line as far as the Lena, then spread southward into the Amur Valley; it thus reached the sea of Okhotsh, whence one coast ran southward across Japan, and the other eastward to Alaska. From many Arctic localities these Triassic rocks are rich in fossils; but the fauna of the Triassic Arctic Ocean is so different from that of the contemporary Mediterranean Sea, that it is doubtful whether there was any direct connection between them.

After the close of the Trias there is a considerable gap in the annals of the Arctic Ocean. When the record is resumed in the middle and upper parts of the Jurassic period, we find that the sea has either again grown very considerably, or has materially shifted its position. Thus the sea, instead of ending near Spitsbergen, has encroached to Greenland on the west, and extended southward to the Lofoten Islands, to southern Sweden and to England, France and Germany; and further east a series of gulfs ran southward up the valleys of the Petchora, Obi, Yenesei, and the Lena. The Jurassic Arctic Ocean, therefore, appears to have been connected with whatever sea there may then have been in the North Atlantic; but, unlike its Triassic predecessor, it was separated from the Pacific by a broad belt of land.

In the succeeding Cretaceous period we get the last geological proof of an Arctic Ocean before that of the existing period. The sea had receded in the Old World, but it had gained considerably in America; for marine Cretaceous deposits occur in Central British North America, and the sea seems to have entered that area by the Mackenzie River depression. In the Tertiary era all the positive evidence relates to land conditions, excepting some obscure fossils in one or two localities, and some patches of Miocene shell-beds bordering the Pacific, as on the shores of the sea of Okhotsh. The Arctic Ocean therefore appears to have shrunk very considerably, and the land areas to have once again broken up the basin of the northern sea.

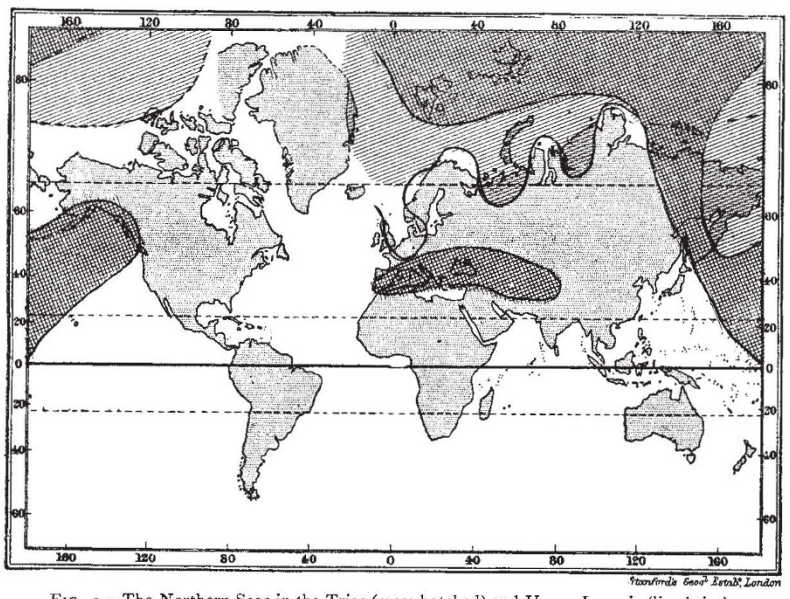

FIG. 3.—The Northern Seas in the Trias (cross-hatched) and Upper Jurassic (lined tint). [In Eastern Asia, the lined area should not come south of the broken line in lat. 75°.]

A general summary, therefore, of the facts of Arctic geology show that the Arctic Ocean has varied greatly, both in position and size. The Arctic Basin is at the present time bounded by a rim of land which is supported by five great blocks of Archean rocks; these blocks form, respectively, Scandinavia and North-western Russia; Labrador and North-eastern British America; Greenland; Alaska and North-eastern Asia; and the Archean block of Central Siberia. These Archean blocks were each more or less completely surrounded by bands of sedimentary rocks. At least two of them have never been below sea-level; and there is no satisfactory evidence to prove that the other blocks have been submerged, at least, since Middle Palæozoic times. In fact, the geological history of the Arctic Basin is the record of the alternate enlargement and diminution of the Arctic seas by the elevation and depression of parts of the bands of sediments, which surround the Archean blocks. The blocks themselves are of great geological antiquity, and the successive earth movements have been moulded upon them. As the main nuclei of the great land masses of the Arctic regions are therefore of vast antiquity, it may be thought only reasonable to assume an equally great age for the central ocean basin. But if we look at a map of the Polar regions showing the strike of the rocks and the trend of the mountain chains, we see that these all run north and south, and end abruptly on the margin of the Polar Basin. This meridianal trend occurs in the branch of the Rocky Mountains that forms the western boundary of the Mackenzie River, in the Archean axes of Boothia and Melville Peninsula, in the strike of the rocks of Northern Greenland and Western Spitzbergen. In Asia it is particularly well shown by the Ural and Verkhanoysk Mountains and their respective geological continuations, Nova Zemlya and the New Siberian Islands, and by the parallel chains between the Lena and Behring Straits.

Analogy with similar truncated mountain lines elsewhere renders it probable that all the mountain ranges, having what von Tol calls a "Ural orientation," once extended further to the north. If they did so, they would have effectually broken up the existing Polar Basin. At the present time our knowledge is insufficient for a final conclusion. But the evidence of the historical geology, physical structure and earth movements of Arctic lands are all consistent with the origin of the Arctic Basin as a great area of subsidence (a "senkungsfeld" of Suess) later than the deposition of the lower Tertiary plant beds. The geological facts attest such great geographical changes in that region, that geologists are not at present bound to abandon helpful explanations, which are in themselves probable and are in harmony with the geological evidence, simply because they may be inconsistent with the permanence of the Arctic Basin.

J. W. GREGORY.

SCIENTIFIC INVESTIGATIONS OF THE SCOTTISH FISHERY BOARD.

THE third part of the Fifteenth Annual Report of the Fishery Board for Scotland, dealing with the principal scientific investigations conducted under the auspices of the Board in 1896, has just been published. The work done may be judged from the subjoined summary, which is abridged from the general statement prefixed to the detailed reports on the investigations carried out.

In the course of the year, the investigations which were carried on under the supervision of the Scientific Superintendent, Dr. Wemyss Fulton, were prosecuted on the same general lines as in previous years, and have resulted in further extensions of knowledge respecting the life-history and habits of the food fishes, and by the physical conditions and changes in the sea which bear upon fishery problems. Special attention was given to certain hydrographical questions concerning the circulation of the water in the North Sea and the adjacent parts of the North Atlantic. In addition to such inquiries, the hatching and artificial propagation of some of the important food fishes have been continued at the Board's Marine Hatchery at Dunbar.

One of the most important results of the work has been to show that the food fishes which form the basis of the fishing industry—such as plaice, cod, haddock, ling, turbot, &c.—do not spawn on the east coast within the three-mile limit, as was previously supposed. On the other hand, it is not known at what distances from the shore or in what precise localities the spawning areas are chiefly situated. It would obviously be of great advantage to obtain accurate information on this subject, and to be able to map out on a chart the regions where the various species of the food fishes spawn.

THE INFLUENCE OF BEAM TRAWLING.

The results of the trawling experiments carried on in 1896, together with the tables embodying the details of the observations, are given in a special report. The trawling experiments have for the present been suspended in the Firth of Forth and St. Andrews Bay, where they were most systematically and regularly conducted for a number of years. The general results, so far as concerns the most important subject of the experiments in these waters, the increase or decrease in the abundance of the food fishes since beam trawling was prohibited, showed that while the relative numbers of most of the round-fishes, such as cod and haddock, and the unimportant flat-fishes, the dabs, had slightly increased, there was a decrease among the more valuable flat-fishes, the plaice and lemon sole, a circumstance probably due to the increased trawling in the offshore areas where these fishes spawn.

THE HATCHING AND REARING OF FOOD FISHES.

In previous reports, detailed descriptions were given of the methods and processes adopted at the Dunbar Hatchery in connection with the artificial propagation of marine food fishes. Operations have been conducted for the most part with the valuable flat-fishes, especially the plaice, but also the turbot, sole, and lemon sole, and also on a lesser scale with certain round-fishes, such as the cod and haddock. The total number of the various species which have been hatched and placed on the fishing grounds since the work was begun in 1894 is 92,920,000.

During the current season (1897) the artificial propagation of plaice is being proceeded with on a large scale, but owing to the earlier publication of the annual report this year, it was not possible to give a statement of the results of the work, which is still in progress. As mentioned in last year's report, the fry produced in the hatchery are being transferred to certain sea-lochs, which are, to a large extent, cut off from free communication with the open sea, and observations are being made to test the results on the relative abundance of the same species within the areas selected.

The hatching work has hitherto been much impeded by the want of suitable ponds or enclosures of sea-water in which the adult spawners could be retained from one season to another, and by means of which it would be possible to retain the fry until towards the close of the post-larval stage, when they begin to assume the form and habits of the adult, and are in a much better condition to successfully meet the influences tending towards their destruction. The present report contains a paper by Mr. Harald Dannevig, giving the results of experiments he has made with the view of ascertaining the methods by which this may be accomplished. Some of the fry of the plaice which were hatched in the establishment were kept in suitable vessels of unfiltered water, to which tow-net collections—that is to say, the gatherings of minute organisms found naturally in sea-water—were added. By this means the fry were reared through their post-larval stages, until they had undergone their transformation into little plaice and settled on the bottom. Their food consisted to a small extent of diatoms, and chiefly of minute crustaceæ and larval molluscs.

These experiments point to a method by which the utility of artificial propagation might be considerably extended, namely, by retaining the fry for a few weeks in suitable enclosures of sea-water before they are transferred to the sea.

THE CURRENTS IN THE NORTH SEA AND THEIR RELATION TO FISHERIES.

In recent years, the attention of a number of investigators has been directed to the hydrography of the North Sea, and several inquiries and series of observations have been made with the object of determining its principal physical conditions with especial relation to the movement of its waters. During the last two years and a half some thousands of drift-bottles have been thrown into various parts of the North Sea, about five hundred of which have been recovered, and from careful comparison of the course taken, combined with a study of the prevailing winds throughout the period, it has been possible to ascertain the general circulation of the surface water. The results are given in a paper in the present report by Dr. Wemyss Fulton, who shows (1) that surface water passes into the North Sea from the Atlantic round the north of Scotland and in the neighbourhood of the Orkney and Shetland Isles, and then moves southwards along the east coast of Scotland and England to the neighbourhood of the Wash; (2) that it then travels in an easterly direction towards the coast of Denmark, and then northwards to the Skagerak, which it may or may not enter, and finally passes northwards along the west coast of Norway, at least as far as the Loffoden Islands.

Drift-bottles were found scattered along a stretch of about 1700 miles of coast, in Scotland, England, Holland, Germany, Denmark, Sweden, and Norway, between 53° and 69° N. latitude.

A detailed study of the winds prevailing during the time the experiments were in progress, based upon over 12,000 observations, appears to show that this circulation of the surface water in the North Sea is principally due to the preponderance of south-westerly and westerly winds, which tend to heap up the surface water on the western or continental coasts, when, as it cannot escape southwards owing to the shallows and the narrow orifice of the Channel, it passes to the north; but subsidiary influences may aid the movement. For some weeks last winter, owing to prolonged gales and strong winds, first from a south-easterly and then from a north-easterly direction, the circulation was reversed, the surface water passing rapidly northwards along our east coast, from Norfolk to the Shetlands.

The main object of the experiments was to determine the part taken by the surface currents in transporting the floating eggs and larvæ of the food fishes from the great spawning areas lying off the coast to the territorial waters and inshore grounds. It is shown that as the normal current moves along our east coast in a southerly direction at a mean rate of about two or three geographical miles a day, and as the floating eggs, according to the species and the season, take from about a week to over three weeks to hatch, and the larvæ are exposed for some weeks additional to the action of the current, they may be carried for very considerable distances from the place where they are spawned.

From a study of the mean temperature of the surface waters off the east coast of Scotland in each month throughout the spawning season, namely, from January to August, and of the duration of the development of the embryonic fishes within the eggs of the various species at such temperature, it is shown that the spawning grounds of early spawners, as the cod, haddock, and especially the plaice, may be normally situated more than fifty or sixty miles to the north of the locality where the young fishes are found. With summer spawners, on the other hand, whose eggs develop with much greater rapidity, owing to the higher temperature of the surface waters, the distance between the spawning area and the "nurseries" of the young fishes is much less. The spawning areas off a particular part of the coast do not normally supply the inshore waters opposite to them, but those situated further south; thus, for example, the breeding grounds off the coasts of Forfarshire and Kincardine stand in relation to St. Andrews Bay and the Firth of Forth, while the breeding grounds situated to the east of the latter stand in relation to the coasts of Berwickshire and Northumberland.

It is shown that the southward drift of the floating eggs and larvæ of the plaice is in agreement with the migratory movement of the adults and growing fish, which is in the opposite, or northerly, direction.

The easterly surface drift from the neighbourhood of the Dogger Bank also tends to explain the enormous aggregation of immature flat-fishes in the great bight between the north coast of Holland and the coast of Denmark. The southerly drift is not improbably related to the movements of the herring shoals during summer and autumn, but the connection has not yet been thoroughly investigated.

THE LIFE-HISTORIES AND DEVELOPMENT OF THE FOOD FISHES.

Prof. M'Intosh describes the life-histories of the cod, haddock, and whiting from very early stages. It is shown that, while the spawning grounds of the cod are offshore, the eggs and larvæ are wafted inshore, or that the post-larval stage is attained in the former region, the young fish moving shorewards subsequently, when from about half an inch to three-quarters of an inch in length. During June and July they frequent the shallow rock-pools at ebb-tide in company with the green-cod or saithe, and as they grow older many of them pass outwards again to the off-shore waters. Young haddocks have a different distribution from the young cod, and are found in the deeper water at a distance from shore, as appears also to be the case with the

younger stages of the whiting. The appearance and diagnostic characters of the various stages, which have frequently been difficult to distinguish in the past, are described very fully, and are illustrated by a series of figures.

THE DISTRIBUTION OF PELAGIC EGGS.

Mr. A. T. Masterman furnishes a review of the work done by the *Garland* in connection with the distribution of the pelagic eggs of food fishes in the years 1890-96, with special reference to the determination of the spawning areas and seasons of the various species and the direction taken by the eggs after they are shed. The observations made in the Firth of Forth and St. Andrews Bay throughout the above period are brought together and compared, lists being furnished of the principal species dealt with. The more important conclusions drawn from the study of the distribution of the pelagic eggs agree with those previously derived from the investigations into the distribution of spawning adults, namely, the season at which the various species spawn, and the place where the eggs are shed. It is shown that the more valuable forms, such as the cod, haddock, plaice, coal-fish, turbot and ling, spawn outside the three-mile limit, the floating eggs appearing first at the seaward stations and being gradually drifted in; on the other hand, less important species, such as the gurnard, flounder, and dabs, spawn within the limit as well as beyond it, and the sprat spawns principally within the limits of the Firth of Forth.

THE REARING OF LARVAL AND POST-LARVAL PLAICE AND OTHER FLAT-FISHES.

In connection with the artificial propagation of the food fishes a series of experiments were made by Mr. H. Dannevig in the rearing of the young fishes derived from the artificially fecundated eggs, which have yielded results of scientific interest. The natural food of the early post-larval plaice has been determined, and also the duration of the larval and post-larval periods. It was found that the larvæ from plaice eggs which were fertilised on April 28 and hatched on May 10, took eight days to absorb the yolk and enter on the post-larval stage, and other thirty-four days, or forty-two days from the date of hatching, before they settle permanently on the bottom as typical little flat-fishes. The changes during their development are described and illustrated in a plate.

MARINE DIATOMS.

Mr. George Murray, F.R.S., Keeper of the Department of Botany of the British Museum, conducted on board the *Garland* during part of the year an investigation into the distribution and reproduction of diatoms and minute floating vegetation found in the sea, which form an important constituent of the food of minute crustaceans and of fishes in their very early stages. In the paper describing the results it is pointed out that during the first months of the year there is a remarkable prevalence of diatom life in the sea off both the east and west coasts, the quantity diminishing towards the end of March, and thereafter remaining at a fairly constant minimum. The part taken by these minute vegetable forms in furnishing food for crustacea and young fishes is described, as well as the reproductive processes of the diatoms, respecting which the observations have been of great scientific importance.

Prof. Cleve, of Upsala, Sweden, also contributes a paper to the report, describing the characters and distribution of the diatoms and minute plant-life collected by tow-nets in the Faroe-Shetland channel during the expedition of H.M.S. *Research* to that region in August last year. The chief object of the inquiry was to determine, by comparison of the abundance and distribution of minute floating organisms, the movements of the water towards and from the North Sea.

THE INVERTEBRATE FAUNA.

Mr. Thomas Scott contributes to the report a paper describing the invertebrate fauna, as well as the fishes, of Loch Fyne, and furnishing lists of all the species which have been found in that loch, together with notes of their distribution. An account is also given of the parasites of the common copepod, *Calanus finmarchicus*, which forms an important constituent of the food of fishes. In another paper Mr. Scott gives the results of his continued investigations on the invertebrate fauna of the inland waters of Scotland, including that of several lochs in Cantyre, Bute, and Forfarshire, as well as of Shetland, in the examination of which he was assisted by Mr. Robert Duthie. Through these investigations some important additions have been made to the fresh water fauna of Scotland. In a third paper the invertebrate fauna, collected by tow-nets used on board H.M.S. *Research* in the Faroe-Shetland Channel, in August, is described, notes being furnished showing the distribution of the various species obtained.

PHYSICAL INVESTIGATIONS.

In addition to the regular determinations of the temperature and density of the sea water at various stations by the *Garland*, special physical investigations were made last year in the Faroe-Shetland Channel and in Loch Fyne. By the courtesy of Admiral Wharton, the Hydrographer to the Admiralty, a series of temperature observations were taken in the former area by the officers of H.M.S. *Research*, under the command of Captain Moore, and a large number of samples of water were secured from various depths for the subsequent determination of the density. Mr. H. N. Dickson has prepared a special paper on the subject, which is printed in the present report. The work was undertaken with the view of forming part of the continued hydrographic survey of the North Sea and the North Atlantic, instituted as an international scheme with Sweden, Denmark, Norway, and Germany in 1893, and the observations made on board H.M.S. *Research* form an important contribution to the subject. The observations in Loch Fyne and the Firth of Clyde were made by Dr. H. R. Mill in April and September, and are dealt with in another paper. They serve to confirm the previous conclusions as to the circulation of the waters in Loch Fyne.

THE PHYSIOLOGY OF THE EMOTIONS.[1]

THE respiratory movements have wide-reaching effects. They not only lead to the flow of air to and from the lungs, but they profoundly influence the circulation of the blood and lymph; they also affect the functions of the abdominal and pelvic viscera by rhythmically compressing and dislocating them. Now, these movements are liable to constant modification in the physiological acts of talking, shouting, singing, laughing, crying, sighing, and yawning (as also in the occasional and semi-pathological acts of sneezing, coughing, vomiting, and hiccoughing), and it therefore follows that these acts are more far-reaching in their effects than would at first sight appear, and hence are worthy of our careful study. This will the more readily be granted when it is added that they affect the body, not only by modifying the respiratory movements and thus producing the effects already mentioned, but by involving the expenditure of a considerable amount of neuro-muscular energy, and by inducing definite psychic phenomena which themselves have their physical accompaniments.

Seeing, then, how far-reaching are the effects of these several acts, and remembering how large a part they play in normal life, we may safely conclude that they influence the functions of the body beneficially, and that an undue interference with them is injurious. One is apt to forget how strong is the instinct to shout and sing, laugh and cry. It is especially noticeable in the savage and in the child. If these instincts are unduly repressed in the child he is sure to suffer. Crying should certainly be restrained within limits, but there can be no doubt that it is primarily physiological, not only favouring the proper expansion of the lungs and accelerating the circulation, but deadening the effects of pain and relieving nerve tension (especially in woman). Rosbach thinks it not improbable that many evils which manifest themselves in later life, such as chlorosis, contracted chest, and the phthisical habit, "may take their origin in the practice of mothers to stop their infants from screaming by soothing them to sleep in their arms or by stupefying rocking in the cradle." (Von Ziemssen's "General Therapeutics," vol. iii. p. 581). It is well known that children show a strong instinct to chatter and sing the first thing in the morning, and it should be allowed full vent as far as is practicable. The shouting which young people indulge in during their play is quite remarkable and is manifestly physiological. The same tendency to shout is observed in young adults, especially among the poorer classes in holiday time. Though from the physiological point of view justifiable, and even

1 "The Therapeutical Aspects of Talking, Shouting, Singing, Laughing, Crying, Sighing, and Yawning." By Dr. Harry Campbell. (Abridged from *The Lancet*, July 17.)