The Scottish Marine Station and its Work.

By William E. Hoyle, M.A.

THE "Scottish Marine Station for Scientific Research" has now been at work for a little over four years, so that the present seems a fair opportunity to inquire what has been accomplished by its means. The object of the present article is to supply this information, and to show to what extent the results obtained have justified the expectations of its promoters.

It may be well at the outset to lay before the reader in a few words the circumstances which led to the establishment of this institution, as well as the means which have been at its disposal. The nucleus of its pecuniary resources was a sum of £1400, the surplus from the Edinburgh Fisheries Exhibition of 1882, which was handed over to the Scottish Meteorological Society for the purpose of carrying on investigations which they had already commenced into the herring and other fisheries, "with power to establish a zoological station and also to endeavour to get Government to assist them in the work." The application to Government for assistance was unsuccessful. Dr. John Murray, of the "Challenger" expedition, however, offered to found a zoological station, and to maintain it for at least three years, provided the Council of the Society would give him an annual grant from the fund of £250 for these years. This offer was accepted, and on April 14th, 1884, the Institution was inaugurated, and systematic work commenced. At the outset Dr. Murray received assistance from friends and others interested in the work, and has also received grants from the British Association, and the Government Grant Committee.

The station had its head-quarters in the old quarry at Granton, about two miles and a half distant from Leith,

which had been flooded in 1855 owing to its outer wall giving way. It has an area of seven acres, and there is a narrow opening leading to the sea, through which a vessel drawing six feet of water can be navigated at about high water. The late Duke of Buccleuch granted Dr. John Murray a fifteen years lease of the quarry at the almost nominal rent of 15*s.* per annum.

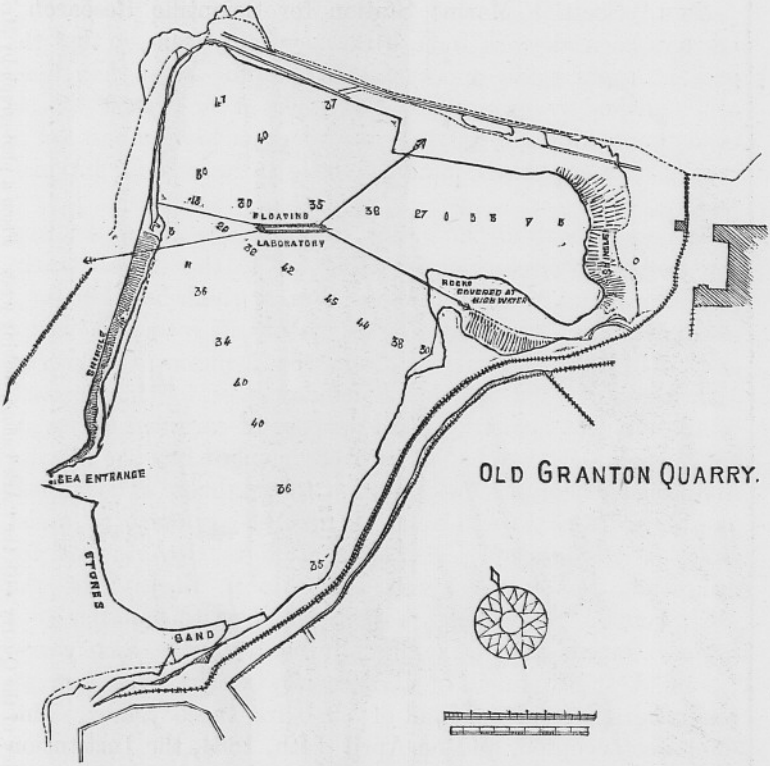

FIG 1.—Plan of Granton Quarry, the original site of the Scottish Marine Station. From a survey by Mr. H. J. Gifford. The figures represent the depth in feet.

Two large vessels, the "Ark" and the "Medusa," with several rowing boats, made up the outfit, and still constitute a most important part of the Station's appliances. The former is a floating laboratory, and was moored in the

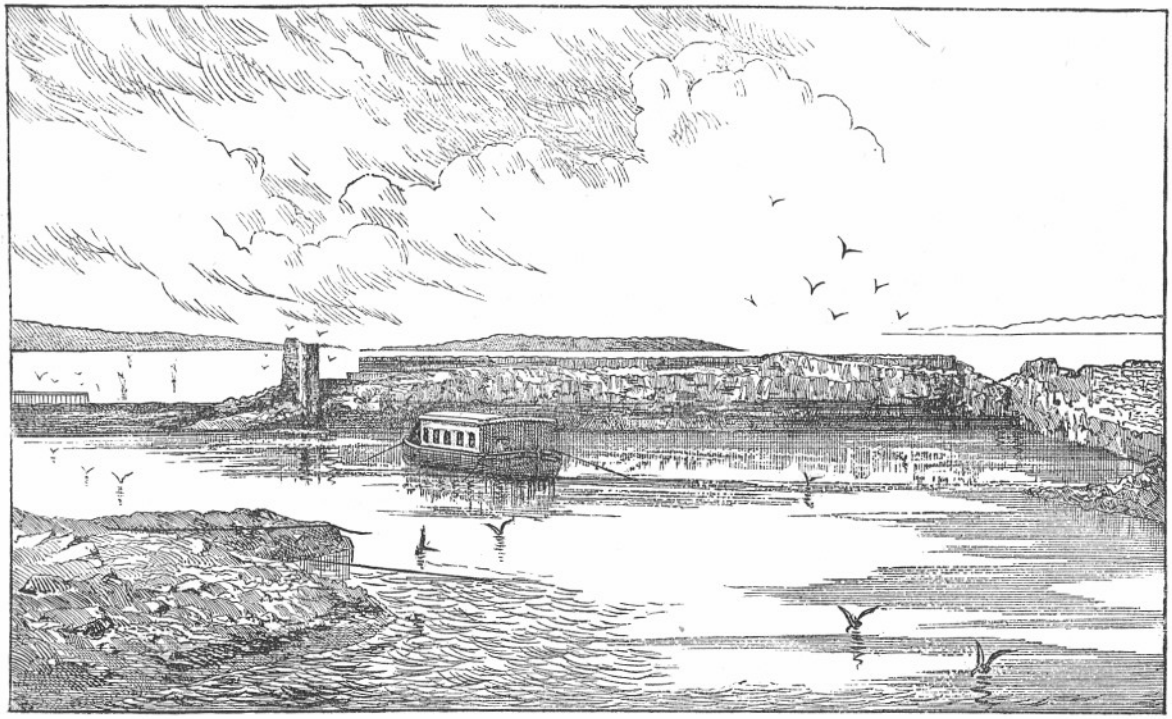

FIG. 2.—View of the Quarry with the "Ark" afloat, looking west. From a photograph by Mr. H. J. Gifford.

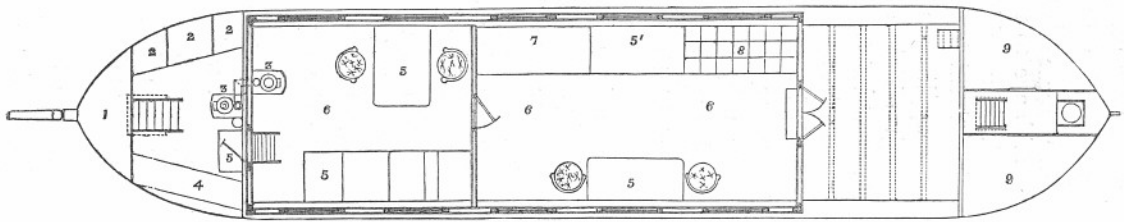

FIG. 3.—Plan of the "Ark," showing the internal arrangements. 1, Coal bunker; 2, lockers; 3, stoves; 4, keeper's berth; 5, wooden tables; 5′, 7, 8, tables for aquaria; 6, lockers under flooring; 9, fore-cabin.

centre of the quarry. She consists of an iron hull, sixty-four feet long by thirteen feet broad, formerly used as a lighter; about the centre of her length a raised cabin was built, leaving a free space at either end, and thus imparting to the whole a striking resemblance to the craft of the toy-shops after which she is named. The cabin is divided into two compartments, one of which is furnished with arrangements for physical work, and with appliances for keeping specimens alive in vessels through which a constant stream is passed, a wind-pump on the roof raising the water for this purpose. The other room contained tables for microscopic work, shelves for reagents, and the usual paraphernalia of a biological laboratory. The quarry itself was made to serve as a kind of natural aquarium by enclosing specimens of various kinds in submerged cages, which were attached either to the "Ark" itself or to suitable floats in various places.

The "Medusa," the steam yacht used for sounding and dredging, is fifty-one feet in length, twelve feet in beam, and a little over thirty tons burthen, yacht measurement. There is a single mast in the fore part of the vessel, and from it there projects forwards a derrick with blocks through which pass the sounding or dredging lines. Each of these has its own special drum, placed on an axle abaft the mast, and actuated by a small steam engine. In the after part of the vessel is a cabin, capable of holding several persons, in which it is possible to examine the captured material with the microscope.

The sounding line is of hemp, this being regarded as safer where instruments are attached, while the depths are so small that but little saving in time would be effected by the use of wire. The dredging rope is of phosphor bronze, nearly half an inch in diameter, and 200 fathoms of it are coiled round the drum.

Since the station was inaugurated several changes in its arrangements have taken place. A spacious laboratory with aquaria in the basement has been erected on shore at Granton within a large enclosure, and the "Ark" has been removed to Millport in the Firth of Clyde, where it serves as a kind

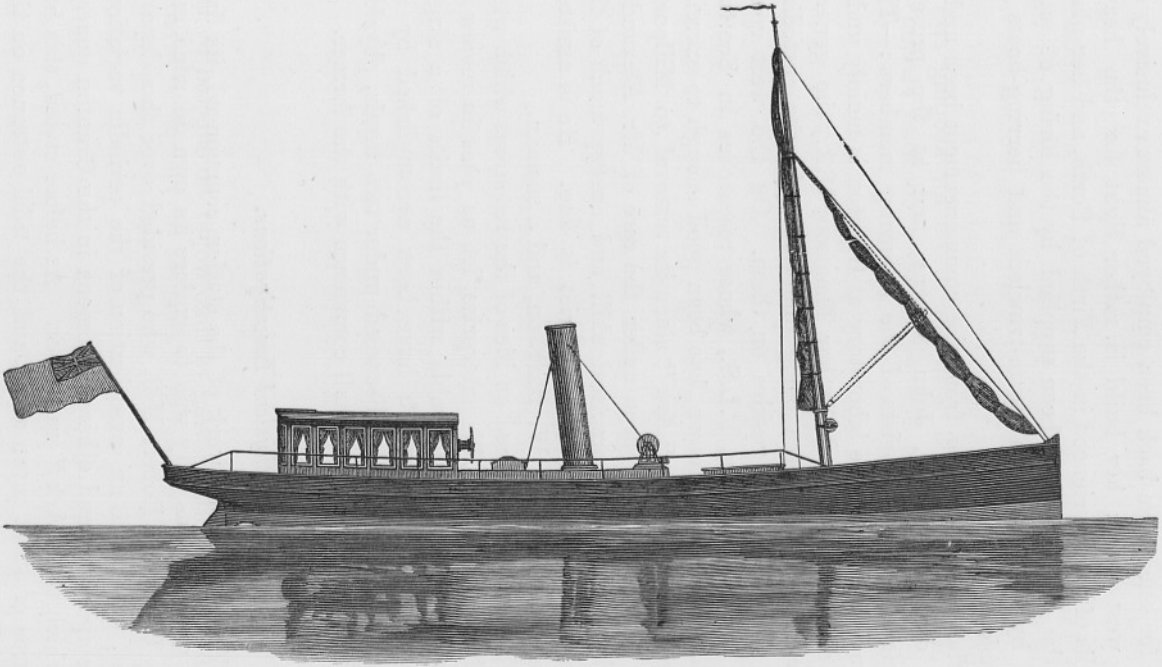

FIG. 4.—The "Medusa." Scale, one inch to the foot.

of head-quarters for work on the west coast. The "Medusa" has for some time back been employed almost exclusively on the west coast; her build is rather light for the heavy swells often experienced in the Firth of Forth, and her place on the east coast has been supplied by the hiring of tugs, and by expeditions in steam-trawlers and herring-boats as occasion requires.

The institution has from the commencement been under the direction of Dr. John Murray, and at the present moment the staff consists of the following members :—The scientific work of the laboratory at Granton is mainly under the direction of Mr. J. Arthur Thomson, M.A., the general charge of the premises being undertaken by the custodian Mr. W. Bell, who resides on them. On the west coast Mr. David Robertson, F.L.S., whose researches in Scottish zoology are so well known, has been good enough to exercise supervision over the "Ark" since its removal to Millport; the "Medusa" has been under the care of Mr. Alexander Turbyne, to whose practical skill and energy much of the success of the work in this district is due. He is assisted by an engineer, Mr. W. Harrison, and a seaman.

Having thus obtained an idea of the resources which were at the command of this enterprise, let us pass in review as completely as is practicable within the limits of a single article, the results which have been accomplished by its means. These will be discussed under two heads, physical and biological, and we shall commence with the former.

Physical Investigations.

When the actual work of the station commenced, its first and most obvious duty was to explore its own domains, and thus Dr. Hugh Robert Mill, who presided over this department, was led to an investigation of the periodic variations of temperature and other phenomena in the Granton quarry, in which the "Ark" was afloat. As before stated, this has an area of about seven acres, and the tidal entrance on the west side is so situated that no water can enter till about half tide; it then runs in very rapidly for some three

quarters of an hour, when the speed diminishes, and near high water it is the same as that of the rising tide along the shore. The ebb is gradual at first, but when the entrance has been narrowed by the exposure of its banks, it is accelerated for about an hour and a half. Then it runs out very slowly, its exit continuing until the flow recommences. For some five hours, however, the level of the water inside is practically unchanged. The depth of water in the quarry is from five to eight fathoms at low water. Temperatures were taken of the air and of the water, both at the surface and the bottom, at as short intervals as circumstances allowed, in some cases every half hour for thirty-six hours consecutively. The results of these observations are thus summarised by Dr. Mill:

"(1) During daylight the air was always at a higher temperature than the water, but after sunset the water was warmer than the air; and taking an average for the whole period, the mean temperature of the air was the higher.

"(2) The surface temperature followed that of the air, and was little affected by tidal changes.

"(3) The bottom temperature followed that of the air, but the crest of the heat wave was retarded by several hours, and the curve was profoundly modified by the tides.

"(4) The temperature was higher at the surface than at the bottom during the day; but, as a rule, it was higher at the bottom than at the surface by night.

"(5) When the tide flowed in the early morning it exercised a cooling effect on the bottom thermometers, but when it flowed at other times it produced a warming effect."

This preliminary piece of work naturally led to an inquiry into the physical conditions of the Firth of Forth, with reference, in the first place, to the temperature and salinity of the water at various times and states of the tide. For the former purpose Negretti and Zambra's deep-sea thermometer, which registers by inverting, has been used. It is shown in Fig. 5. The neck of the bulb has a contraction at A, beyond which is a reservoir, B, whilst a small receptacle, C, is provided at the other end of the tube. When the instrument is placed bulb downwards the mercury contracts

and expands in the ordinary way, but as it merely enters the reservoir, B, no reading is possible; when, however, it is inverted the mercury breaks off at A, flows down the tube,

FIG. 5.

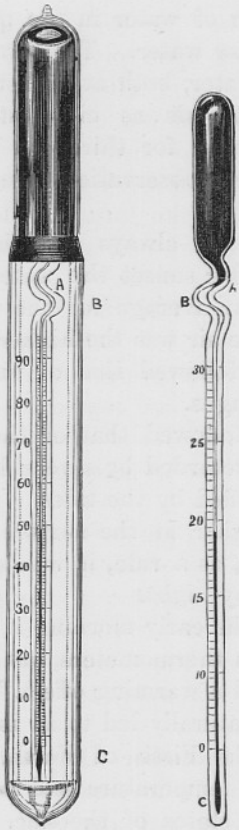

FIG. 5.—Negretti and Zambra's improved Standard Deep-sea Thermometer; and removed from within its protecting tube. A, Constriction above the bulb; B, reservoir; C, dilatation at the end of the stem. (From the "Challenger" Narrative.)

FIG. 6.

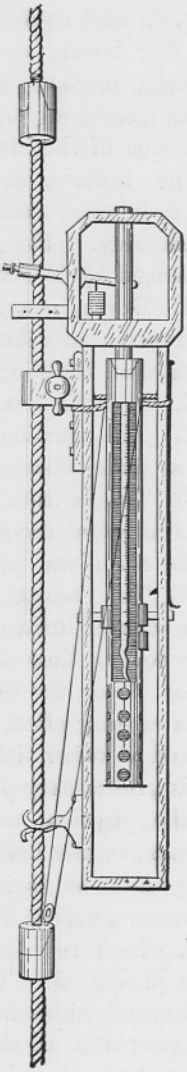

FIG. 6.—The Scottish Deep-sea Thermometer Frame. (From the 'Encyclopædia Britannica.')

filling c and a portion of the tube above. The scale reads upwards from c. Thus, whenever the existing temperature is required it is merely needful to invert the instrument and the reading can be taken at any time afterwards. The left-hand figure shows the thermometer enclosed in a stout glass tube to protect it from the pressure of the water at great depths.

The thermometer is mounted in the "Scottish" deep-sea frame shown in Fig. 6. It is swung upon pivots, and the end, c, is loaded so that it will fall down when allowed to do so by the withdrawal of a pin, which fits into a slot at that end. The outer frame carrying this revolving piece is attached to the sounding line by a double hook below and a screw clamp above. The pin, which fits into the slot, is worked by a lever, the other end of which embraces the rope, so that when it is depressed by a "messenger" (a weight which slides down the line) the pin is lifted out of the slot, and the thermometer at once turns over. When this has taken place it is held in position by a spring catch fitting into a notch. Lest the thermometer should happen to be so accurately balanced as not to turn over, an india-rubber ring is fixed to the upper part of the frame so as to give it the required initial impetus.

The messenger is the invention of Captain Rung, of the Danish Meteorological Institute, and is made in two pieces in such a way that it can be put on the line at any point. When several thermometers are placed on the line at the same time each (except the lowest) has a messenger suspended to it, as indicated in the diagram, to cause the inversion of the succeeding thermometer.

Within the last few months Professor Chrystal has constructed an instrument in which the inversion is accomplished by electricity, thus doing away with any uncertainty which may attend the action of the messengers and rendering the process instantaneous. The sounding line contains two copper wires which are connected with the terminals of a horse-shoe electro-magnet in the upper part of the frame. As soon as the circuit is completed the pin is drawn out of the slot and the thermometer turns over. The apparatus

was tried a few weeks ago in the Firth of Clyde and found to work admirably.

The salinity is a measure of the extent to which the fresh water brought down by the rivers has undergone admixture with the sea-water. It is determined by means of a delicate hydrometer, in the manner adopted by Mr. J. Y. Buchanan on the "Challenger" expedition.* When it is desired merely to study the surface water the collection of samples is, of course, extremely simple, but when it is necessary to observe the salinity of the water at various depths recourse is had to a special water-bottle which has been devised by Dr. Mill for the work.

This instrument is shown open in section in the accompanying figure. The sounding line is threaded through the central axis, A A, a strong tube which supports the whole apparatus, its lower end resting on a knob or a short cross-bar. The sides of the vessel are constituted by the cylinder, I I, F F, the bottom by the base-plate, B; this carries a ring of very soft rubber, C, forming a water-tight joint with the lower edge of the cylinder, F F. Above, complete closure is ensured by the flange, I I, pressing down upon the india-rubber saucer, H H. The weight of the cylinder, of course, drives it well home upon these pads, and so soon as this is the case it is held down by the spring catches, O O. Whilst the bottle is being lowered the cylinder is held up in the position shown by the hooks, L L, which spring outwards. A short tube, M, fits over these, and when this is driven downwards by a messenger detached from the lowest thermometer it compresses these springs and withdraws them from the flanged gallery, K, so that the cylinder is free to fall upon the base-plate and enclose the water-sample. The water is drawn off by the cock, D, air being admitted by E.

In the Firth of Forth twelve stations were fixed upon at approximately equal intervals between Alloa and the Isle of May, and serial temperatures were taken at these positions at frequent intervals. The general result of these observations is that in the landward part of the Firth the range of temperature is greater and the period of the annual maximum

* 'Narr. Chall. Exp.,' vol. i, p. 108, 1885.

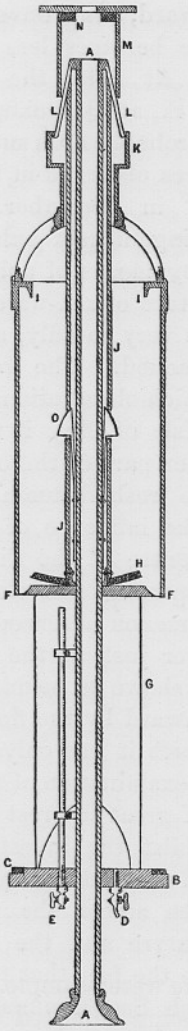

FIG. 7.—Dr. H. R. Mills' Water-bottle. A A, central tube; B, base-plate; C, india-rubber ring, to form a water-tight joint with the lower edge, F F, when the bottle is shut; D, stop-cock for emptying the bottle; E, stop-cock for admitting air; F F, edge of cylinder; G, thin plates of metal (three in number) forming guides to the cylinder; H, india-rubber saucer in which I rests when the bottle is closed; I I, knife-edged flange; J J, tube to protect lock; K, flanged gallery on top of cylinder; L L, springs sustaining cylinder; M, tube for withdrawing L L from K; N, india-rubber buffer; O, spring catches for locking cylinder when closed.

earlier than farther seaward, and, conversely, that as the sea is approached the range becomes less and the date of the maximum is retarded. At Alloa the annual range would appear to be about 35° F., at Queensferry about 20°, while at the Isle of May it probably does not greatly exceed 10°. The extreme temperatures observed in this last locality were 55° in August and 43° in December. These results and certain others are very ingeniously exhibited by Dr. Mill in a diagram constructed by means of polar co-ordinates.*

As regards the admixture of sea-water, it is found that the density increases at first very rapidly, and then more gradually as the sea is approached. The mean density at Alloa for the period during which observations were carried on was 1·00042, whilst at the Isle of May it was 1·02511. When the tide rises in the upper part of the estuary the salt water comes up underneath the fresh, damming it back and gradually mixing with it. The influence of the smaller rivers is not perceptible in the centre of the Firth ; each freshens a tract along the shore apparently not more than a mile wide.

An interesting phenomenon observed was a slight fall in the density of the water just at the mouth of the Firth, which was subsequently shown to be due to the fresher water of the Tay carried southward by the flood tide.

From the Firth of Forth it was only natural to pass to the Firth of Clyde, and the examination of this region presented a variety of questions of great interest owing to the uneven condition of its bed, whilst the investigation is facilitated by its accessibility at all times of the year. A broad submarine plateau stretches across the mouth of the Firth between the Mull of Cantyre and the Ayrshire Coast, and this, in conjunction with the fact that the opening is to the southward into the Irish Sea, diminishes the effect of the ocean water of the Atlantic. A deeper channel runs up on either side of the Island of Arran, that on the east extending directly up into Loch Fyne, where in the neighbourhood of Tarbert it attains a maximum depth of over one hundred fathoms. Between Cumbrae and Bute there is a branch of this depression, whilst a third commences north of the

* 'Proc. Roy. Soc. Edin.,' xiii, pl. vi, fig. 2.

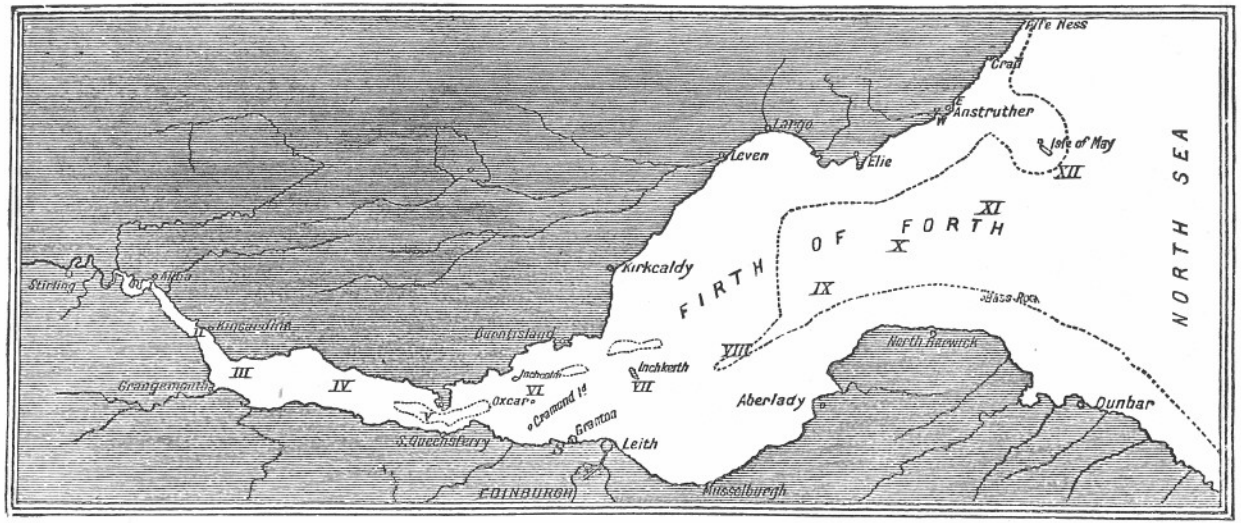

FIG. 8.—Chart of the Firth of Forth, in which the Observing Stations are indicated by Roman numerals.

Cumbraes, and extends past Dunoon up into Loch Long. Several of the lochs enclose deep basins in their upper portions, as, for instance, Loch Fyne, Loch Striven, Loch Goil, and Upper Loch Long. Such being the configuration of this area, we may next inquire how the temperature of the water varies in these different portions.

This has been summed up by Dr. Mill as follows:—(1) The *Irish Channel* has "a uniform temperature from surface to bottom, changing regularly with the season, but higher all the year round than the mean of the enclosed regions; (2) The *deep open basins* in free tidal communication with the ocean resemble the channel at all depths beneath thirty fathoms; (3) The *deep enclosed basins,* almost cut off from the tide and shut in by steep mountain walls, show the greatest range of annual temperature, and the most complicated vertical distribution. The surface water is quite fresh after heavy rains and freezes in winter. The annual range may be 35° or 40° F., while at the bottom (seventy fathoms) 5° is the greatest range observed, and the maximum temperature there occurs in early spring, when the surface water is at its minimum; the minimum at the bottom occurs in the beginning of autumn, when the surface attains a maximum."

Last year a new departure in the way of marine temperature observations was inaugurated by Dr. John Murray, namely, the study of the effect of the wind upon the distribution of submarine temperature. For such an inquiry the land-locked fjords of the west coast of Scotland are particularly well adapted; the depth of the lochs in conjunction with the frequent presence of a bar across their mouths renders the change of their contents but slow, while the moderate size of many of them makes it practicable to ascertain the condition of the whole loch as regards temperature at pretty frequent intervals. To give many figures bearing upon an inquiry of this kind would be out of place in a sketch like the present; a brief notice of one or two interesting cases must suffice. On September 7th, 1887, an examination was made of Loch Lochy, the most southerly of the three which lie in the course of the Caledonian Canal, a small body of fresh water nearly ten miles long and about

seventy-five fathoms in its maximum depth. The wind was north-easterly in direction, thus blowing directly down the loch, and its force was 1 or 2 of Beaufort's scale. Under these circumstances a mass of water, extending five-sixths of the distance up the loch, and averaging fifteen fathoms in depth, had a temperature of over 55° F.; below this a stratum of water, varying in thickness from nine fathoms at the south end of the loch to twenty fathoms at the north end, had a temperature of from 50° to 55°, whilst the whole of the water below this was at less than 50°. By September 9th the direction of the wind had changed to west-south-west, and its force had increased to from 5 to 6; it was thus blowing along the loch almost in the contrary direction. It was now found that the water of over 55° occupied the northern two thirds of the loch, extending to a depth of fifteen fathoms at that end of it; below it was a layer of nearly the same average thickness as before of water between 50° and 55°, but it now came to the surface at the southern extremity of the basin, whilst the mass of comparatively cold bottom water remained unchanged.

On the same trip a very similar phenomenon was observed in Loch Ness, a much larger body of water on the same canal. Just before the gale from the south-west set in, water above 53° formed a moderately even layer all over the surface, varying in thickness from fifteen fathoms at the south end of the loch to thirty fathoms at the north. A few hours later it was ascertained that the whole mass of water above this temperature had been blown up the loch so far that the surface water of the southern fifth of it had a temperature of below 53°. In connection with the above, reference may be made to a series of observations carried out on the 25th and 26th April during a south-westerly gale. In this case it appeared that the strong wind had so displaced the normally horizontal position of the strata of water, that the surfaces separating them were almost vertical. Observations having on the whole similar results have been carried out in Loch Striven, Loch Fyne, and other localities.

The advice and assistance of the Scottish Marine Station have been freely placed at the disposal of any bodies which

were engaged in similar work, and the services of Dr. Mill have more than once been secured by the Fishery Board for Scotland, in whose annual reports his work for them will be found recorded.

Biological Investigations.

The biological work of the Scottish Marine Station may naturally be considered under two headings—Morphological and Faunistic. The papers in the former category are nearly all the work of Mr. J. T. Cunningham, who was for a period of more than three years the Superintendent of the Granton Laboratory. During the year 1885, much of his attention was devoted to the study of the development of the herring, for which purpose he not only worked in the Firth of Forth itself, but spent several weeks at the village of North Sunderland on the Northumberland coast. The eggs were collected during nocturnal trips in the herring boats, and kept whilst developing on glass plates in wooden boxes sunk near the shore, so that they could be examined when required. The time of development and the temperature of the water were carefully observed, and it was found that the eggs hatched in eight days when the temperature of the water varied from 11·5° C. to 14·5° C. One obscure structure in the herring embryos received Mr. Cunningham's special attention. This is a small rounded cavity, which is known from its discoverer as Kupffer's vesicle, and which appears at an early stage of development between the posterior end of the embryo and the yolk; it is clearly visible on the third day and remains so for eight or nine hours, but cannot be seen on the fourth day. This cavity appears from careful investigation by means of sections to be the last rudiment of the cavity of invagination, by which the primitive intestine is formed in all except the lowest animals. The theoretical bearing of this and other developmental researches has been discussed by Mr. Cunningham in several papers, which are too technical for abstraction here.

The "glutinous hag" or "sucker" (*Myxine glutinosa*),

a semi-parasitic fish allied to the lamprey, is not uncommon on the east coast, and is a great pest to the fishermen by devouring the cod on the lines or taking the bait from the hooks. It is, however, an object of great interest to zoologists, from its exhibiting several very primitive characters in its organisation, which render a knowledge of its developmental history a great desideratum. It has long been known that the mature egg is contained in a hard, horny husk, at either end of which is a bunch of stiff processes like bristles, but with two or three hooks at the end of each ; hitherto only two such eggs have been found,* and Mr. Cunningham, in spite of numerous efforts and much expenditure of time and money, was unable to obtain more, even by keeping adult animals for months in an aquarium, so he took advantage of the opportunity offered by his having numerous specimens at his disposal to make a careful investigation of the development of the reproductive products, which has led to some interesting results. The horny envelope of the egg appears to correspond to the so-called " zona radiata " of the egg of other fish, that is to say, it is a primary egg-membrane and not an extraneous growth. Male specimens are exceedingly rare, but in the great majority of those in which the eggs are immature the hinder part of the generative gland is a well formed testis ; and Mr. Cunningham is inclined to think that these immature animals are functionally males and that most eggs are fertilised by them.

A department of knowledge in which science is at present very backward, is that which relates to the eggs and young stages of food-fishes ; this inquiry was successfully prosecuted by Mr. Cunningham, and the results of his work, containing not only descriptions and figures of the eggs of about a dozen species, but also an account of previous researches in this direction, have been published by the Royal Society of Edinburgh. At the time of his departure from Granton, Mr. Cunningham was engaged in a systematic and anatomical study of the Annelida of the Firth of Forth, a work which

* Dr. Fridtjof Nansen has just informed me that he has discovered a third egg among the stores of the Bergen Museum, which was dredged thirty years ago by Dr. Danielssen near Molde.

has already yielded fruit in the publication of several papers on this interesting group of animals.

The small crustacean *Nyctiphanes norvegica* is pretty commonly found in the Firth of Clyde in deep water; when alive it is a most graceful creature, swimming rapidly round the aquarium, with the dorsal or ventral surface indifferently uppermost. Its chief interest, however, consists in the possession of luminous organs, which it shares with most, if not all, the Euphausiidæ. The fact that certain Schizopod Crustacea have the power of emitting light appears to have been first noticed by Vaughan Thompson,* and the organs in question were described by Claus† under the name "accessory eyes." The phenomenon was a matter of frequent observation during the "Challenger" expedition,‡ and the phosphorescent apparatus was described as such by Sars,§ in his report on the Schizopoda, both in *Euphausia* and in a new species of *Nyctiphanes* (*N. australis*). He did not, however, enter upon a histological examination of these organs, and with a view of supplying this lacuna in our knowledge Mr. Rupert Vallentin, with the co-operation of Mr. Cunningham, subjected them to a thorough investigation. A large number of specimens were obtained in ninety-five fathoms off Brodick Bay, and conveyed to the "Ark" at Millport for examination. Each animal possesses ten of these organs: one in each eye-peduncle, one in the basal joint of each second and one in the basal joint of each seventh thoracic appendage, while the remaining four are unpaired and situated, one in the lower surface of each of the first four abdominal segments. Each "photosphere" (a name proposed by Messrs. Vallentin and Cunningham for these structures) is a spherical body lying immediately beneath the epidermis, and almost entirely independent of the surrounding tissues. Its posterior half is formed by a stratified, fibrous, non-cellular, hemispherical cup, within which is a layer consisting of large cubical cells internally,

* 'Zoological Researches,' ii, 1829.

† 'Zeitschr. f. wiss. Zool.,' xiii.

‡ 'Narr. Chall. Exp.' I, ii, p. 743.

§ 'Zool. Chall. Exp.,' xxxvii, pp. 70, 119.

and smaller cells externally. The hollow of the hemisphere is filled with a fibrous mass, the constituent fibres of which are perpendicular to the cellular layer outside, but cross each other at right angles at the centre. This is succeeded in front by a homogeneous, highly refractive lens, surrounded by a ring similar in structure to the stratified layer, and without this again is a stratum of cells smaller than those mentioned above. The posterior half of the organ is overlaid by a coating of flat, polygonal, red pigment-cells, which seem to be merely a specialised form of the chromatophores, which are scattered in various parts of the body. A connection with the nervous system, although it almost certainly exists, has not yet been demonstrated. These luminous bodies may be acted on either by mechanical or chemical stimuli, and it was ascertained that the light proceeds from the innermost part of the stratified cup above described, which appears to possess the property of fluorescence in a remarkable degree.

A few months ago an adult whale (*Balænoptera rostrata*) came ashore in the narrow entrance to the quarry, and was speedily killed by the dwellers in the neighbourhood. It was thereafter towed round to Granton Harbour, hoisted on a railway truck, and thus conveyed within the walls of the Marine Station, where it continued to attract crowds of visitors for some time. An anatomical examination of it was undertaken by Sir William Turner and several assistants.

The faunistic work was at first the special province of Mr. J. R. Henderson, until his appointment to a Chair of Biology in Madras deprived the station of an accurate and energetic worker. Before his connection with the Granton station Mr. Henderson had acquired a large private collection illustrating the local marine fauna, and by means of the new facilities at his disposal he was able to make many interesting additions to the fauna of the Firth of Forth. He specially devoted himself, however, to the Crustacea; and his 'Synopsis of British Paguridæ' gives an orderly account of a group which had for long been much neglected, whilst his 'Catalogue of the Decapod and Schizopod Crustacea of the Firth of Clyde' includes twenty-one species which have

been added to the British fauna since the publication of Bell's great work, and five (including a new genus) are recorded for the first time. It contains, also, a list of all the higher Crustacea from the West of Scotland compared with similar lists from Scandinavia and the Mediterranean.

The numerous trawlings and dredgings which have been conducted by Mr. John Murray on the west coast are of great interest. Large collections have been sent to the British Museum, and it is hoped that all the lists prepared by the naturalists of that institution may shortly be published, for they contain records of the occurrence of many interesting forms, some of which have not hitherto been known to inhabit British seas.

The examination of the fishes has been conducted by Dr. Günther, and an interesting report upon them was communicated to the Royal Society of Edinburgh on March 5th of the present year.

Excluding certain common species forty-seven different forms were collected, some of which are of special interest. The Arctic genus *Triglops* is represented by a new species (*T. Murrayi*), whilst *Cottus Lilljeborgii* and *Gadus Esmarkii* are new to the British Fauna. *Callionymus maculatus* was recorded by Dr. Günther in 1867 from the Hebrides, but is now shown to be fairly abundant in Kilbrennan Sound at a depth of twenty-six fathoms.

As might be expected such investigations, carried on for a considerable period, have yielded a mass of information of more or less miscellaneous character which it is impossible to summarise; a few items are selected, for mention here. Some instances of peculiar distribution have been recorded from the lochs of the west coast, which furnish additional proof of the fact demonstrated by the "Porcupine" and "Triton" expeditions,* that submarine barriers have a preponderating influence in the limitation of marine faunistic areas. For instance, *Conchœcia elegans*, a pelagic Ostracode of the deep Norwegian waters, is found nowhere on the Scottish coast except in Upper Loch Etive, at depths of from

* 'Proc. Phil. Soc.' Glasgow, xvii.

thirty to seventy fathoms. The genus *Pasiphæa* occurs in the Mediterranean and off Norway, and has recently been detected in deep water in Loch Etive, Kilbrennan Sound, Lower Loch Fyne, and other localities, but never in Upper Loch Fyne, Loch Long, or Loch Goil. It may be mentioned in passing that *Nephrops* also is never got in Upper Loch Fyne. *Nyctiphanes norvegica* is abundant in Upper Loch Fyne, but has not been found either in Upper Loch Etive or Loch Aber; at the mouth of Loch Sunart a few specimens have been caught, and in Loch Hourn it is abundant. The allied *Boreophausia* is common in Loch Duich. *Euchæta*, a large Copepod, is pretty generally distributed in the Clyde Basin, though it is not found abundantly in Kilbrennan Sound and towards the Mull of Cantyre; farther north it occurs in Loch Etive, but not in Loch Aber, Loch Sunart, or Loch Carron. *Euchæta* and *Nyctiphanes* are never found on the surface in the adult condition, but their larval forms seem from recent tow-nettings to be not uncommon on the surface in the spring. The present writer has within the last few weeks found what appear to be the eggs and the Nauplius and Cyrtopia stages off the coast of Arran, and Mr. George Brook has the Metanauplius and several Furcilia stages from the same district. Dr. Murray further states that these eggs and larvæ have been abundant at the surface all over the Clyde sea area for the past two months.

Most of the forms enumerated above are deep-sea animals, not being found within the 100 fathom line, except in these land-locked fjords, to which perhaps they may have been confined by the gradual rising of the land after the glacial period.

Another observation deserving of mention here is the fact that in the early spring an extensive layer of Diatoms (*Coscinodiscus, &c.*) appears upon the surface of the water and gradually sinks as summer advances. Concurrently with this swarms of larvæ are developed, the examination of whose stomachs proves conclusively that they are nourished by these Algæ whilst they themselves furnish the food of the Loch Fyne herring and other fish, which seem to approach the surface at this period. The

herring itself is said by the fishermen to be subject to a disease known as "poke-gut," which they believe to be due to the fish "eating some black substance which burns through them like quicklime." Dr. Murray has ascertained that this black material is due to the pigmented eyes of Schizopod larvæ, which have been devoured in quantities by the fish and undergone such rapid decomposition that even in a few hours they will penetrate the abdominal wall.

It seems more than doubtful whether the herring migrate, as is commonly supposed, between these deep lochs and the open ocean. It appears more probable from several indications that they winter in the deep water, and come to the shallows for breeding purposes. This would account, amongst other things, for the fact that each district has a recognisable variety of herring peculiar to itself. During the winter months herrings have been captured in depths of forty fathoms with their stomachs distended with adult *Nyctiphanes*, and young herrings have been taken at similar depths throughout the whole year.

After such an account of work, as even this brief record supplies, it seems a work of supererogation to attempt any justification of such an institution as the Scottish Marine Station. Before it is possible to attempt an intelligent regulation of our fisheries, the first requisite is more knowledge, a detailed acquaintance not only with the fish themselves and their habits of life, but also with the physical conditions in which they dwell, and of the life-history and distribution of the organisms which serve as their food. Such an acquaintance with the subject is merely in its infancy at present, and with our best efforts many years must elapse before it can be even approximately adequate to our needs. One Zoological Station, however well equipped, can only explore a limited area, and there is room in this field for many workers, whose results when collected and compared will lead to such generalisations as may render it possible to legislate upon these questions with sure hope of success.

List of Papers referred to in the Article.

CUNNINGHAM, J. T. Marine Station for Scientific Research, Granton, Edinburgh. Edinburgh: 1884, 8vo. 18 pp.

—— The Scottish Marine Station for Scientific Research, Granton, Edinburgh; its Work and Prospects. Edinburgh: 1885, 8vo. 54 pp., 6 pls.

—— Critical Note on the latest Theory in Vertebrate Morphology, *Proc. Roy. Soc. Edin.*, xii, pp. 759—765, woodcut, 1884.

—— On the Nature and Significance of the Structure known as Kupffer's Vesicle in Teleostean Embryos, *op. cit.*, xiii, pp. 4—14, pls. i, ii, 1885.

—— The Significance of Kupffer's Vesicle, with Remarks on other Questions of Vertebrate Morphology, *Quart. Journ. Micr. Sci.*, xxv, pp. 1—16, pl. i, 1885.

—— The Relations of the Yolk to the Gastrula in Teleosteans and in other Vertebrate Types, *Quart. Journ. Micr. Sci.*, xxvi, pp. 1—40, pls. i—iv, 1885; abstract, *Proc. Roy. Soc. Edin.*, xiii, pp. 167—171, 1886.

—— On the Structure and Development of the Reproductive Elements in *Myxine glutinosa*, L., *Quart. Journ. Micr. Sci.*, xxvii, pp. 49—76, pls. vi, vii; abstract, *Proc. Roy. Soc. Edin.*, xiii, pp. 597—602, 1886.

—— The Eggs and Larvæ of Teleosteans, *Trans. Roy. Soc. Edin.*, xxxiii, pp. 97—136, pls. i—vii, 1887.

—— and R. VALLENTIN. The Luminous Organs of *Nyctiphanes norvegica*, Sars., *Proc. Roy. Soc. Edin.*, xiv, pp. 351—356; also *Quart. Journ. Micr. Sci.*, xxviii, pp. 319—343, 1888.

MURRAY, J. The Physical and Biological conditions of the Seas and Estuaries about North Britain, *Proc. Phil. Soc. Glasgow*, xvii, pp. 306—330, 1886.

—— On the Effects of Wind on the Distribution of Temperature in the Sea and Fresh-Water Lochs of the West of Scotland, *Scot. Geog. Mag.*, iv, pp. 345—365, 1888.

MILL, H. R. Physical Exploration of the Firth of Clyde, *Scot. Geog. Mag.*, ii, pp. 347—357, 1886.

—— Configuration of the Clyde Sea Area, *op. cit.*, iii, pp. 15—21, map, 1887.

—— On the Periodic Variations of Temperature in Tidal Basins, *Proc. Roy. Soc. Edin.*, xii, pp. 927—932, pl. xii, 1884.

—— On the Salinity of the Water in the Firth of Forth, *Proc. Roy. Soc. Edin.*, xiii, pp. 29—64, pls. iii—v, 1885.

MILL, H. R. On the Temperature of the Water in the Firth of Forth, *t. c.*, pp. 157—167, pls. vi, vii, 1886.

—— Note on the Salinity of the Tay Estuary and of St. Andrew's Bay, *t. c.*, pp. 347—350, 1886.

—— On Water-Bottles, with the Description of a new form of Slip Water-Bottle, *t. c.*, pp. 539—546, pl. xx, 1886.

—— and T. M. RITCHIE. On the Physical Conditions of Rivers entering a Tidal Sea; from Observations on the Spey, *t. c.*, pp. 460—485, pls. xiii—xv, 1886.

—— and J. T. MORRISON. On the Tidal Variation of Salinity and Temperature in the Estuary of the Forth, *t. c.*, pp. 790—799, pl. xxviii, 1887.

HENDERSON, J. R. Recent Additions to the Invertebrate Fauna of the Firth of Forth, *Proc. Roy. Phys. Soc. Edin.*, viii, pp. 307—313, 1885.

—— A Synopsis of the British Paguridæ, *op. cit.*, ix, pp. 65—75, 1886.

—— The Decapod and Schizopod Crustacea of the Firth of Clyde, *Trans. Nat. Hist. Soc. Glasgow*, N. S. i, pp. 315—353, 1887; also separately. Glasgow; 1886, 8vo, 43 pp.

The Meteorological Observations of the Station are published periodically in the *Journal of Scottish Meteorological Society.*