

**First Report of the Council of the Marine Biological Association of the United Kingdom on work carried out in connection with the International Fishery Investigations.\***

TO SIR EDWARD W. HAMILTON, K.C.B., K.C.V.O.

*Chairman of the North Sea Fisheries Investigation Committee.*

SIR,

I am instructed by the Council of the Marine Biological Association to submit for the information of the North Sea Fisheries Investigation Committee the first Report on work done in connection with the International Investigation of North Sea Fisheries, dealing chiefly with researches carried out during the years 1902 and 1903, together with the detailed reports upon that work which have been drawn up under the Council's direction by those members of the scientific staff to whom the different sections of the investigations have been entrusted.

The Council desire to report as follows :—

**I.—General.**

At the request of His Majesty's Government, the Council of the Marine Biological Association undertook to conduct the scientific part of the scheme of fishery investigation adopted by the International Conference held at Christiania in 1901 in the southern portion of the area assigned to Great Britain, subject to such modifications as might be introduced by the International Council subsequently established, and in accordance with the general regulations of that Council.

The following is a list of members who have served on the Council since the commencement of the investigations in 1902 :—

*President*—Professor E. Ray Lankester, LL.D., F.R.S.

\* Reprinted from *International Fishery Investigations. First Report on Fishery and Hydrographical Investigations in the North Sea and Adjacent Waters (Southern Area). Conducted for His Majesty's Government by the Marine Biological Association of the United Kingdom, 1902-1903.* Presented to both Houses of Parliament by Command of His Majesty. London : Printed for His Majesty's Stationery Office, 1905. *Blue Book Cd. 2670.* Price 8s. 9d.

*Members of Council*—Messrs. G. L. Alward, G. P. Bidder, G. C. Bourne, Prof. T. W. Bridge, F.R.S. (joined 1904), Francis Darwin, F.R.S., Prof. J. B. Farmer, F.R.S. (retired 1903), G. Herbert Fowler, S. F. Harmer, F.R.S., Prof. W. A. Herdman, F.R.S., E. W. L. Holt (joined 1905), the late Prof. G. B. Howes, F.R.S., J. J. Lister, F.R.S., Hugh Robert Mill, Prof. E. A. Minchin, Prof. Charles Stewart, F.R.S. (retired 1904), Prof. D'Arcy W. Thompson, C.B., R. N. Wolfenden, M.D.

*Governors*—Messrs. the late J. P. Thomasson, The Prime Warden of the Worshipful Company of Fishmongers and E. L. Beckwith (representing the Fishmongers' Company), Prof. Sir J. Burdon Sanderson, Bart., F.R.S. (representing the University of Oxford), A. E. Shipley, F.R.S. (representing the University of Cambridge), Professor W. F. R. Weldon, F.R.S. (representing the British Association for the Advancement of Science).

*Hon. Treasurer*—Mr. J. A. Travers (late Prime Warden of the Worshipful Company of Fishmongers).

*Secretary*—Mr. E. J. Allen.

The section of the international work which was undertaken by the Marine Biological Association fell into two main divisions, (1) a survey of the fishing grounds in the southern part of the North Sea, together with an investigation of the life-histories of the principal food fishes found upon them, and (2) an investigation of the physical conditions and of the plankton or minute floating organisms of the waters of the English Channel.

The following is a list of the scientific staff employed by the Council to carry out these investigations:—

*Director and Secretary to the Council*.—E. J. Allen, D.Sc.

*Naturalist in charge of Fishery Investigations* (who is also in charge of North Sea Survey)—W. Garstang, M.A.

*Assistant Naturalists for Fishes*—H. M. Kyle, M.A., D.Sc. (until April, 1903), F. Balfour Browne, B.A. (until January, 1903), W. Wallace, D.Sc.

*Assistant Naturalists for Invertebrates*—C. Forster-Cooper, B.A. (until August, 1903), R. A. Todd, B.Sc., J. O. Borley, M.A.

*Assistant Naturalist for Plankton*—L. H. Gough, Ph.D.

*Hydrographer*—D. J. Matthews.

*Assistants*—J. Potter, A. L. Ansell, G. T. Atkinson.

The Council desire to report that in their opinion the naturalists entrusted with the different branches of the investigations have carried out their duties with efficiency and success.

In order to undertake the necessary experimental work at sea, the Council hired the steam trawler "Huxley," a vessel 115 feet long and of

191 tons gross, for a period of three years from August 21st, 1902. Some difficulty was experienced in obtaining a vessel suitable for the work with the funds available, but the Council had the good fortune to be assisted in the matter by one of its members, Mr. G. P. Bidder, who purchased the "Huxley" from her former owners and let her to the Association upon very favourable terms. The alterations required to fit her for the work of scientific exploration were made to the vessel, suitable cabins for the use of the naturalists were built in the fish hold, and a small laboratory was provided on deck. The "Huxley" made her first voyage to the fishing grounds on November 1st, 1902. Since that time she has been constantly employed in the North Sea and English Channel, and has proved suitable and efficient for the work required of her.

To carry out the North Sea work adequately, the Council found it necessary to establish a laboratory on the east coast of England. After careful consideration, and in view of the area in which the investigations were for the most part to be conducted, the port of Lowestoft was selected as the one offering the best facilities. Premises were hired near the trawl-market and fitted out temporarily to suit the requirements of the work. The laboratory work connected with the investigations in the English Channel has been done in the Association's laboratory at Plymouth, their steamer "Oithona" being used to make the observations at sea during the summer months, whilst for the winter observations the "Huxley" has come round from the North Sea.

The detailed memoirs prepared by the naturalists to whom the carrying out of the different portions of the investigations has been assigned are printed in the present volume. These memoirs deal chiefly with the work done during the first year of the commission of the Association (1903), though certain special experiments carried out in the second year (1904) also receive attention.

In considering the record of results contained in these memoirs, it is first of all essential to remember that they deal with operations undertaken in connection with one portion only of an extensive scheme of co-operative work. They must therefore be looked upon primarily as a statement of observed facts, contributed to the common stock of information which is being gradually brought together. For this reason it has been necessary to print the records of observations in considerable detail and in a form which shall be as convenient as possible for the use of other workers, but until the work done in other countries has been published in a similar way and the whole of the observations have been duly co-ordinated and considered, it will not be possible to estimate the results derived from the international undertaking.

At the same time, considering the English work alone, as it is set forth in the series of special reports by the naturalists, the Council of

the Association feel confident that our knowledge of a number of the most essential matters, upon a proper understanding of which any attempts to improve the yield of the deep sea fisheries must in future be based, has already been considerably extended, and they are not without hope that at no distant date practical measures founded on a rational appreciation of the problems involved may be undertaken with certain profit to the fishing industry. Meanwhile the Council draw attention to the following points raised in the special memoirs, which in their opinion seem worthy of particular consideration.

## II.—Fishery Investigations in the North Sea.

Experiments made by marking fishes, more especially Plaice, with numbered labels and returning them to the sea, where they have subsequently been recaptured by fishermen, have furnished much information on three important subjects—the migrations of the fishes, the growth of the fishes, and the intensity of the commercial fishing in the North Sea. The experiments have shown that the larger Plaice are capable of very extensive migrations in a comparatively short time. The extent and variety of the possible journeys may be illustrated by two instances. A Plaice, 33 centimetres (13 inches) long, liberated on December 12th, 1903, on the Leman Ground, in the latitude of Lincolnshire, was recovered by a Hastings trawler off Winchilsea, in the English Channel, on March 23rd, 1904, having travelled a minimum distance of 175 miles in a little over three months, whilst another fish, marked and liberated on August 12th, 1903, off the Lincolnshire coast, near Mablethorpe, was recaptured in April, 1904, eight months afterwards, in St. Andrew's Bay, having travelled 210 sea miles from the point of liberation. Such extensive migrations, however, appear to be confined chiefly to Plaice of larger size, the smaller fishes (below 8 inches) being seldom found to travel long distances at a rapid rate. During the summer months there seemed to be a general tendency for the Plaice on the shallow-water "nurseries" off the coast of Holland to move into deeper waters towards the north and west, whilst the fish marked in the southern bight of the North Sea showed a disposition to move in a northerly direction. In the winter (1902-3 and 1903-4), on the other hand, many of the larger fish (above 9 inches) moved southwards from the Leman Ground and the north-west coast of Holland towards the southern bight of the North Sea.

The intensity of commercial trawling in the North Sea is indicated by the fact that out of 855 marked Plaice above 20 centimetres (8 inches) in length liberated outside territorial limits the number recaptured within twelve months yields a total of 21 per cent, whilst

experiments on the Dogger Bank in the spring of 1904 resulted in the recapture of more than 40 per cent of the Plaice exceeding 25 centimetres (10 inches) in less than twelve months. From this result it seems clear that the total annual catch of the fishermen no longer forms an insignificant proportion of the total stock of Plaice.

Trawling experiments in the area under investigation with an otter- and a beam-trawl of the ordinary commercial patterns have given extensive information as to the distribution of fishes of different sizes, and the results obtained, when combined with those of the marking experiments, have done much towards furnishing a preliminary view of the natural history of the fishes in the southern half of the North Sea, and of the Plaice in particular, its distribution at different sizes, and the seasonal movements which it undertakes.

A series of experiments on the transplantation of small Plaice from the inshore nurseries to the open waters of the Dogger Bank in the middle of the North Sea, carried out in 1904, has thrown much new light upon the condition of the fishing grounds. The increase of weight of small plaice marked and transplanted in early spring from the crowded inshore grounds to the Dogger Bank was found in the following winter to be six times the normal increase of marked fishes of the same size left on the inshore grounds. Such a result suggests that the central grounds of the North Sea possess a larger food supply suitable for the nourishment of the Plaice than is at present made use of, and that they may therefore be capable of maintaining a much larger population of Plaice than now exists upon them, whilst on the nursery grounds owing to undue competition for the food available the Plaice are unable to attain their maximum rate of growth. Whether transplantation on a commercial scale from the small-fish grounds to the Dogger Bank or other suitable localities would be a practical method of increasing the total weight of Plaice available for capture in the North Sea is a problem concerning which further information and experiment will be required. Quite apart from this question, such a result as that already indicated is of the greatest significance for the proper understanding of the condition of the Plaice fishery and of the methods proposed for improving it by the prevention of the capture of immature fish.

Particular attention has been paid to the study of the age of fishes of particular sizes and to their rate of growth. It has now been shown that by an examination of the otoliths or ear-stones a precise estimate of the age of individual fishes can be arrived at, the otoliths showing alternate white and dark rings, the white rings formed in spring and early summer, the dark in late summer and autumn. This method has been applied in detail to a considerable number of Plaice from fishing

grounds in the North Sea and English Channel, and by its means it has been possible to form an estimate of the average rate of growth in different localities, a result which has direct bearings on many practical problems.

A large quantity of information has also been collected as to the food of fishes of different species and at different stages of their growth upon the various fishing grounds of the North Sea, the information being derived in part from the examination of the food-contents of many of the fishes captured in the trawl, and in part by an investigation of the fishing grounds with special apparatus.

### III.—Hydrographical and Plankton Investigations in the English Channel.

Before the commencement of the International Investigations it had been shown that the character of the water filling the North Sea varied greatly from season to season and from place to place. A knowledge of such changes was obviously of the first importance in seeking to understand the migrations of the fishes and the fluctuations of the fisheries. The international programme therefore provided for a co-operative study of these phenomena over the whole area under investigation. To the English investigators was assigned the study of the waters of the English Channel, which were important not only in connection with the fisheries in the Channel itself, but also as constituting one of the sources of origin of the waters of the North Sea.

It was arranged that simultaneous periodic cruises should be undertaken by the different co-operating countries, during which observations should be made at fixed stations scattered over the whole area, and that these observations should be as far as possible supplemented by others taken between the stations and in the intervals between the cruises. There are three chief kinds of evidence which, when known over an extended area, are capable of giving an indication of the course of the prevailing currents, and the probable origin of the water at any particular place. These are (1) the salinity of the water, (2) its temperature, and (3) the character of the plankton or minute floating organisms which it contains. At each of the stations visited on the periodic cruises, therefore, samples of the sea-water were collected at different depths and brought to the laboratory, where their salinity was determined; the temperature of the water at different depths was observed, and samples of the plankton were collected for subsequent examination. Intermediate samples were taken between the fixed stations, and frequent meteorological observations were also made.

Four quarterly cruises, as arranged in the international programme, were carried out in the English Channel in February, May, August, and

November, 1903, simultaneously with similar cruises undertaken elsewhere by other countries. Samples of the surface water were obtained from time to time in the periods between the quarterly cruises, chiefly through the co-operation of officers of the mercantile marine.

Complete records of the observations made on the periodic cruises have been sent to the Bureau of the International Council, and have been published in the quarterly bulletins issued by that authority.\*

The hydrographical observations during 1903 appear to show that the direction of the flow of the waters of the English Channel was from west to east, and that they were derived from a northerly current of about 35.6 per thousand salinity from the Bay of Biscay and from a southerly current of about 35.2 per thousand salinity or less from the Irish Sea and Bristol Channel. The meeting place of these waters may be roughly fixed as south of the Scilly Islands in mid-channel, and it was generally found that the salinity of the water increased as this point was passed from west to east.

Owing to the varying salinity and temperature of these two currents, it has been found that at the entrance to the Channel the water is often divided into distinct layers, whilst the changes of their relative velocity, combined with the general drift up Channel, give rise to alternate areas of high and low salinity which follow one another eastward. On the line between the Isle of Wight and Cape Barfleur the salinity has been low on all four cruises, a state of things due, in all probability, to the amount of fresh water discharged from the Hampshire basin and the Seine. The presence of denser water south of Beachy Head, however, points to the occasional passage of a high salinity current across this line.

It would appear that during the summer and early autumn of 1903 the Channel waters were derived largely from the Irish Sea, while during the rest of the year the high-salinity water of the Bay of Biscay preponderated.

The plankton observations show that a large proportion of the more oceanic organisms found off the mouth of the Channel do not penetrate for any considerable distance up Channel, even along a central axis, the percentage of oceanic species having on each cruise fallen below 40 at the stations on the line from the Isle of Wight to Cape Barfleur. When compared with those taken by other countries in the southern part of the North Sea, the observations indicate that conditions very similar to those found in the southern part of the North Sea, between a line from the Wash to Heligoland and the Straits of Dover exist in the eastern

\* *Bulletin des Résultats acquis pendant les Courses Périodiques, Conseil Permanent International pour l'Exploration de la Mer.* Année 1902-1903, Nos. 3 et 4. Année 1903-1904, Nos 1 et 2.

end of the English Channel (from the Isle of Wight to the Straits of Dover).

The results both of the hydrographical and of the plankton work suggest that during the period under investigation there was on the whole a constant passage of water from the Channel into the southern part of the North Sea, but the rate at which this passage took place must have been very slow.

In conclusion, the Council of the Marine Biological Association would take this opportunity of expressing their indebtedness to all who have assisted them during the course of these investigations, to those who have acted as their agents for the receipt of marked fish returned by the fishermen at the different ports, and more especially to the fishermen themselves, as well as to those officers of the mercantile marine who have supplied samples of sea water and taken observations of its temperature in different localities.

I am, Sir,

Your obedient Servant,

MARINE BIOLOGICAL LABORATORY,

PLYMOUTH,

2 August, 1905.

E. J. ALLEN,

*Director and Secretary to the Council.*

### List of Memoirs which accompany the above Report.

- General Report on the Fishery Investigations.* By WALTER GARSTANG, M.A. pp. 1-12.
- Report on Experiments with Marked Fish during 1902-3.* By WALTER GARSTANG. With 31 Detailed Tables, 2 Appendices, and 6 Charts. pp. 13-44.
- Experiments in the Transplantation of Small Plaice to the Dogger Bank.* By WALTER GARSTANG. With 1 Chart, 2 Illustrations in Text, and 3 Detailed Tables. pp. 45-66.
- Report on the Trawling Investigations, 1902-3, with especial reference to the distribution of the Plaice.* By WALTER GARSTANG. With 6 Figures in the Text, 2 Appendices, 4 Detailed Tables, and 2 Charts. pp. 67-198.
- Preliminary Investigations on the Age and Growth-Rate of Plaice.* By WILLIAM WALLACE, D.Sc. With Diagrams (Figs. 1-4) in Text, Tables A and B and I.-VII. in Text, and Plate I. pp. 199-226.
- Report on the Food of Fishes collected during 1903.* By R. A. TODD, B.Sc. pp. 227-288.
- Report on the Physical Conditions in the English Channel, 1903.* By DONALD J. MATTHEWS. With 6 Plates. pp. 289-324.
- Report on the Plankton of the English Channel, 1903.* By LEWIS H. GOUGH, Ph.D. With 16 Charts and 7 Figures in the Text. pp. 325-377.