THE HYDROGRAPHY OF THE NORTH SEA AND ADJACENT WATERS.

THE fourth report of the North Sea Fisheries Investigation Committee contains a number of papers on hydrographical researches in the northern part of the North Sea and the Færöe-Shetland channel which are of special interest, inasmuch as they provide a *résumé* of the work done since the committee began its labours, and a statement of certain results and conclusions which may now be accepted as definitely established and used as standards for comparison with future observations. These papers are:—(1) and (6) on hydrographical investigations in the North Sea and Færöe-Shetland channel during the years 1906–7–8, by Dr. A. J. Robertson; (2) on the temperature of the surface waters of the North Sea during the years 1906 and 1907, by Mr. Frank G. Young; (3) on the salinity of the North Sea, and (4) on surface-temperature observations between Hull and Hamburg during the years 1877–83, by Prof. D'Arcy Thompson; and (5) on the deep currents of the North Sea as ascertained by experiments with drift bottles, by Captain C. H. Brown. Dr. Robertson discusses the observations made during the periodic cruises executed by the SS. *Goldseeker* on lines laid down by the International Council. Mr. Young subjects to harmonic analysis temperature observations made by captains of passenger steamers and officers in charge of certain lightships and lighthouses. Prof. D'Arcy Thompson reviews in his first paper a long record of surface-temperature observations made between Hull and Hamburg by Captain W. Barron, and examines the relation of the sea temperature in the southern part of the North Sea to the air temperature of the adjacent coasts, and in his second paper gives an account of the mean values of salinity in the waters of the North Sea—the general distribution of salinity, its mean periodic variation, and the epochs of maximal and minimal salinity. Captain Brown reports upon experiments with the drift bottle devised by Mr. G. P. Bidder, which is so constructed as to float a few inches above the sea bottom, being carried along by the bottom current, and in the course of time scooped up by a trawl-net or found stranded on a beach.

In the summary which concludes his report on the observations of 1906, Dr. Robertson makes use of the results obtained by the other investigators, and lays down certain general rules. Tidal action is sufficiently active in the southern part of the North Sea to effect a thorough mixing of waters from surface to bottom; hence over this area, the northern boundary of which, by the way, seems somewhat uncertain in position, surface observations alone will henceforth be deemed sufficient. In the northern section the conditions are altogether different, and no uniformity exists in the surface to bottom distribution. Over the North Sea area the temperature decreases from the shore to the open sea in summer and increases in winter. In summer the warmest water (15° to 18° C.) occurs along the Belgian and Dutch coasts, and the coldest in the deep channel off Norway, while in winter the coldest water is, as a rule, along the Danish coast (2° to 3° C.), and the warmest between Scotland and Shetland (7° C.). The greatest annual variation at the surface occurs along the Belgian, Dutch, and German coasts, where it amounts to 13°, while between Scotland and Shetland it is some 9° less. In the deeper layers over the northern area of the North Sea the value is only 1°, while the smallest variation of all takes place in the deepest parts of the Skagerak, where it amounts to only 0·2°.

Mixing by tidal currents is so strong that water of less salinity than 33 per mille is rarely found more than a few miles from shore; over the North Sea area the variations in salinity are greatest at the surface, and the greatest mean deviation from the average occurs where salinity is lowest. In the northern area the variation seldom exceeds 0·2 per mille. The changes in salinity are thus too small to have any direct effect upon the occurrence or wanderings of food-fishes; they are mainly of interest as a guide in studying the movements of the waters.

Much information has been acquired with regard to the general circulation of the waters within the area, and the extent to which this undergoes changes of periodic and irregular kinds. Large volumes of Atlantic water are normally streaming northward as a surface current through the Færöe-Shetland channel into the Norwegian Sea, comparatively little entering the Norwegian Sea between Færöe and Iceland, where the east Iceland current comes southwards. Under exceptional conditions Polar water extends far enough south to enter the regions of the channel. (Dr. Robertson cites 1908 as one in which this occurrence was very well marked, and it was observed in 1902, as appears from Dr. Wolfenden's observations [*Geographical Journal*, April, 1903] and Dr. Robertson's report to the North Sea Committee, 1902–3 [p. 11]. The conditions observed by H.M.S. *Jackal* in 1893 were also probably somewhat similar.) The deeper layer north of the Wyville Thomson ridge is normally flooded with cold water of salinity 34·9 per mille, which is in direct connection with the bottom area of the Norwegian Sea, but in the southern parts of the channel at least these bottom layers are occasionally displaced by warmer and salter water, showing that marked changes may occur even at the greatest depths. (This also appears, from Dr. Wolfenden's observations, in the summer of 1900.)

Between the Færöes and Fair Isle the centre of the Atlantic stream is situated between 3° and 5° west longitude, where the mean annual temperature is 9·5° C. and salinity 35·29 per mille. Within the regions of the channel its direction of flow varies from north-east to east, and the speed of the surface waters apparently averages about fourteen miles in twenty-four hours. Branches are thrown off which enter the North Sea round the north and south of Shetland, and of these the latter is certainly subject to seasonal variation. A scanty winter salt-water distribution is normally followed by more vigorous inflow during early spring, increasing to a maximum in the beginning of summer, and gradually decreasing again on the approach of the following winter. As exceptional seasons, Dr. Robertson quotes (1) the winter 1905–6, when an unusually powerful Atlantic inflow took place; (2) the summer of 1907, when the maximum inflow was unduly delayed; and (3) the whole of 1908, when the inflow was very scanty.

The greater proportion of the Atlantic water entering the northern part of the North Sea area bends eastward before reaching the 57th parallel of latitude, and after throwing off a branch which enters the Skagerak as an undercurrent is carried back northwards. This rotational movement, due to the configuration of the bottom, gives rise to a cold, deep-water area, an area with a great temperature phase delay over which the maximum value in the bottom layers is not reached until near the close of the year. (This layer appears in the *Jackal* observations, 1893.) A fresh-water current continually streams northward along the Norwegian coast, being exclusively confined to the in-shore regions during the winter months, but extending in summer far out to sea as a thin surface layer; similar movements occur in summer off the Scottish coast.

From the above summary of Dr. Robertson's conclusions it appears that the normal distribution and circulation of the waters in the North Sea area may now be regarded as definitely known. The departures from the normal are, as was supposed, very considerable, but it would seem that the years 1905–6 and 1908 may be taken as representing the nature of the extreme variations which are likely to occur, and it is noteworthy that the older observations of H.M.S. *Jackal* and other vessels indicate conditions which, while showing some abnormal features for the years to which they refer, agree satisfactorily with the more recent and more adequate work as regards the type of distribution and general movement, and fall within the limits of departure from that type which they have themselves recorded.

H. N. DICKSON.

THE THOMSEN MEMORIAL LECTURE.[1]

AMONG the Danes whose names are inscribed as men of science on the eternal bead-roll of fame, that of Julius Thomsen stands pre-eminent—linked indeed with that of Oersted. It is significant of the position which Thomsen acquired in physical science, and of the respect which that position secured for him in the eyes of his countrymen, that his statue should have been erected during his lifetime

[1] Delivered before the Chemical Society on February 17, by Sir Edward Thorpe, C.B., F.R.S., past-president of the Society.