each case the food has been placed between the useful and useless (or rather, unmarketable) fishes that eat it. The pairs are the Whiting and the Angler fish, which both feed on smaller fishes; the Cod and the Pogge, which both feed on Crustacea; and the Sole and the Solenette, which both feed on Annelids.

3. A series of fish parasites, both external, such as Caligus, Lernea, Chondracanthus, Anchorella, Pontobdella, and Saprolegnia (the Salmon disease fungus); and internal parasites, such as Cestode and Nematode worms.

4. A series of the ripe eggs of our chief food fishes. The fishes chosen are as follows:—Sole, Plaice, Witch, Scald fish, Lemon Sole, Dab, Haddock, Gurnard, Cod, Anchovy, and Lumpsucker. With the exception of the Lumpsucker, whose eggs sink in the water, and are, consequently found on the bottom or attached to sea-weeds, all these fishes' eggs are pelagic, or float at or near the surface of the sea. The small size and transparent appearance of most of them will be noticed.

5. Specimens of the Sole *(Solea vulgaris)* and the Solenette *(S. lutea)* at various stages of growth to show the similarity and the distinction between these two fishes. The only possibility of confusion is between the adult Solenette, which never grows larger than four or five inches in length, and the young Sole of about that size (see the specimens in the jars). Besides the occasional black stripes which the Solenette has in its dorsal and ventral fins (each sixth or seventh ray being coloured a deep black), the more sandy colour, the rougher appearance, and a difference in the arrangement of the tags around the mouth, there is also a considerable difference in the scales, as is shown in the figures and description appended to the exhibit.

6. Three food fishes of our district, the eggs of which were hatched out in the tanks of the Marine Biological Station at Port Erin in April, 1896, with specimens of their eggs and embryos preserved at various ages—24 hours, 66 hours, 114 hours, and 168 hours. The three fishes are the Grey Gurnard, the Lemon Sole, and the "Witch."
7. A series of the shell-fish of our district, showing stages in life-history and growth, legal and illegal sizes, injuries and repairs, pearl formation, and pearls.
8. Jars showing the Shrimp and its food. For the other economic crustacea see the window case in the Fisheries room.
9. Jars showing the Sole, "Flustra" ground, and the food of the Sole.
10. Piece of wooden stake covered with young mussels illustrating their mode of attachment on a Bouchot.
11. Series of Food Matters from the Sea; leading from Mud through Diatoms to Copepods, then through other animals to Pagurus, which is the food of the Cod.

Other scientific exhibits of a similar nature to those in Case A will be found in the cases round the Fisheries Room.

CASE B contains printed matter, plates, photographs, and drawings illustrating the publications, both administrative and scientific, of the Lancashire Sea-Fisheries Committee, and other work bearing upon the fisheries of the district.

One end of the case is occupied by the series of photographs taken recently by Mr. Andrew Scott to illustrate Mr. Dawson's lecture on the methods of fishing in Lancashire. These show the appearance of the fleets and the fishing boats, of different kinds, in different positions, and also such peculiar methods of fishing as the cart shrimp net, the power net, using the "jumbo" and the "craam," and "treading for cockles."

The opposite end of the case contains a set of drawings and water-colour sketches, made by Professor Herdman, in illustration of his joint investigation with Professor Boyce, on "oysters and disease." These show the external appearance and the internal structure of various kinds of oysters—natives, French, Dutch, and American, in both healthy and unhealthy conditions. Some of the drawings represent the minute structure as seen under the microscope.

A further series of drawings, and a large number of specimens, microscopic and otherwise, in illustration of the oyster investigation, will be found in another case.

At this same end of Case B, below the drawings, are exhibited some series of the microscopic slides which are prepared in the laboratory in the course of the scientific investigations. Some of them are thin sections of fishes and other marine animals, others are scales, eggs, embryos and various pieces of internal organs, prepared, stained, and mounted for microscopic examination.

Of the two sides of this case, the one is occupied by samples of the administrative literature, the other by the scientific. The administrative includes the superintendent's quarterly reports, the statistics, the various printed forms in use by the fishery officers, copies of the bye-laws, etc.

The scientific papers include the annual reports from the laboratory, syllabuses of courses of fishery lectures, catalogue of the sea-fisheries collection, papers on the marine fauna and flora of the district, report on shell-fish culture in France, and other papers; photographs and plates illustrating investigations by Professor Herdman, Mr. Scott, and others.

The upper part of this case is occupied, on both sides, by selected samples of the different kinds of lantern slides, photographs and diagrams, used at University College, Liverpool, in illustration of fishery lectures.

CASE C illustrates the Administrative work of the Committee, carried out by the Superintendent (Mr. R. A. Dawson) and his Assistants.

The principal exhibits are:—

1. The Bye-Laws of the Committee for the purpose of regulating the fishing industries of the district.
2. Models of trawling nets of different kinds as used in our district.
3. Models of shrimp trawls.
4. Model of Fleetwood prawn ("red shrimp") trawl.
5. Model of improved form of shrimp net, designed by Mr. R. A. Dawson, to minimise the destruction of young food fish (see also description on card).

6. Patterns of the different sizes of mesh used in fish trawl and shrimp nets. The meshes are measured around the four sides. A "seven-inch-mesh" therefore is one having each side of the square $1\frac{3}{4}$ in. from knot to knot. The size of fish-trawl mesh ($4\frac{1}{2}$ inch) in use in this district before the institution of the Committee, and the size (7 inch) now enforced by the Committee's bye-laws are shown, as well as the smaller sizes (both old and new) used in shrimping and prawning, and the 5 in. and 6 in. mesh used specially for a fixed period in each year for the capture of soles (by deep sea trawlers on the off-shore grounds).

7. Two large glass vessels containing common food-fishes of various sizes, illustrating the average style of catch obtained by the nets in use before and since the introduction of the Committee's bye-laws. Reprints on cards of statistics from the Superintendent's reports are placed alongside and show the results of experimental hauls made with the two sizes of mesh ($4\frac{1}{2}$ inch and 7 inch). The four jars on the shelf above show the actual kinds and sizes of the fish caught by the 7 in. mesh, as mentioned in these statistics. The three jars below show those caught by the $4\frac{1}{2}$ in. mesh. The very large number of small sized fish destroyed by the smaller mesh will be noticed in these last jars.

8. Glass vessel showing an average sample of the fish caught in a shrimp net in some parts of our district. This illustrates the destruction to young food-fish caused by the indiscriminate use of shrimp nets in localities which serve as fish

nurseries. Statistics of actual hauls are given on the card alongside.

9. Model of improved Otter trawl net boards, lately invented and patented by Messrs. Richard Cowell and R. W. Mason of Fleetwood.

10. Model of shrimp hose-net, as used at Ince in Lancashire.

11. Model of shrimp push-net used in this district.

12. Models of craams, jumbos, rakes, and other instruments used for taking shell-fish (cockles and mussels) in our district.

13. Riddle (on one of the tables) to regulate the size of cockles collected.

14. Complete set of the testing gauges for sizes of meshes and of shell-fish, used by the fishery officers in enforcing the bye-laws of the Committee.

15. Facsimiles of the complete set of standard gauges as used in court in cases of prosecution.

16. Instruments used on board the fishery steamer "John Fell" for obtaining samples of water and for ascertaining the temperature at any required depth below the surface.

17. Set of Kiel hydrometers and thermometer used in taking the physical observations at the time of each experimental haul (in side case).

18. Badges, compass, and telescope as used by fishery officers in execution of their duties.

On the tables and in the cases round the walls of this room, and hanging from the roof, will be found the remaining models and samples illustrating the Lancashire fishing industries and the administration of the Committee's bye-laws. They are as follows :—

19. Model of the s.s. "John Fell," the Lancashire Sea-Fisheries Committee's steamer.
20. Model of the police sailing cutter.
21. Model of Fleetwood steam trawler "Bassein."
22. Model of Liverpool steam trawler, exhibited by R. Harley, Esq.
23. Model of full-rigged second class fishing boat "Arrow," of Fleetwood, with fish trawl.
24. Models of other fishing boats, etc., exhibited by Messrs. John Gibson and Sons, Fleetwood.
25. Model of a fish trawl net, arranged to show the different sizes and quantities of fish captured with large and small meshes respectively, as used in the investigations made by the Lancashire Sea-Fisheries Committee.
26. Model of sand baulk-stake net for taking flat fish.
27. Models of two fish trawls.
28. Mussel rake, as used in this district.
27. Full-sized river boat's fish trawl net (on roof).
28. Lines and tees for taking sea-fish (in side case).
29. Samples of illegal nets (in side case).
30. Tow-net for catching surface life.
31. Reversing deep-sea thermometer.
32. Naturalists' dredges, trawls and other nets.

33. Exhibited by the Anglo-American Rope and Oakum Co.:—

(1) Model of trammel net.

(2) Pollock, cod, mackerel and whiting lines.

(3) Sinkers for drift and seine nets.

(4) Specimens of twines used in manufacture of different nets.

(5) Samples of various hooks used for capturing sea-fish; flies used in trawling for mackerel; tripod hooks for trawling; swivels used in long lines.

(6) Samples of fishing lines used in district.

(7) Bow net for taking shrimps.

(8) Cast net used for scientific purposes.

(9) Prawn trap.

(10) Ground part of shrimp trawl neck and back of same.

34. Shrimp push net used in the district.

Also, round the walls and on tables will be seen:—

Maps of the district.

Tabular forms for use in the scientific work and by the bailiffs.

Photographs of biological stations and fish hatcheries (Tarbert, Dunbar, and Port Erin).

Photograph of improved trawling apparatus invented and patented by Mr. J. H. Maclure, of Hull.

Model of Dutch oyster farm, on the Schelde (see specimens illustrating Dutch oyster culture in Fisheries Room—H).

Model showing French Bouchot system of mussel culture, in the Bay of Aiguillon.

Model of the floor of the Irish Sea.

Samples of fishery reports, monographs, and plates from other countries (in side case).

Plan of the courses taken by drift bottles set free to determine the currents, specimen of drift bottle, and samples of the records returned.

On one of the tables will be found a series of microscopes showing fish eggs, and embryos, young stages of shrimps, crabs, etc., the minute structure of parts of fishes, and the microscopic food of fish and shell-fish.

Tow-nets, travelling microscope, and other appliances for collecting surface life of the ocean from vessels steaming at full speed, are laid out on a table in the Fisheries Room.

Alongside is Prof. Herdman's folding Deck-table fitted up with microscope, dissecting dishes, note-books, &c., for biological work at sea

FISHERIES ROOM.

(On Ground Floor, to South of Main Hall.)

The specimens in this room exhibit:—

A. The Series of Fishes of the district—whether edible or not.

B. Series showing the Reproductive Organs, the Spawn, and the young stages in the development and life-history of Fishes from the Egg onwards.

C. Series of Foods of various Fishes, both young and old.

D. Series of Fish Parasites—internal and external.

E. Other Enemies of Fishes.

F. Collection showing Diseases or abnormal conditions of Fishes.

G. Collection of Edible Shell-fish of our district.

H. Collection illustrating Oyster culture in France, Holland, and other countries.

I. Collection of Edible Crustacea.

K. Collection of the Sea-bottoms and other submarine deposits.

L. Collection of Natural Baits used in the Fisheries.

M. Collection of Models of fishing implements, of apparatus for fish culture and hatching, and of shell-fish cultivation.

N. Series of Photographs and Lantern Slides illustrating the Lancashire Sea-Fisheries District.

O. Collection illustrating the Regulations of Sea-Fisheries Committees and other Authorities.

[For further details see the separate Catalogue of the permanent Fishery Collection.]

GALLERY.

(Stair from Vestibule.)

The collection of Local Marine Invertebrates, which occupies the greater part of the wall cases round the gallery, is largely the result of the work of the Liverpool Marine Biology Committee. The series commences to the left of the door with the Sponges, and continues round the cases labelled Cœlenterata, Echinodermata, Polyzoa, Vermes, Crustacea, Mollusca, and Tunicata.

In the windows of the gallery are arranged a series of lantern slides, prepared by the Rev. T. S. Lea, from his photographs of the sea-weeds and animals on the shore round the south coast of the Isle of Man.

In some of the desk cases round the rail of the gallery will be found a collection of Sea-bottoms, ancient and modern, both from shallow and deep water. These include a series of the gravels, sands, muds, and organic deposits found in the various parts of our own district.

Two of the desk cases, on the north side, show an interesting series of the Microscopic Copepoda, and enlarged representations of their structure, prepared by I. C. Thompson, Esq.