

# REPORT ON INVESTIGATIONS AT THE WESTERN END OF THE ENGLISH CHANNEL.

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## HYDROGRAPHY.

The most important series of observations in the area was made during the period 1903—1909 in connection with the International Investigations. Cruises took place in February, May, August and November of each year, extending in a south-westerly direction to a station about 60 miles west of Ushant and in a north-westerly direction to the mouth of the Bristol Channel. In August 1906, and in May and November, 1909, additional stations were worked further to the westward in the neighbourhood of La Chappelle Bank. At the fixed stations temperature readings and water-samples were taken at the surface, at 5, 10, 15, 20, 30 metres and then at intervals of 10 metres to the bottom. Frequent surface observations and samples were taken whilst running between the fixed stations. All the water samples were subsequently titrated with silver nitrate, with potassium chromate as indicator, at the Plymouth Laboratory, and from the chlorine content the salinity was calculated by means of Knudsen's Tables.

In addition to the work done on these periodic cruises, many surface temperature observations were made and surface water samples taken throughout the year at the Seven Stones Lightship and on board commercial vessels traversing the area.

The results are published in the Bulletin of the International Council (8) and are discussed in a series of reports by Mr. D. J. Matthews in the Marine Biological Association's Reports on International Investigations (4, 5, 6, 7). In general the results show that a current of warm water of high salinity runs into the English Channel from the Bay of Biscay, whilst a current of cooler water of low salinity presses southwards from the Irish Channel, and the principal variations in the hydrographical conditions appear to be due to differences in the relative strengths of these two currents. There are indications of a two year

period in the results, it being probable that the high salinity water from the Bay of Biscay sets in somewhat earlier in alternate years (the »odd« years) and extends further up Channel. (7).

1. Physical Investigations. By H. N. Dickson, Journ. M. B. A. N.S. ii. 1891—92, pp. 159, 272.
2. Report on the Surface Drift of the English Channel and Neighbouring Seas for 1897. By W. Garstang, M. A. Journ. M. B. A. N. S. v. 1897—99. p. 199.
3. Notes on the Physical Conditions existing within the Line from Start Point to Portland. By H. M. Kyle, D. Sc. Journ. M. B. A. N. S. vi. 1903, p. 528.
4. Report on the Physical Conditions in the English Channel, 1903. By Donald J. Matthews. Internat. Fish. Investigations. Mar. Biol. Assoc. Report I., 1902—03 (Cd. 2670). 1905, p. 289.
5. The Surface Waters of the North Atlantic Ocean, South of 60° N. Latitude, September, 1904, to December, 1905. By Donald J. Matthews. Internat. Fish. Investigations. Mar. Biol. Assoc. Report II. Part. I. 1904—05. (Cd. 3837). 1907, p. 269.
6. Report on the Physical Conditions in the English Channel and Adjacent Waters, 1904 and 1905. By Donald J. Matthews. Internat. Fish. Investigations. Mar. Biol. Assoc. Report II. Part 2, 1904—05 (Cd. 4641). 1909, p. 279.
7. Report on the Physical Conditions in the English Channel and Adjacent Waters, 1906, with a Note on the Mean Conditions for 1903—1909. By Donald J. Matthews. Internat. Fish. Investigations. Mar. Biol. Assoc. Report III. 1906—08 (Cd. 5546). 1911, p. 269.
8. Conseil permanent international pour l'exploration de la mer. Bulletin des résultats acquis pendant les courses périodiques publié par le bureau du conseil. Bulletin Hydrographique. 1903—1909.
9. ditto. Année 1906—1907. Partie supplémentaire. Contenant résumé de l'hydrographie des mers explorées par le conseil; avec 23 planches donnant les moyennes de la salinité et de la température de la mer du nord.
10. Conseil permanent international pour l'exploration de la mer. Rapports et Procès-Verbaux des Réunions. Volume VI. 1905—06. The Salinity of the North Sea and adjacent waters calculated on the basis of Observations from the period August, 1902 — May, 1905. With 15 plates. By Martin Knudsen and Miss Kirstine Smith.
11. Report on the Sea and Inland Fisheries of Ireland for 1904. Hydrographical Observations at Irish Light Stations, 1904. (Salinities). By D. J. Matthews.

### PLANKTON.

During the hydrographical cruises described in the last section plankton samples were collected at each station by means of vertical and horizontal townets made of silk of different sized mesh. These collections were examined and the species identified, a rough determination of the relative proportions of each species in each sample being given by the use of the usual international signs. The results were published in the Plankton tables of the International Bulletin (15) and in papers by Gough and Bygrave in the Marine Biological Association's Reports on International Investigations (12, 13, 14). As a result of this work it may be said that a fairly complete knowledge of the qualitative nature of the plankton of the area has been gained and of the general distribution of individual species. The relative distribution of oceanic and neritic species was specially studied. In some cases also information as to distribution in depth was obtained. Of special interest for the area is the account of the distribution of *Muggiaea atlantica* in 1904 given by Gough in Publications de Circonstance, No. 29. (19). Recently the microplankton has been specially studied in the neighbourhood of Plymouth, (see Lebour (20), Allen (21).

12. Report on the Plankton of the English Channel, 1903. By Lewis H. Gough, Ph. D. Internat. Fish. Investigations. Mar. Biol. Assoc. Report I. 1902-03 (Cd. 2670). 1905, p. 325.
13. Report on the Plankton of the English Channel in 1904 and 1905. By Lewis H. Gough, Ph. D. Internat. Fish. Investigations. Mar. Biol. Assoc. Report II. Part 1, 1904-05 (Cd. 3837). 1907, p. 165.
14. Report on the Plankton of the English Channel in 1906. By W. Bygrave, B. A. Internat. Fish. Investigations. Mar. Biol. Assoc. Report III. 1906-08 (Cd. 5546). 1911, p. 235.
15. Conseil permanent international pour l'exploration de la mer. Bulletin des résultats acquis pendant les courses périodiques, publié par le bureau du conseil. Bulletin Planktonique. 1903-1909.
16. Conseil permanent international pour l'exploration de la mer. Bulletin trimestriel des résultats acquis pendant les croisières périodiques et dans les périodes intermédiaires. Résumé des observations sur le plankton des mers explorées par le conseil pendant les années 1902-1908. Première Partie, 1910. Deuxième Partie, 1911. Troisième Partie, 1913.
17. Conseil permanent international pour l'exploration de la mer. Publications de Circonstance No. 33. Catalogue des espèces de plantes et d'animaux observées dans le plankton recueilli

pendant les expéditions périodiques depuis le mois d'août 1902 jusqu'au mois de mai 1905. Publié par le bureau, avec la coopération (pour le plankton végétal) de C. H. Ostenfeld.

18. Conseil permanent international pour l'exploration de la mer. Publications de Circonstance No. 48. Catalogue des espèces de plantes et d'animaux observées dans le plankton recueilli pendant les expéditions périodiques depuis le mois d'août 1905 jusqu'au mois de mai 1908. Publié par le bureau, et rédigé par C. H. Ostenfeld, pour le zooplankton avec la coopération de C. Wesenberg-Lund.
19. Conseil permanent international pour l'exploration de la mer. Publications de Circonstance No. 29. On the Distribution and the Migrations of *Muggiaea atlantica*, Cunningham, in the English Channel, the Irish Sea, and off the South and West Coasts of Ireland, in 1904. By Lewis Henry Gough. With 3 charts and 2 figs.
20. The Microplankton of Plymouth Sound from the Region beyond the Breakwater. By M. V. Lebour. Journ. M. B. A. N. S. XI. 1916—18. p. 133.
21. A Contribution to the Quantitative Study of Plankton. By E. J. Allen. Journ. M. B. A. N. S. XII. 1919, p. 1.

### BOTTOM FAUNA AND DEPOSITS.

Much work has been done in the detailed description of the distribution of the bottom fauna and the nature of the bottom deposits in the area. The fauna in the immediate neighbourhood of Plymouth has been dealt with in great detail (29), special investigations have been made along the 30 fathom line from the Eddystone to Start Point (24, 25), and near the 40 fathom line south of the Eddystone. (28, 27, 26). In August, 1906, a number of stations were worked in deep water to the westward of Ushant in the neighbourhood of La Chappelle Bank, and the results are dealt with in a series of papers in the Journal of the Marine Biological Association. (56, 34, 35, 36, 37, 38, 39, 40, 41).

22. Report of a Trawling Cruise in H. M. S. Research off the South-west coast of Ireland. By G. C. Bourne, M. A, with addendum by the Rev. Canon Norman, F. R. S. Journ. M. B. A. N. S. i. 1889—90, p. 306.

23. Notes on the Echinoderms collected by Mr. Bourne in Deep Water off the South-west of Ireland in H. M. S. Research. By F. Jeffrey Bell, M. A. Journ. M. B. A. N. S. i. 1889—90, p. 324.
24. On the Fauna and Bottom-deposits near the 30-fathom line from the Eddystone to Start Point. With seven Tables and sixteen Charts. By E. J. Allen, B. Sc. Journ. M. B. A. N. S. V. 1897—99, p. 365.
25. The Bottom Deposits of the English Channel from the Eddystone to Start Point near the 30-fathom line. By R. H. Worth. Trans. Devon. Assoc. XXXI. 1890, p. 356.
26. On Rock Remains in the Bed of the English Channel. An Account of the Dredgings carried out by S. S. Oithona in 1906. By L. R. Crawshay, M. A. Journ. M. B. A. N. S. viii. 1907—10, p. 99.
27. The Dredgings of the Marine Biological Association (1895—1906), as a Contribution to the Knowledge of the Geology of the English Channel. By R. Hansford Worth, Journ. M. B. A. N. S. viii. 1907—10, p. 118.
28. On the Fauna of the Outer Western Area of the English Channel. By L. R. Crawshay, M. A. Journ. M. B. A. N. S. ix. 1910—13, p. 292.
29. Plymouth Marine Invertebrate Fauna: Being Notes of the Local Distribution of Species occurring in the Neighbourhood. Compiled from the Records of the Laboratory of the Marine Biological Association. Journ. M. B. A. N. S. vii. 1904—06, p. 155.
30. The Fauna of the Salcombe Estuary. By E. J. Allen, D. Sc., and R. A. Todd, B. Sc. Journ. M. B. A. N. S. vi. 1900, p. 151.
31. The Fauna of the Exe Estuary. By E. J. Allen, D. Sc. and R. A. Todd, B. Sc. Journ. M. B. A. N. S. vi. 1902, p. 295.
32. Polychaeta of Plymouth and the South Devon Coast, including a List of the Archiannelida. By E. J. Allen, D. Sc. Journ. M. B. A. N. S. X. p. 592. 1913—15.
33. Notes on the Invertebrate Fauna and Fish-food of the Bays between the Start and Exmouth. By R. A. Todd, B. Sc. Journ. M. B. A. N. S. vi. 1903, p. 541.
- 34a. The Mollusca collected by the Huxley from the North Side of the Bay of Biscay in August, 1906. By Alexander Reynell. Journ. M. B. A. N. S. viii. 1907—10, p. 359.
- 34b. The Brachiopoda collected by the Huxley from the North Side of the Bay of Biscay, in August 1906. By Alexander Reynell. Journ. M. B. A. N. S. viii. 1907—10. p. 392.
35. The Decapoda collected by the Huxley from the North Side of the Bay of Biscay in August, 1906. By Stanley Kemp, B. A. Journ. M. B. A. N. S. viii. 1907—10. p. 407.
36. The Amphipoda collected by the Huxley from the North Side of the Bay of Biscay in August, 1906. By E. W. Sexton. Journ. M. B. A. N. S. ix. 1910—13, p. 199.

37. Notes on some Amphipoda from the North Side of the Bay of Biscay. Families Pleustidae and Eusiridae. By E. W. Sexton, Proc. Zool. Soc., 1909, p. 848.
38. The Schizopoda and Isopoda collected by the Huxley from the North Side of the Bay of Biscay, in August 1906. By W. M. Tattersall, M. Sc. Journ. M. B. A. N. S. viii. 1907—10, p. 189.
39. The Echinoderms collected by the Huxley from the North Side of the Bay of Biscay in August 1906. By W. De Morgan. Journ. M. B. A. N. S. ix. 1910—13, p. 530.
40. The Alcyonaria, Antipatharia, and Madreporaria collected by the Huxley from the North Side of the Bay of Biscay in August, 1906. By Prof. S. J. Hickson, M. A., F. R. S. Journ. M. B. A. N. S. viii. 1907—10, p. 6.
41. The Hydroids collected by the Huxley from the North Side of the Bay of Biscay in August, 1906. By E. T. Browne, Journ. M. B. A. N. S. viii. 1907—10, p. 15.

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### PELAGIC FISHES.

*Mackerel.* The spring mackerel fishery at the mouth of the English Channel is of great importance and has been the object of considerable work. Reference may be made to the papers by Allen (50) on the habits and migrations of this fish and Garstang (51) on the races. Bullen (52) has studied the food of the mackerel and the relation of plankton distribution to the mackerel fisheries. Allen (53) has suggested a relation between the abundance of mackerel in May and the amount of sunshine in the district earlier in the year. Notes on the young stages of mackerel will be found in several of the papers considered in the next section of this report.

*Herring.* The principal herring fishery in the Plymouth district takes place in December and January, when spawning shoals come into the bays to the eastward of the port. Material for a study of the race of these fish has been collected on a large scale by Orton (48).

*Pilchard.* The life history, reproduction and development of this fish was studied by Cunningham (43, 44, 45, 46), who first described the larval stages. Although young pilchards suitable for the manufacture of sardines have been found in the English

Channel they have never been obtained in sufficient numbers to establish a local sardine industry.

*Anchovy.* The occurrence of anchovies in the western part of the English Channel has been frequently demonstrated (see Cunningham (42)) but attempts to capture the fish on a commercial scale have not been successful.

42. The Migration of the Anchovy. By J. T. Cunningham, M. A. Journ. M. B. A. N. S. iii. 1893—95, p. 300.
43. The Spawn of the Pilchard. By J. T. Cunningham, M. A. Journ. M. B. A. Old Series No. 2. 1888, p. 247.
44. The Reproduction and Growth of the Pilchard (with Plate X). By J. T. Cunningham, M. A. Journ. M. B. A. N. S. 1891—92, p. 151.
45. Year-old Pilchards. By J. T. Cunningham, M. A. Journ. M. B. A. N. S. ii. 1891—92, p. 393.
46. The Life History of the Pilchard. By J. T. Cunningham, M. A. Journ. M. B. A. N. S. iii. 1893—95, p. 148.
47. The Capture of Small Pilchards for the Sardine Industry. By J. T. Cunningham.  
Fishing with small meshed nets for small Pilchards. By J. T. Cunningham. Cornwall County Council. Report of the Lecturer on Fishery Subjects. Years 1898—99 and 1899—1900.
48. An Account of the Researches of Races of Herrings carried out by the Marine Biological Association at Plymouth, 1914—15. By J. H. Orton. Journ. M. B. A. N. S. XI. 1916—18, p. 71.
49. The Plymouth Mackerel Fishery of 1880—90. From data collected by W. Roach, Associate M. B. A. By W. L. Calderwood. Journ. M. B. A. N. S. ii. 1891—92, p. 4.
50. Report on the Present State of Knowledge with Regard to the Habits and Migrations of the Mackerel (*Scomber scomber*). By E. J. Allen, B. Sc. Journ. M. B. A. N. S. v. 1897—99, p. 1.
51. The Variations, Races, and Migrations of the Mackerel. By W. Garstang, M. A. Journ. M. B. A. N. S. v. 1897—99, p. 235.
52. Plankton Studies in Relation to the Western Mackerel Fishery. By G. E. Bullen. Journ. M. B. A. N. S. viii. 1907—10, p. 269.
53. Mackerel and Sunshine. By E. J. Allen, D. Sc. Journ. M. B. A. N. S. viii. 1907—10, p. 394.
54. Some Notes upon the Feeding Habits of Mackerel and certain Clupeoids in the English Channel. By G. E. Bullen. Journ. M. B. A. N. S. ix. 1910—13, p. 394.
55. The Scientific and Economic Aspects of the Cornish Pilchard Fishery. I. The Food and Feeding Habits of the Pilchard in Coastal Waters. II. The Plankton of the Inshore Waters in 1913 considered in relation to the Fishery. By Harold Swithinbank and G. E. Bullen. Mera Publications Nos. 1 and 2.

56. The Fishes collected by the Huxley from the North Side of the Bay of Biscay in August, 1906. By L. W. Byrne. *Journ. M. B. A. N. S.* viii. 1907—10, p. 1.

### EGGS, LARVAE AND YOUNG STAGES OF FISHES.

Earlier work on the eggs and larvae of fishes from the district is summarised by Cunningham in his book on Marketable Marine Fishes (57). Since that book was published in 1896 continued attention has been given to the subject by Scott (58), Holt (59, 60, 61), Balfour Browne (62) and Hefford (63), so that it may now be said that the eggs and larvae of practically all our common fishes are well known. In recent years the post-larval and young adult stages have been specially studied and accounts of them published by Clark (64) and Allen (65). An account of the food and feeding habits of these stages, in which it is shown that at a very early age the young fishes select particular kinds of food from the plankton, has been published by Lebour. (66, 67).

57. The Natural History of the Marketable Marine Fishes of the British Islands. Prepared by order of the Council of the Marine Biological Association especially for the use of those interested in the Sea-Fishing Industries, By J. T. Cunningham, M. A. With a preface by E. Ray Lankester, M. A., LL. D., F. R. S. London: Macmillan and Co., Ltd., 1896.
58. A Record of the Teleostean Eggs and Larvae observed at Plymouth in 1897. By E. W. L. Holt and S. D. Scott, B. A. *Journ. M. B. A. N. S.* v. 1897—99, p. 156.
59. Preliminary notes on the Reproduction of Teleostean Fishes in the South-Western District. By E. W. L. Holt. *Journ. M. B. A. N. S.* v. 1897—99, p. 41.
60. Notes on the Reproduction of Teleostean Fishes in the South-Western District. By E. W. L. Holt and L. W. Byrne, B. A. *Journ. M. B. A. N. S.* v. 1897—99, p. 333.
61. Notes on the Reproduction of Teleostean Fishes in the South-Western District. By E. W. L. Holt. *Journ. M. B. A. N. S.* v. 1897—99, p. 107.
62. Report on the Eggs and Larvae of Teleostean Fishes observed at Plymouth in the Spring of 1902. By F. Balfour Browne, M. A. *Journ. M. B. A.* vi. 1903, p. 598.
63. Notes on Teleostean Ova and Larvae observed at Plymouth



- in Spring and Summer, 1909. By A. E. Hefford, B. Sc. Journ. M. B. A. N. S. ix. 1910—13, p. 1.
64. General Report of the Larval and Post-Larval Teleosteans in Plymouth Waters. By R. S. Clark. M. A. Journ. M. B. A. N. S. X. p. 327. 1913—15.
65. Post-Larval Teleosteans collected near Plymouth during the Summer of 1914. By E. J. Allen. Journ. M. B. A. N. S. XI. 1916—18, p. 207.
66. The Food of Post-larval Fish. By M. V. Lebour. Journ. M. B. A. N. S. XI. 1916—18, p. 433.  
The Food of Post-larval Fish. No. II. (1918), by M. V. Lebour. Journ. M. B. A. N. S. XII. 1919, p. 22.
67. Feeding Habits of Some Young Fish. By M. V. Lebour. Journ. M. B. A. N. S. XII. 1919, p. 9.

### APPARATUS AND METHODS.

A description of the principal methods and kinds of apparatus employed by the Plymouth Marine Laboratory will be found in the handbook issued by the Challenger Society entitled *Science of the Sea*. (68).

68. *Science of the Sea. An Elementary Handbook of Practical Oceanography for Travellers, Sailors, and Yachtsmen.* Prepared by the Challenger Society, Edited by G. Herbert Fowler. London, John Murray. 1912.

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