1899.
NEW ZEALAND.

NEW ZEALAND FISHERIES AND ACCLIMATISATION
(REPORT ON, BY L. F. AYSON).

Presented to both Houses of the General Assembly by Command of His Excellency.

SIR,— Masterton, New Zealand, 31st May, 1899.

In accordance with instructions from the Government of New Zealand, I left the colony on the 8th April, 1898, arriving at Brindisi on the 27th May.

While in Italy I visited the trout hatcheries at Brescia and Peschiera, where lake trout are dealt with much on the same lines as in New Zealand; also Gardone, where the peculiar species found in the Lago di Garda, carpione trout, are dealt with. This variety inhabits great depths, and is a very fine table-fish, which should not be lost sight of, as it might suit some of our deep lakes. It is, however, a difficult fish to deal with in captivity or to establish in new waters.

I also visited the extensive lagoon fish-farms near Venice, and the great fish-market at Chioggia, on the Adriatic; but, while there was much to learn, of which I took full notes, I hardly think the conditions applicable to New Zealand.

From Italy I proceeded to Switzerland and Alsace, visiting the large hatchery at Hüningen and the smaller hatcheries at Bâle, Züg, Olten, Lucerne, and Berne, where much interesting work is carried on. A large supply of Rhine salmon-ova could be obtained from Hüningen, where the price quoted was 5s. 6d. per thousand eggs, packed and placed on the train. Alpine char could also be obtained here if required. I have full notes about these hatcheries, but find that the Continental system differs but little from that we carry on here, though it is undertaken by the State on a very extensive scale.

Arriving in England on the 24th June, I spent the next three months and a half in inspecting the principal marine and fresh-water hatcheries in Great Britain, devoting special attention to the trawling industry at Grimsby, the Agent-General affording me every facility.

From there I proceeded to America, where, thanks to the courtesy of the officials of the Canadian and United States Governments, I was enabled to visit the principal hatcheries, and obtained some little insight into the working of their immense fisheries, many features of which I think are suitable for this colony.

As formerly reported to you, I brought over a consignment of two million whitefish ova, about 65 per cent. of which was successfully liberated as fry, in Lake Kanieri.

Both the Governments of Canada and the United States offered to supply this colony with a large quantity of Pacific salmon-ova for the cost of packing and transport, and I recommend the acceptance of this generous offer.

While in America I also entered into negotiations paving the way for future importations into this colony of certain animals and birds, and purchased a number of Virginian quail (about four hundred of which arrived safely), and a few Canadian wild geese.

I have now the honour to enclose a report, divided into three headings—(1) On Marine Fisheries; (2) On Fresh-water Fisheries; and (3) On the Importation of certain Animals and Birds —which may, I trust, be of some service in helping to develop the fishing industries of the colony and the work being carried on by acclimatisation societies. I have, &c.,

The Hon. the Minister of Marine, Wellington. L. F. AYSON.

PART I.—MARINE FISHERIES.

Masterton, New Zealand, 31st May, 1899.

IN forwarding the attached memoranda relative to deep-sea trawling, marine hatcheries, and the importation of marine fish, I have the honour to point out that hitherto it seems to me our marine fisheries have not had the attention bestowed on them which the importance of their development requires; and, with a view to attempting to remedy this state of affairs, I would respectfully tender the following recommendations:—

1. That the work of the Minister of Marine and his department be extended, so as to include, in future, marine and fisheries.

2. That Fishery Commissioners be appointed for New Zealand, consisting of gentlemen with some knowledge of the subject, and who take an interest in it, whose duty it would be to advise the Minister of Marine and Fisheries, and endeavour to infuse new life into the industry, under skilled supervision. Such Commissioners should have a fairly free hand, and a practical organizing Inspector to work under them, together with the assistance of the Department of Marine and Fisheries.

3. That a report be prepared as to the present state of the fisheries in the colony, with suggestions as to the best means of improving and fostering such industry in each locality.

4. That arrangements be made for testing fishing-grounds round the coast by subsidising one of the small steam-trawlers, with a good practical man in charge, and that the trawling industry be encouraged—(*a*) By inducing the local bodies to provide suitable fish-markets; (*b*) by endeavouring to induce the shipping companies to provide better means of transport of fish to Australian markets; (*c*) by fostering the canning and fish-curing industry, and pointing out how the by-products, such as oil, fish manure, &c., can profitably be dealt with; (*d*) by carrying fish by rail at the lowest possible rates; and (*e*) by publishing reliable data as to the results of the tests made on the coast, so as to assist local trawlers and induce some of the large English trawling firms to take up the business.

5. That one or more marine scientific stations be established, and reliable data as to the temperature, currents, and marine life round our coasts be collected and published.

6. That arrangements be made for careful tests and experiments being made in Europe and America as to the best and most economical method of introducing such fish as the herring, haddock, turbot, &c., into these waters; and that crustacea such as crabs and lobsters be imported and planted at the marine scientific station for breeding purposes.

7. That the fur seal be very stringently protected, and rookeries, if possible, re-established on the coasts.

8. That the oyster-fisheries be regulated and conserved, the Commissioners of Fisheries being especially instructed to devote considerable attention to this branch of the fisheries.

With its extent of coast and abundance of fish, the Colony of New Zealand ought to be a large fishing centre in the Southern Pacific, and rear a hardy seafaring population, which would be invaluable in time of war.

These Islands lie between latitudes 34° to 47° south, the same latitudes as, say, from the north of Africa to Switzerland or Central France, in Europe. Wellington is on about the same latitude as Naples. Doubtless the climate of this colony is much influenced by ocean surroundings and currents; but I feel confident that if the fish-supply were abundant and cheap the health of the inhabitants of New Zealand would be much benefited by substituting to a certain extent a lighter diet of fish for the present heavy meat diet, and, as we have markets abroad for our meat, the farming industry would not be interfered with materially.

In countries fortunate enough to possess a large supply of food-fishes the harvest of the waters is recognised as a great and extremely reproductive one for the employment of labour and capital, and it seems to me unwise to allow this great wealth to lie comparatively ungarnered at our doors.

DEEP-SEA TRAWLING.

At Aberdeen, Leith, Hull, and Grimsby I had an opportunity of inspecting deep-sea trawlers and liners, and also the system of packing fish. The steam-trawler "Brazilian," shown in the attached Plate II., may be taken as an average Grimsby trawler; the length over all was 117 ft.; beam, 20 ft. 6 in.; depth, 11 ft. 8 in.; gross tonnage, 183; and speed, 10·6 knots. The cost of such a steam-trawler as the "Brazilian" is about £5,000 ready for sea, and a crew of from eleven to thirteen men would be required to work her. I furnish herewith details of the arrangement of space on board.*

These ships are provided with an insulated ice-store and packing-chambers for the fish. Before leaving port the store is filled with crushed ice; and the fish, when caught, are placed in the packing-chambers in the following order: A layer of crushed ice on the floor of the chamber; then a single layer of fish, neatly placed; the fish are then covered with ice; boards fitting into the side of the packing-chamber are then placed above this layer of fish and ice, forming a shelf, on which the next layer of fish are placed; and so on up to the top of the chamber. By packing thus, with boards between each layer of fish, they are not injured by the weight of those above. If packed in ice as soon as caught, fish keep fresh a long time. The trawlers I saw come in to Grimsby had been over two weeks out, some of them bringing their fish twelve hundred miles, from near the coast of Iceland. Besides having insulated storage for dead fish, a good many trawlers are what is called "welled boats," and carry the fish alive to port.

In encouraging deep-sea trawling, the Government would be doing valuable work in building up an important industry. It means providing a regular and plentiful supply of fish for all classes at a reasonable price. In the past it has been a general complaint all over the colony that the supply of fish has been insufficient, irregular, and far too high in price to allow it to be a staple food-supply for all classes. Thus, the inauguration of deep-sea trawling in New Zealand waters means: First, placing a regular and sufficient supply of fresh fish within the reach of every one; second, the opening-up of an important trade in fresh fish with Australia; and third, the establishment of more fish-curing and -canning factories, and the manufacture of various fish products, which will provide a new source of employment for the people, and materially assist in increasing the population as well as the earning-capacity of our workers. In her fisheries (both sea and fresh-water) New Zealand has a most valuable asset, as her natural advantages in this connection are undoubtedly superior to those possessed by any other country in the Southern Hemisphere.

* The plan of the internal fittings cannot well be reproduced here, but is left with the Marine Department.

Experimental trawling round the coast by the Government would greatly assist this industry. If the Government steamers are not too heavy, and could be utilised for this purpose, the prospecting of different areas could be carried out as the steamers visited the various lighthouses and store depots around the coast. If they prove to be unsuitable, arrangements could be made with a practical man, who owns a suitable vessel, to test certain areas for the guidance of fishermen, and to prove where the most valuable fish exist in sufficient numbers to warrant a trawler working them.

MARINE HATCHERIES.

Taking into consideration the abundant supply of excellent fish on the coast of New Zealand, the resources of which have scarcely yet been tested, I do not consider the establishment of a sea-fish hatchery, with the object of increasing the supply of indigenous fish, is a wise project at the present juncture. In the Old World the utility of marine hatcheries as a means of increasing the stock of fish in the ocean is still problematical, opinions of practical experts being fairly divided; but in dealing with comparatively virgin waters, such as those surrounding those isolated islands, the weight of evidence would, I think, be against incurring the expense of a marine hatchery on a sufficiently large scale to do any good. On the other hand, a marine scientific station, where the life-habits of our best food-fishes could be studied, with suitable sea-water enclosures or ponds to hold and propagate any forms of marine life that might be imported into this colony, would be a most valuable undertaking, and would materially assist in the development of our fisheries. There are few civilised countries which have not already established such institutions, from which have issued valuable contributions to our knowledge of marine forms of life in various parts of the world. Different work would fall within the scope of such a scientific station, but having a direct bearing on the practical and mercantile aspects of the fishing industries.

The investigation of certain areas around the coast would place in the fisherman's hands valuable information, directing him to new grounds, and saving him from trials of unproductive areas, and often bringing under his notice valuable fish of the abundance of which he was not aware.

The deterioration of areas once productive, the partial or total disappearance of certain fish, and other like problems, can best be solved by accurate and systematic work carried on from some central station on the coast.

The introduction of new species of great market value, and the creation of new industries, are ways in which science is able to benefit the fisheries. The nature of the food, and all the conditions influencing the welfare, growth, and increase of such newly established species, are matters for scientific investigation preliminary to practical steps being taken. Such scientific investigation would have been invaluable in the past in connection with the introduction of salmon into the waters around New Zealand.

A complete biological survey of the coastal waters of New Zealand would be of great value, and could be accomplished gradually. The best economic methods of procuring and transporting fish could be thoroughly tested, and new improvements made known. The large question of ocean currents materially affects the fisheries on our coast, and requires careful study.

If a favourable situation could be obtained near one of the larger cities the work would, no doubt, enlist the sympathy and help in various ways of the universities and professors, and students could assist in the investigations carried on.

It is, of course, important that the conditions of marine life, temperature, &c., should be favourable wherever a scientific station is placed, and a careful investigation should be made before deciding hurriedly upon a site.

The assistance of the Government steamers in any way practicable would be of the utmost value, and that assistance might be rendered from time to time, as opportunities occurred, on their periodical trips to the lighthouses round the coast; and observations taken by lighthouse-keepers could be worked into the chain of coastal knowledge, which would, taken systematically, largely increase our information as to the marine surroundings of New Zealand.

Attached to this memorandum will be found a description of the Dunbar Hatchery, copied from the report of the Fisheries Board of Scotland; also of a marine hatchery in America—at Woods Hole, Massachusetts.

I am indebted to Professor E. E. Prince's report for some of the foregoing remarks on marine hatcheries, which express better than I can the results of my observations.

An Account of the Sea-fish Hatchery at Dunbar, by Dr. T. Wemyss Fulton, F.R.S.E., Superintendent of Scientific Investigations.

In previous reports mention was made of the sea-fish hatchery which has been in course of erection at Dunbar, with the view of enabling the valuable food-fishes to be dealt with on a large scale, and great numbers of their young to be placed on the fishing-grounds. This hatchery was completed early in the spring of the present year, and active operations in the hatching of flat-fishes have been carried on in it since that time. When the Board decided to proceed with the erection of a hatchery for sea-fishes, the writer visited the well-known establishment at Flödevig, near Arendal, and subsequently prepared a scheme for the erection of an establishment at Dunbar as far as possible on the model of the one in Norway. Captain Dannevig, the director of that institution, came to Scotland and visited the proposed site at Dunbar, of which he approved. This particular part of the coast was selected for a hatchery for several reasons, the most important of which were that the water was found to be well suited for the hatching of buoyant fish-eggs, and that the Magistrates and Council of Dunbar had cordially granted the use of certain adjacent sea-creeks necessary for the full success of the work. Dunbar is also within convenient distance of important fishing-grounds, and in the neighbourhood of the sea areas where most of the scientific fishery work has been carried on, and where, therefore, the influence of fish-hatching may best be ascertained.

The site of the hatchery (Fig. 1) is close to the Victoria Harbour, adjoining the old castle of Dunbar. The greater part of the buildings are situated within the Castle Park, on ground the use of which was granted for the purpose by the War Office, to which it belongs; the remainder is placed on ground adjacent, with the consent of the Magistrates and Council of the burgh. The hatchery consists of—(1) The hatching-house, in which the special apparatus for hatching the eggs is placed; (2) the spawning-pond, which contains the spawning fishes when the work is going on; (3) the chamber in which the fish-eggs are collected and the water which supplies the hatching-house is filtered; (4) the house containing the pumps and boiler; (5) the tidal pond, to serve for the retention of the spawners until the actual hatching-work begins, and thereafter as a reservoir of filtered water for the hatching apparatus. The position of these parts may be seen on the plan. During the progress of the work Professor McIntosh has on various occasions visited the hatchery, and has given the benefit of his great experience in the arrangement of many matters connected with it. The working-plans, and the plate accompanying this paper (Plate I.), were prepared by Mr. A. D. Melville, Dunbar.

1. The Spawning-pond.

This pond (Figs. 2 and 3) is constructed of concrete, from plans prepared by Messrs. Strain, Robertson, and Thomson, C.E. It is a very strong and solid structure, placed at a higher level than the other buildings, and sunk in the ground. The best London-made Portland cement was used, the test-bricks being capable of standing a tensile strain of 350 lb. to the square inch. The pond is 40½ ft. in length by 11 ft. 2 in. deep; the breadth at one end is 26½ ft., and at the other end 18 ft., the variation in the breadth being due to the nature of the ground. These measurements refer to the dimensions inside. The walls are all 4 ft. in thickness for the distance of 5 ft. from the floor, except that at the broader end, which is placed against a cliff; one of the walls is 4 ft. thick all the way to the top, the other two, which are heavily embanked outside, diminish in thickness to 3 ft., and finally to 2 ft. The bottom is also formed of concrete 18 in. thick, placed mainly on solid rock, and partly on a concrete arch, where the foundation was soil. A large amount of excavation, both of rock and soil, was necessary to prepare the foundation. The capacity of the pond is about 10,060 cubic feet, or over 62,000 gallons. It is situated at a distance of 27 ft. from the hatching-house, and on a higher level than the latter, so that the head or flow of water might be ample, as is explained later. The difference of level is such that the floor of the hatching-house is nearly 6 ft. lower than the bottom of the pond, and the level of water in the pond, when it is full, about 15 ft. above the level of the hatching apparatus, and about 10 ft. above the upper edge of the water-wheel. The spawning-pond is enclosed by substantial wooden walls resting upon and securely bolted to the concrete, and it is covered in with a roofing of galvanised corrugated iron resting upon eight strong couplings. The roof is lofty and capacious, and provided with eight skylight windows made to open, and which may be darkened when required. The upper surface of the concrete walls forms a convenient marginal pathway. A door is placed at the north-west corner, opening to the outside, and at the north-east corner the pond-house is continuous with the spawn-collecting and filtering chamber.

The feed-pipe by which the pond is supplied with sea-water is carried from the pumps along the top of one of the concrete walls to the south-west corner, or that furthest from the spawn-collector, where the overflow takes place (Fig. 2). Here it descends for 5 ft. into the pond; but, the terminal sections of the pipe being movable, the water can be poured in at any level. In order to empty the pond or lower the level of the water as desired, two 4 in. galvanised-iron pipes pass through the bottom of the wall next the hatchery. They are placed 6 ft. apart, and are united outside to a fire-clay drain-pipe 6 in. in diameter, which is embedded in concrete, and runs to the harbour, receiving on its way all waste water from the water-wheel, hatching-house, pump-house, &c. It was deemed advisable to have two outflow-pipes to diminish the risk of the accidental stoppage of one. Each of the outlet-pipes is controlled by a gun-metal cock, which may be opened and shut by means of a galvanised-iron rod attached to it, and worked from above by a key (Fig. 3.). On the bottom of the pond, lying loose on the concrete, there is a system—or, rather, two systems—of branched perforated piping, of diminishing diameter, and made of galvanised iron. One of these systems occupies one-half of the floor, and is connected with one of the 4 in. outflow-pipes; the other lies upon the other half of the floor, and communicates with the other outflow-pipe. The object of this arrangement is to allow of the bottom layer of water (which soonest becomes tainted) being rapidly drawn off without unduly depressing the level of the water in the pond. Above these pipes, about 18 in. from the concrete, a flooring of smooth boarding is placed, spaces being left between the boards in order to allow excrementitious matters, remains of food, &c., to pass through, when they may be quickly removed in the manner just indicated. It is upon this wooden flooring that the flat-fishes rest, and its height from the concrete floor, as also the width of the spaces between the boards, may be varied according to the species of fish being dealt with, or as other circumstances indicate. Three 2 in. galvanised-iron pipes are carried at different levels, but in the same vertical plane, through the wall of the pond into the filtering-chamber (Fig. 3). One is 3 ft., the second 6 ft., and the third 8 ft. above the concrete floor. By means of these pipes water can be drawn from the pond to drive the water-wheel or supply the hatching apparatus during the night, or at any other time, and this arrangement has been of the greatest service.

As has been said, it is into this pond that the adult fishes, males and females, are placed at the spawning-time. The spawning process, the ejection and fertilisation of the eggs, goes on naturally as it would in the sea, and the fishes require only to be fed and supplied with sufficient water to keep them in good health. The eggs, being buoyant, rise towards the surface, and are carried by the overflow from the pond into a special apparatus, the "spawn-collector," where they are retained, while the water passes away to the water-wheel. The spawn-collector might be called the egg-filter. Its construction is as follows: A horizontal wooden shoot, 3 ft. in breadth and 8in. deep, is let into a corresponding depression in the top of the concrete wall. It is about 6 ft. in length, and passes into a large rectangular horizontal wooden box, 6 ft. long, 4 ft. broad, and 16 in. deep, which may be considered an expansion or dilatation of the shoot. From the other end of this box the shoot which takes the overflow water to the water-wheel passes. Within the large box described is fitted a movable wooden frame, open towards the pond, but covered on the sides, bottom, and other end with haircloth, and projecting above the level of the water. It is so arranged that a space is left all around and below it. The object is to form a filter, with a large surface, in which the eggs will be retained, while the flow of water through it is comparatively gentle, and does not subject the collected eggs to injurious pressure. The level of the water is regulated by wooden slides. During the greater part of the day the flow of water through the pond is just sufficient to preserve the spawners in health and to turn the water-wheel; these are the two factors which regulate the quantity. The eggs carried into the collector in this process are, of course, retained; but, when the collection for the day is to be made, a large volume of water is poured into the pond, with necessarily a correspondingly large overflow, and the eggs are then collected in abundance. They are lifted out by means of a haircloth tray, the process usually occupying some hours. A slight modification, by the use of large bags of silk bolting-cloth, is being tried. The eggs, when collected, are transferred to the hatching-boxes.

2. The Pumping Apparatus.

As will be seen on the plan (Fig. 1), the boiler and pumps are placed midway between the spawning-pond and the harbour. The wooden house in which they are contained is 33 ft. in length by 18 ft. broad. The floor is concrete and the roof galvanised corrugated iron. It is divided by partitions into three compartments—the coal-house, 9 ft. in breadth, and capable of accommodating over 12 tons of coal; the boiler-house, 10 ft. in breadth; and the pump-room, 12 ft. in breadth. Drain-pipes for waste water communicate with the main waste-pipe from the spawning-pond. In selecting the pumps and motive-power careful inquiries were made as to various systems—gas-engines, oil-engines, pulsometers, &c.; but ultimately it was decided to use steam-power and direct-acting pumps. The boiler chosen was of the locomotive type, made of steel, by Robey and Co., Lincoln, and of 8-horse power. It supplies two direct-acting and double-acting high-pressure pumps, made by the Worthington Pumping-engine Company. They are specially adapted for pumping sea-water, being brass-lined and fitted with gun-metal valves. There are two double-acting plungers in each pump, which are placed high in the chamber, some inches above the suction-valves, thus allowing subsidence of sand or grit, and diminishing the wear. Each pump is capable of throwing from 2,040 gallons to 3,900 gallons per hour, according to the speed, and they work with the greatest smoothness, and without noise. They have been in almost continuous use since the end of February without giving the least trouble. The suction- or supply-pipes are two in number (Fig. 1), one being carried to the harbour entrance, a distance of about 205 ft., and the other to the tidal pond (referred to below), a distance of about 170 ft. They are both made of the best galvanised-iron steam-piping, 2½ in. in diameter, and provided with foot-valves and tinned-copper strainers. They are not fitted directly to the pumps, but to a central chamber between, which has gun-metal valves so arranged that water may be drawn—(1) By either of the pumps, or by both at the same time, from the harbour; (2) by either or by both from the tidal pond; (3) by either from the harbour and the other from the pond; (4) by one pump from both harbour and pond.

It was originally intended to draw water from the nearest point in the harbour; but it was deemed better to go to the entrance, where the water is not liable to be contaminated by the refuse from the herring-boats, as may occasionally happen at the parts nearer. From a little below the coping of the harbour quay the terminal portion of this supply-pipe is duplicated, one of the pipes ending below the level of low-water of ordinary tides, and the other being carried much further down, so as to be covered at all tides. Cocks are provided to both pipes, and the water for the hatchery is mainly obtained from the higher level, where it is more free from sand or weed. The delivery-pipe from the pumps is of the same material and diameter as the suction-pipes, and through it water is forced for supplying the spawning-pond and the hatching-house (Fig. 2). The distance from the pumps to the point of delivery in the spawning-pond is about 115 ft., and the height to which the water has to be forced is about 25 ft. At a point about 75 ft. from the pumps, before the pipe enters the spawning-pond house, a 2 in. branch pipe of galvanised iron is given off, which runs to the filtering-chamber, so that the hatching apparatus may receive a supply direct from the pumps. Cocks regulate the amount which passes either way—namely, to the pond or to the hatchery.

3. The Spawn-collecting and Filtering Chamber.

This chamber occupies the space between the spawning-pond and the hatching-house, and is therefore built on the sloping bank (Figs. 2, 3). It is 27 ft. in length, 12 ft. in greatest breadth, and 8 ft. in height, and is continuous above with the spawning-pond house. It is built of wood, roofed with galvanised corrugated iron, and has a flooring of cement, up the middle of which runs a wooden stairway; it is suitably lighted. The chamber contains—(1) The spawn-collector, which has been already described; (2) the shoot from this to the water-wheel and the water-wheel; and (3) the filtering apparatus. The filtering apparatus consists of two series of four wooden boxes, one series on either side of the central stairway. The object in having double series is that they may be used alternately, to facilitate the cleaning of the filtering-cloth. The boxes in each series are placed at successively lower levels, so that the water passes from one to another, and finally to the hatching apparatus. Each box is 4 ft. long, 2 ft. wide, and 18 in. deep, and is provided with two movable frames (2 ft. square), which fit into the top, and are covered with filtering material. The delivery-pipe from the pumps, previously described, on entering the chamber, divides into two, one for each series of filters. The water falls on the top of the filtering-cloth from the arms of a horizontal T pipe, 3 ft. long, which is perforated with a series of holes below (Fig. 2). Passing through the filter into the box, it escapes from the latter by a similar T pipe going out horizontally near the bottom of the box, and so on successively from box to box. The filtering material of the first box of each series consists usually of cheese-cloth, and the rest of flannel of increasingly fine texture. The pipes from the last box of each series join together, and the pipe is then carried on to the hatching-house. Such was the original arrangement of the filtering apparatus. It was, however, found that the boxes, from their size, allowed a considerable quantity of sediment to become deposited in them, especially the upper ones, and in stormy weather; to obviate this being carried on to the next filter, as was largely the case, the outflow from each box was raised from the bottom to near the top, so that the box was kept almost full of water, and facility afforded for the subsidence of suspended matter. The boxes are occasionally cleaned out by means of a hole in the bottom, which is closed by a plug. It was further found that by this method the water was forced with considerable pressure againt the flannel, tending to force through the suspended matter, and that the water usually only came in contact with and passed through a limited portion—that, namely, lying under the perforated pipe. Two modifications are being tried. In one the movement of the water in the box is reversed; it enters from a point midway between top and bottom, passes gently upwards through the whole surface of the flannel, and overflows into a pipe which enters the second box in like fashion. The frames in this case are wedged against rubber. The other method consists in tying on to the end of the pipe coming from each box a large flannel bag which lies in the box below and is changed from time to time. As may be seen from Mr. Dannevig's report, the water during the greater part of the season required comparatively little filtration. But during certain winds, especially from the south-east, the current comes along the coast and enters the harbour by the eastern entrance, passing out by the western end. In such cases a considerable amount of fine matter is carried in suspension in the water, and during its continuance a finer material was used for filtering, with complete success. The water in the spawning-pond was also in such cases rendered obscure, so that the fishes at the bottom could scarcely be seen, or not at all. To obviate this on such occasions the water for the spawning-pond will in future pass through a chamber in which most of the suspended matter may settle, and, when necessary, also through a flannel bag. It may here be mentioned that a great variety of crustacea, including *Copepoda*, *Isopoda*, and *Amphipoda*, as well as other small invertebrates, appeared in the pond; the presence of at least the larger forms is of doubtful utility. The filtered water in the hatchery is, of course, free from them.

The water-wheel is placed in a recess at the side of the hatching-house, at the bottom of the chamber, below the end of the shoot coming from the spawn-collector (Figs. 2, 3, 4). It is of the overshot variety, 5 ft. in diameter, and when doing its ordinary work makes two revolutions a minute, with a supply of from 700 to 800 gallons an hour; the waste water passes into a bricked well, and is thence conveyed by a fireclay pipe to the main drain. The axle passes through the wall of the hatching-house, where its movement is made use of in a manner to be shortly described. A large wooden sink for washing the filtering-frames is placed at the bottom of one of the series of filtering-boxes; it is supplied by water from the water-wheel shoot (Fig. 3). Water from the spawning-pond can also be obtained by means of the three pipes passing through the concrete wall, as previously mentioned, and led by canvas hose as required to the water-wheel or the filtering apparatus.

4. The Hatching-house.

This house contains the hatching apparatus, and the incubation of the eggs takes place here (Figs. 2, 3, 4). It consists of a substantial and ornamental wooden building, with double walls, 35 ft. in length, 24 ft. broad, and about 20 ft. in height. The woodwork was made in Norway, under the supervision of Captain Dannevig, and erected by local joiners on a foundation of brick and concrete, a space of 3 ft. being left between the flooring and the soil for the circulation of air and the convenience of piping. The house is provided with twelve large windows, abundance of light being desirable—four on each side and two on each gable. Between the latter, at either end, a door is placed. The room is capacious, airy, and well lighted, and very suitable for the work. At present sixteen of Dannevig's hatching apparatus have been fitted up. This apparatus, which forms the special feature in the Norwegian method, consists of an oblong wooden box 8 ft. in length, 2 ft. 3 in. in breadth, and 1 ft. deep. It is divided into two series of seven watertight compartments by one central longitudinal and six transverse partitions. The first and the last compartment in each series—those at the ends—are narrow, being 4 in. broad; the inflow and outflow pipes communicate with them respectively. The other five compartments in each series are wider, and it is in these that the hatching-boxes, which contain the eggs, are placed. Each hatching-box is 11½ in. long, 10¾ in. broad, and 11½ in. deep; the sides are of wood ⅝ in. thick, and the bottom of haircloth, with meshes fine enough to prevent the escape of eggs, while admitting a free circulation of water. The boxes are attached to the top of the transverse partition by leather hinges, and when the apparatus is full of water the free end floats up. The apparatus, each with its ten boxes, are arranged in pairs, four on each side of the apartment, and they are placed on trestles, so that the end furthest from the wall is about 3 in. lower than the end next the wall (Fig. 4). Two 1½ in. galvanised-iron pipes pass from the 2 in. supply-pipe, which enters the room from the filtering-chamber, one along either wall. They are provided with sixteen gun-metal cocks, one for each apparatus, by which the quantity of water can be regulated. The water from the cock falls into one of the narrow compartments, which communicates with its fellow, and when both are full it overflows into the first pair of hatching-boxes, and through the haircloth bottom into the compartments in which the boxes are contained; this overflows into the second pair of boxes, and so on until the narrow compartments at the lower end are reached, from which the water escapes by a vertical pipe passing through the floor (Figs. 3, 4). The water passes into the top of each hatching-box by a broad metallic spout, fitted into a depression, and it escapes from it through the haircloth bottom. As has been said, the hatching-boxes are hinged at one side; as the compartment becomes full, the free edge of the box is floated up, until it projects about 3 in. above the level of the water. This gives scope for the application of a special feature of Dannevig's method—the forcible depression of the box at intervals, which forces water up through the haircloth bottom. The current of water passing in by the spout falls on the surface, but it alone is insufficient to maintain the buoyant eggs, if present in large numbers, in a state of equal distribution throughout the mass of water. The up-and-down movement imparted to the boxes is accomplished as follows: A galvanised-iron rod, 7 ft. 3 in. long, is jointed to the middle of the upper end of the hatching apparatus, and passes down the centre between the series of boxes. It possesses five short transverse pieces, one resting on the free edges of each pair of boxes, and it is weighted sufficiently to keep the boxes depressed and submerged in the water. When the rod is raised the buoyancy of the boxes causes them to float up, as has been described. The movement of the rod is brought about by the use of an excentric wheel or cam, which revolves about twice in a minute, and is driven by a strap from a wheel placed on the axle of the water-wheel, which, as has been seen, projects into the room at one corner (Fig. 3). Resting on the cam is one end of a wooden beam, about 15 ft. in length, which moves on a hinge. The beam rises and falls on the cam, and this motion is conveyed to the galvanised rods by a system of wires, cranks, and pulleys, so that they are slowly lifted from the boxes, and allowed rather suddenly to fall upon them and press them into the water, which rises through the perforated bottom. By this means the floating eggs are kept equably distributed, as may be demonstrated by a dip-tube passed down to the bottom of the box. If the movement is stopped the eggs collect in a layer on the surface. The other end of the poised beam is weighted, so that the amount of work to be performed by the water-wheel in lifting the iron rods is very small. The speed of the wheel can be simply regulated. After a season's experience at Dunbar it may be said that Dannevig's system is simple and efficient, and requires comparatively little attention.

The fish-eggs obtained from the collector, as before described, are placed in the boxes, and a constant current of water maintained through them. Dead eggs are easily recognisable, and are removed from time to time.

5. The Tidal Pond.

It has been stated that one of the principal reasons which determined the selection of the site for the hatchery was the presence of convenient sea-creeks adjoining, the use of which had been granted for fishery-work (Fig. 1). These creeks, if enclosed, would provide a volume of pure sea-water amounting to a little over half a million gallons, and would furnish an admirable enclosure for rearing the fry, preserving large numbers of spawners, and for carrying on other important work. The Board have not yet been in a position to deal with these creeks; but for temporary purposes a small arm or inlet of one of them, which passes in under the ruins of the old castle, has been utilised (Figs. 1, 5). This sub-creek formed, indeed, a cave, roofed with a lofty natural arch of rock, closed towards the east by the massive masonry of the harbour and by a stone wall, and opening westwards by a narrow mouth, through which the sea from the creeks flowed and ebbed. It formed part of the ancient dungeon of the castle. The entrance, which is about 10 ft. wide, was closed by a strong wall of concrete, 13 ft. high and 8 ft. thick for 3 ft. up from the base, tapering thence to a thickness of 3 ft. at the top, the inside surface being vertical, and covered with a layer of fine concrete 6 in. thick. Two 6 in. iron pipes, provided at the inner ends with suitable gun-metal valves, are carried through the wall—one at the base, for the purpose of emptying the pond, and the other at a height of 5 ft., for the admission of water (see Fig. 1). The valve of the lower or flushing pipe is of the sliding type, worked from above by an iron rod, while the upper pipe is provided with a flap-valve, placed at an angle with the axis of the pipe. This valve works automatically, opening with the flowing tide and closing with the ebb, so as to retain the water which has been admitted. Suitable gratings are fixed to the outer ends of the pipes. In order to enlarge the area enclosed, a considerable quantity of rock was quarried from the bottom and partly from one side. The top of the concrete wall came to within about 3 ft. of the upper limit of the arched entrance, this space being left open. But it was found necessary to close this gap, since in storms seaweed was carried over the wall, sometimes in considerable quantities. It was also found that, notwithstanding the presence of a fine-wire grating on the outer end of the inflow-pipe, seaweed was battered through in a comminuted form by the force of the waves, and accumulated on the bottom of the pond. To obviate this a strong wooden box was made, 10 ft. long, 2 ft. wide, and 18 in. deep, which was bolted erect to the inside of the concrete wall, and into which all the water coming in by the pipes entered. It was made watertight, and was fitted with two filtering-frames on indiarubber jointing, through which the inflowing water passed, and with a door similarly jointed opposite the outflow below. Cheese-cloth was found to be an efficient filtering material. This arrangement has given complete control of the water, and has been found to work well. In stormy weather the water entering can be passed through any suitable filtering material and rendered limpid. As has been said, the apparatus works automatically: when the tide rises outside above the level of the upper valve and of the water inside the valve is forced open (and the extent of the opening can be regulated), and water pours into the filtering-box, and thence into the pond; when the tide ebbs and the level of the sea outside falls below the level of the water inside the valve closes and the water is retained. The floor of the pond has been covered with a layer of concrete, and a doorway made through the eastern wall, which opens to the harbour quay. Light is admitted by natural apertures and by the glass panels of the doorway. A gangway passes from the masonry of the quay to the concrete wall, and gives access to the filtering-box and valves.

The tidal pond thus constructed is about 42 ft. in length; the breadth varies, but may, on an average, be taken at about 20 ft., and the depth of water at high tides is about 9 ft. or more. It is capable of containing about 7,560 cubic feet, or 47,000 gallons, of water. One of the suction-pipes from the pumps is carried into this pond, from which filtered water may be drawn in stormy weather, when the tides are low, or as desired. It also serves as a small storage-pond for the spawners to be used in the hatchery, and is very serviceable in this respect, but not of sufficient size to accommodate all the fishes required.

6. The Work at the Hatchery.

The hatchery at Dunbar has been established for the purpose of enabling many millions of the young of the valuable food-fishes to be placed on the fishing-grounds each year. At the similar institutions in the United States, Norway, Canada, and Newfoundland the species of food-fish which has been almost exclusively dealt with is the cod, which forms a very important element in the fisheries of those countries. Experiments on a comparatively small scale were also made by Dannevig in hatching the eggs of the flounder and common dab, and by the United States Fish Commission with the winter sole (*P. americanus*). In this country the cod, while a most important factor in the fish-supply, is not the most valuable, and there is no very definite evidence that it is diminishing in numbers. On the other hand, there is clear evidence that the valuable flat-fishes, such as turbot, soles, lemon soles, and plaice, are becoming much more scarce than they were even a few year ago—especially on inshore grounds, and in comparison with the increase in the machinery of capture. This has been shown in previous reports of the Fishery Board, in various statistics published by the Board of Trade, and by the inquiry made by the Parliamentary Committee on Sea-fisheries last year. It was therefore decided to begin the work at Dunbar by hatching those flat-fishes in as large numbers as possible—namely, turbot, soles, plaice, and lemon soles.

The Plaice (Pleuronectes platessa).

The plaice, which is the earliest of the flat-fishes to spawn, was the first dealt with; but, as the hatchery was not sufficiently completed to allow operations to be begun until early in March, full advantage could not be taken of the spawning of this species. The spawning season of the plaice extends from about the middle, or even the early part, of January until the end of April or beginning of May. In December and February a number of living plaice were obtained by the "Garland," and put into the tidal pond. Stormy weather, however, interfered with this source of supply, the "Garland" being then unable to trawl offshore; and it was found necessary to send the mate of the "Garland" on board one of the local trawlers, provided with large tubs, through which a constant circulation was maintained, and in which the most suitable specimens might be preserved. From the comparatively small size of the tidal pond, and the lateness of the season, it was necessary to transfer the fish, on landing, at once to the spawning-pond, a procedure open to several objections. Even with so hardy a form as the plaice, a considerable proportion are injured in the process of capture, especially when, as in this instance, they are heavy and bulged with spawn. Such injured specimens are not always easily detected, and they mostly die subsequently and cause trouble. They tend to taint the water, and may even inhibit the spawning of the healthy fishes confined with them in the pond. The proper course is for the individuals intended to be used as spawners to be first of all kept in the tidal pond, or similar enclosure, until those that have been injured have been weeded out, and only the healthy vigorous fishes which have become accustomed to confinement transferred to the spawning-pond. This implies gradual collection of the fishes before the spawning season; and the best spawners should be kept from year to year. None of the fifty-eight plaice which had been put into the tidal pond in December and February and transferred to the spawning-pond in March succumbed during the season. The greatest number of adult plaice in the pond at one time was about 390, but it might well have held between five and six hundred. In regard to the proportion of the sexes, the males were in rather less numbers relatively to the females than obtains in the sea; but almost all the eggs examined were found to be fertilised. It is probable that, from the comparative quietude and the limited volume of the water, a smaller proportion of males than naturally exists will be sufficient to insure impregnation of the eggs, and thus the functional capacity of the pond may be considerably increased.

The number of eggs of the plaice collected from the spawning-pond between the 9th March and the 8th May was 27,250,000, and the number of fry hatched and placed on the fishing-grounds was 25,060,000. The percentage of loss was therefore very low, amounting to no more than 4·4 per cent. Had it been possible to begin the work early enough to include the whole of the spawning period of the plaice, and to stock the pond to its full extent, three or four times the number of plaice-eggs might have been obtained.

The Sole (Solea vulgaris).

This very valuable fish is extremely scarce in Scottish waters; the number obtained by the "Garland" in the course of a year might be counted on the fingers. In order to obtain a supply for the hatchery, the "Garland" proceeded last summer to the Yorkshire coast, and carried on trawling there, with the permission of the Committee of the North-eastern Sea-fisheries District.* The soles were preserved alive in tubs, but a considerable mortality occurred, although the utmost precautions were taken. Most of them were placed at selected spots in St. Andrews Bay, and as many as it was judged the tidal pond would contain were put into it. But many of them died subsequently, and on examination were found to possess patches of congestion on the lower surface or the fins, where the skin had been abraded. The pond at this time was not completed, and the difficulties from ingress of seaweed and from other causes were considerable. The soles were removed to allow the bottom of the pond to be concreted, and, some time after they were replaced, numbers succumbed, apparently by the action of the concrete before it had hardened. But when the difficulties referred to were overcome the remainder were preserved throughout the winter in perfect health. It was necessary, however, to increase their number before beginning operations, and as this fish is very scarce on the east coast of Scotland, and inquiries elicited the fact that the "Garland" would be unable to procure them in the spring off the English coast, it was arranged, through the instrumentality of Mr. Alward, of Grimsby, and Mr. Holt, to send Mr. Liston with tubs on board a large North Sea trawler—the "Tynecastle." This vessel was fishing from the 29th April to the 5th May off the coast of Holland, and a large number of soles were caught, but it was found impossible to preserve them alive. Out of several hundreds which had been tried in the tubs only twelve were living when the English coast was sighted, and these perished before they could be landed. They all seemed to have been too much injured in the trawl, which was dragged for six or seven hours. Mr. Liston came to the conclusion that this method would not succeed. At this stage the Lancashire Sea-fisheries Committee, through Mr. John Fell, the Chairman, and the Superintendent, Mr. Dawson, kindly agreed to allow their steamer—the "John Fell"—to trawl for soles off the Lancashire coast, specially for the use of the hatchery. In this case the trawl was dragged only for short periods, the soles were vigorous when brought to deck, and Mr. Liston had no difficulty in preserving them alive while on board. In order to transport them from Fleetwood to Dunbar by rail three galvanised-iron tanks, with compartments for ice, lent for the purpose by Mr. Anderson, fishmonger, were used. These tanks were 3 ft. long, 20 in. broad, and 16 in. in depth. The railway journey, *viâ* Carlisle and Edinburgh, occupies about ten hours. Three journeys were made. On the first fifty soles were placed in the boxes; on arrival at Dunbar only six were alive (and they died in a few hours), and the water was full of slime. On examination of the dead fishes it was found that their surfaces were much rubbed and the scales removed. The lids fitted loosely, allowing the water to jolt and splash about, and it was evident the soles had succumbed chiefly by friction against the bottom and against one another from the movement of the train. After some experiments on the behaviour of particles in vessels containing water and a little air, and in vessels containing water and devoid of air, when shaken about, it was found that the most suitable mode was to exclude air altogether, and to bring the fish in—so to speak—a block of water in which wave-motion could not occur. The iron boxes were accordingly so arranged as to be kept during the journey absolutely full of water, by means of watertight lids. Wooden boxes were also made, furnished with lids fitting on a depressed fillet, covered with indiarubber strips, so as to be quite watertight, and provided with ice-tins. This plan succeeded well. On the second journey forty soles were brought, and they were all alive, save one, on reaching Dunbar, and the water was clear; but five died later. The temperature during the journey was kept at or somewhat below the original temperature of the sea-water in which they were contained. On the third journey forty-two of forty-seven were brought in good condition. Air was at intervals blown into the boxes through tubes, by means of bellows. The soles thus obtained were at first placed in the tidal pond. When sole-eggs (unfertilised) were observed in the water the fish were transferred to the spawning-pond, a special arrangement, described below, having been adopted in order to allow turbot at the same time to be contained in the pond. The experience with the sole shows that it is a fish very easily injured, and requires careful handling and treatment. Those to be used as spawners in hatching operations should be collected some time before the spawning season.

The Turbot (Rhombus maximus).

The difficulties in procuring a supply of living turbot were also great. One of the staff was on board an Aberdeen steam-trawler for a few weeks for the purpose, but, owing to bad weather and other causes, comparatively few were caught, and it was found impossible to keep them alive. The local fishery officer (Mr. John Murray) succeeded, on board a Granton trawler, in procuring several specimens, some of which were, however, a little injured, and died later. The best mode was found to be to get the fish on the Ayrshire coast, where they are caught not by the trawl, but in set-nets, and are not so much injured. Adopting the same method as in the transport of soles, seven were brought on one journey, twelve on another, and twenty-one on a third, making forty in all, of which seven died. The number of turbot now in the spawning-pond is thirty-eight, of which about twenty are females and the rest males.

The modifications, above referred to, made in the spawning-pond in order to adapt it for containing spawning soles and turbot at the same time, are as follows: The wooden floor has been raised to a height of 3 ft. from the concrete bottom, about 8 ft. of water being therefore above it. The pond has been divided into two compartments by a transverse partition of stout waterproof canvas, extending from about 6 in. above the level of the water to nearly the concrete bottom, and carried, therefore, more than 2 ft. below the wooden flooring on which the fishes rest. At the sides the canvas is wedged firmly and accurately against the concrete wall, the only communication between the two compartments being close to the concrete bottom. Each compartment is supplied with a separate inflow-pipe, and a wooden shoot, provided with suitable watertight sliding-pieces, is carried from the second compartment to the fixed spawn-shoot. By this means the overflow can be taken from either compartment as desired, and the collection of eggs made alternately, by using only the inflow and outflow of the particular compartment. The possibility of the floating eggs from one compartment finding their way, against the current, down through the flooring, for a distance of nearly 3 ft., to the concrete bottom, and up into the next compartment, is exceedingly remote. At all events, from the dissimilarity of the eggs of the sole and turbot, such an occurrence, should it take place, can easily be

* The work of the "Garland" was guided and assisted by the efforts of Mr. John Woodall, of Scarborough, who sent his yacht "Valotta" to aid in the work; and by Mr. Ernest W. L Holt, of the Marine Biological Association, who has on various occasions courteously given information and assistance.

detected by subsequent examination of the eggs collected; and, from the practical point of view, it would be of little importance so long as the period of incubation approximately corresponds in the two cases, and the fry are to be placed on the same grounds. Sperms, no doubt, might occasionally pass, by their own movement, from one compartment to the other by the route indicated; but there is little apprehension on this account, as it is pretty certain, from the observations made with the plaice, that the eggs are impregnated by the attendant male at the moment of their ejection.

The Lemon Sole (Pleuronectes microcephalus).

This is one of the most valuable of the flat-fishes in Scottish waters. The spawning season extends from the end of April or beginning of May to the beginning of September; the spawning is greatest in July. While the "Garland" was carrying on her ordinary trawling-work, such specimens were preserved alive as seemed suitable for hatching purposes, and as many of these as could be accommodated were placed in the tidal pond. It was decided to collect the eggs of this fish in the tidal pond, and for this purpose a special arrangement has been made.

7. The Treatment of the Fry.

With the present arrangements, it is necessary to transfer the fry directly from the apparatus in which they are hatched to the fishing-grounds where they are to be placed, without the intervention of a period in rearing-ponds. The larval fishes, after emerging from the eggs, are retained in the hatching-boxes until the yolk is nearly absorbed and they are capable of eating; but without large enclosures, such as exist in pisciculture establishments for freshwater fishes, no attempt can be made to feed them; they are therefore placed in the sea while they are still in the larval stage. At this period, it need scarcely be said, the fry of flat-fishes resemble those of round fishes, such as cod or haddock. The eyes are placed one on either side of the head, and the body is symmetrical. The characteristic appearance of a flat-fish is absent; it is only after an interval of two months or so, which are passed in the surface waters, that this flattening is completed, and the young creature acquires the form and habits of the adult, and becomes fitted for life on the bottom. There can be no question that the destruction of the young from natural causes during this period of pelagic life is very great, and that a great step in advance would be made if it were possible to protect them artificially until they were about to complete the transformation which adapts them for a bottom life, and enables them to secure natural protection by resemblance to the ground on which they lie, and by burrowing. They are still, at this stage, very small, and multitudes could readily be dealt with. For the purpose of thus dealing with them it is necessary to have control of a large body of water, such as is shown in the sea-creeks on the plan (Fig. 1), in which many millions of fry could be simultaneously reared for the necessary period before planting them on the fishing-grounds. The supply of food naturally existing in such a volume of sea-water could be largely increased by keeping various invertebrates, at the time when they are spawning, in tanks shown at A on the plan (Fig. 1). A reference to the plan will show that a flow of water from the spawning-pond could be maintained through these tanks into the creeks, which would thus receive a constant supply of water charged with embryos and minute organisms, upon which the young fishes live. The rearing of the young fishes in this way for a few weeks would very greatly increase the usefulness of the hatchery to the fishing industry.

8. The Capacity of the Hatchery.

The present hatching-house contains, as has been stated, sixteen of Dannevig's hatching apparatus, each of them capable of accommodating at one time about 5,000,000 cod-eggs, or 80,000,000 altogether. Since, during the continuance of the spawning season of any species, the hatching-boxes may be refilled at least twice—newly collected eggs replacing the fry which have been hatched and removed—the capacity of the present hatching apparatus may be stated as equal to about 160,000,000 cod-eggs during one season. Plaice-eggs are larger than those of the cod (about 1·6 mm. compared with 1·2 mm.), and a smaller number go to a box, but the number that might be dealt with in the course of the season may be stated at about 100,000,000. The eggs of the sole are about the same size as those of the cod, and those of the lemon sole and turbot slightly smaller, so that the working-capacity of the present apparatus in the course of a year may be put down at several hundred millions. Further, in arranging for the more costly parts of the hatchery care was taken to provide for sufficient water-supply and spawning-space for a much larger number of hatching apparatus. Dannevig's experience at Flödevig is that about 92 gallons of water are required per hour for each apparatus—that is, for about 5,000,000 cod-eggs. For sixteen apparatus the supply therefore requires to be about 1,500 gallons per hour, and, adding 800 gallons for the spawning-pond, the total quantity for 80,000,000 cod-eggs is about 2,300 gallons per hour. The pumps are, however, capable of throwing over 7,000 gallons per hour, and thus the quantity of spawn that may be dealt with may be more than doubled by a comparatively inexpensive extension of the hatching-house and increase in the number of apparatus.

The first year's work, so far, has been satisfactory. The boiler, pumps, water-wheel, and all the apparatus have been in continuous use without any hitch occurring; and the filtration of the water was accomplished without much trouble, and it has proved eminently suitable for hatching-work. The greatest difficulty, as has been said, was in procuring supplies of spawners in time to take full advantage of the spawning season. At the sea-fish hatcheries in the United States, Norway, and Newfoundland ample accommodation has been provided for large numbers of spawners—at Woods Hole, for instance, as many as 3,000 adult cod have been accommodated at one time. Thus, by obtaining, before the spawning season begins, the full number of adult fishes required to keep the hatchery going at its full working-capacity, the number of fry produced may be very largely increased, and at a trifling additional expense, since it costs almost as much to produce 50,000,000 as it does to produce 200,000,000.

(Diagram of Dunbar Fishery attached, Plate I.)

Woods Hole Marine Station, Mass. (Superintendent, E. F. Locke.) (Plate III.)

This hatchery is situated in a sheltered bay protected by an island outside. The following are the kinds of fish propagated there: Cod, lobster, flat-fish, tautog, sea-bass, and mackerel. In 1896 the number of eggs collected from all species amounted to 225,950,000, and the number of fry planted from these eggs was 165,284,000. Water for the hatchery is pumped up to a cistern with a 12-horse-power engine. The cistern holds 18,000 gallons, a quantity sufficient to supply the boxes with water for twenty-four hours, in case of repairs having to be made to the machinery. The bottom of the cistern is 6 ft. above the top of the boxes, so as to give the pressure required.

Fish of the different kinds dealt with are either netted by the United States Commission steamers or purchased from fishermen, who are paid a fair price to land the fish alive at the station. On arrival there the cod-fish are confined in crates which are moored inside a pond protected on all sides by a wharf, which breaks the force of the sea in stormy weather, and affords a sheltered place for handling the fish when taking the eggs.

The process of taking the eggs is similar to stripping trout or salmon, with this exception: that the eggs of the Salmonoids all separate from the ovaries at the same time, and the fish are stripped at the one operation; whereas cod only yield part of their eggs at a time. The mature eggs are taken, and the fish turned back once more into the crates, and in a few days they are stripped again. When the ovaries have discharged all their eggs the fish is released into the ocean. Of the cod-fish penned annually in the protected basin at Woods Hole only about a quarter yield good eggs. The dry method of fertilisation is generally used.

Flat-fish, from which eggs are obtained, are plentiful during February near the Woods Hole Station, and as many as seventy are sometimes taken in a net at one time. The ripe fish captured are stripped artificially as soon as they are caught; and the unripe ones are confined in wooden tanks, supplied with constantly changing water, until ripe. The eggs are quite small, there being thirty in a lineal inch. Unlike the eggs of the cod, haddock, and some other marine fishes, they do not float, but sink to the bottom of the vessel in which they are held. When first deposited the eggs are very adhesive, and stick together in one mass, or in clusters of different sizes. This adhesiveness is overcome, in a measure, by thoroughly washing them. The use of dry powdered starch is very effective for this purpose, and mixes readily with salt water, and admirably overcomes the glutinosity of the eggs. Its action is purely mechanical. The period of incubation at a mean temperature of 37° Fahr. is seventeen to eighteen days.

Flat-fish eggs may be hatched in several different kinds of apparatus, but the Chester jar is most used, in combination with the McDonald tidal box, employed in incubating cod-eggs. The fry are quite hardy, and stand transportation well. In planting them they are put into the transportation-cans commonly used for such purposes, and are taken in a boat to the localities in which the brood fish are found.

The McDonald automatic tidal boxes are used for buoyant ova, such as the cod, mackerel, and the most pelagic fishes. This apparatus (Plate IV.) is the outcome of long experience and study, and has as its special features the closest possible simulation of natural conditions. The motion or circulation is got by means of a brass siphon-cap, which fits over the upper end of the waste-pipe. The cap is a tube, closed at the top, 9 in. long and 1¼ in. in diameter. It is kept at any desired height on the waste-pipe by wire springs in the cap. By virtue of the siphon attachment the water in each box rises to the height of the top of the waste-pipe, and begins to run over; this partly exhausts the air in the cap, more water rushes in, and the pipe becomes filled with water; then the siphon begins to act, and takes off the water to a level of the bottom of the siphon-cap. Usually the siphon-cap is pushed about half-way down the waste-tube, although the height of the water in the box after the discharge of the siphon is regulated by the manner is which the eggs are working. About seven minutes are required for the water to be drawn down and the box to again fill, and, approximately, two-fifths of the water is taken off at each discharge. By this arrangement the water in the boxes is constantly rising and falling automatically. The movements of the waves are thus simulated, the eggs are kept in constant circulation, and fresh water is continually entering the boxes. When the supply of water is well regulated the motion of the eggs is perfect. I have watched them for hours, and could detect no sign of "banking."

Size of Trough and Boxes.

The dimensions of the troughs in which the boxes are placed are as follows: Length over all, 13 ft.; width, 2 ft. 7 in.; depth, 12 in.; and they are made of 1½ in. timber. The box compartments are separated by 1¼ in. partitions, and are 22 in. long, 12 in. wide, and 11 in. deep. The hatching-box is made of ½ in. timber, and is 22 in. long, 12 in. wide, and 9 in. deep in the centre, but only 8 in. at the ends. The bottom slopes upward towards the ends of the box, and is covered with linen scrim. A wooden strip, ½ in. thick, and conforming to the shape of the bottom of the box, extends the length of the box.

The water is introduced to the egg-box in two places; the most important supply comes in through a ¼ in. hole through the centre of the partition and end of the box immediately above the lengthwise strip. The water goes through the small hole with considerable force, creating a strong current, and keeping the eggs in a rotary motion. This current is one of the principal features of the apparatus.

Cod-fry are planted almost as soon as hatched out. About two hundred thousand can safely be carried in a 10-gallon can. Deposits are usually made on the natural spawning-grounds.

Gloucester Marine Station, Mass. (Superintendent, C. G. Corliss). (Plate V.)

This station is situated on Ten-pound Island, off the Massachusetts coast. The hatchery is fitted up similarly to the one at Woods Hole—that is, with McDonald tidal boxes for all buoyant eggs and Chester and McDonald jars for heavy eggs.

The water-supply tank holds 15,000 gallons. As at Woods Hole, the water is pumped up with an engine. The hatchery has room for 25,000,000 eggs, which are collected in a similar manner to those at Woods Hole. Cod and flat-fish are principally dealt with. Mackerel are also hatched, but great difficulty is experienced in getting a supply of eggs.

Gloucester is the principal fishing port on the Atlantic Coast, and there are also large fish-curing and packing establishments there. Cod and mackerel are the principal fish dealt with.

IMPORTATION OF MARINE FISH.

Beyond doubt the successful transplanting of some of the more valuable marine fishes of the Northern Atlantic, such as the herring, cod, and turbot, to the Southern Pacific Ocean would be a valuable work, worth a considerable expenditure on the part of the inhabitants of these islands at the antipodes. To the general public the transport of the ova or fry of these fish may seem an easy matter, but the conditions surrounding it are widely different from those involved in the transport of *Salmonidæ*, which are now well known; but little is as yet known as to the best means of carrying delicate marine ova or fish for great distances, involving a journey of some six weeks' duration, and with great changes of temperature. The short journeys they have been carried in European waters are really no test, and any attempts to import these fish into New Zealand waters at the present juncture would, I am confident, be highly experimental, and involve costly plant being placed in any steamer fitted up to try the experiment.

What I would suggest is that in the first instance the Fisheries Board for Scotland be requested to ask some of their scientific experts to make experiments at their marine stations, with a view of determining the best and most economical method of procedure before the colony authorises the fitting-up of the necessary tanks and apparatus and the payment for skilled attendance during the voyage, all of which probably means a considerable outlay. I should like to see the question of transport reduced by experimental work at the hatcheries to the same level as that of salmon- and trout-ova before a shipment is authorised, so that we may be able to say that, under certain conditions, and with proper care on the voyage, the fish or ova should arrive in good condition. It would be an interesting study, both from a scientific and practical point of view, and a study which I feel sure would be undertaken *con amore.*

The necessary plant for receiving the consignment would have to be provided in this colony, and it would be wise, I think, to have observations as to temperature and conditions out here recorded and sent to the experts trying the experiments. If a marine scientific station is established here all this could be carried out by correspondence, and much valuable information might be noted. Once a marine station is established out here I think crabs and lobsters should be brought over and kept in captivity for breeding purposes, Mr. Purvis, the late chief engineer of the "Ionic," having brought some out from England some time ago in tanks fitted up for the purpose.

I attach some interesting letters and remarks bearing on the subject, which will be useful for reference :—

LETTER FROM PROFESSOR MCINTOSH, M.D., LL.D., F.R.S., F.R.S.E., ETC., ST. ANDREW'S MARINE LABORATORY.

DEAR SIR,— Gatty Marine Laboratory, University, St. Andrew's, 17th September, 1898.

In reply to your inquiry concerning the possibility of transmitting the eggs or examples of the herring, plaice, turbot, haddock, and cod to New Zealand, I beg to make the following observations :—

In the first place it is taken for granted that the local experts have satisfied themselves that the conditions of marine life and the environments are such that a reasonable prospect of success would attend the arrival of living examples of the species mentioned; secondly, that they are assured that the manipulation of the native forms—with all the help science can give—would be less advantageous than the introduction of the northern species. Considerable experience is necessary to determine these problems.

1. *Herring.*—So far as my experience goes, there should be little difficulty in transporting this species. Thus in an early report of the Scotch Fishery Board it is recorded that Baltic herring were acclimatised to fresh water, and then transported in an ordinary sailing-ship to the Marine Laboratory at St. Andrew's. They lived in fresh water there for more than a year, their loss being due to their activity, for, by leaping out of their own vessel, they fell into a tank of sea-water, and were killed. The hardihood showed by these acclimatised herrings could not be surpassed, and when further explained that the sailors simply put them (in the Baltic) into their ordinary hogshead of drinking-water, and used it for drinking as usual on the homeward voyage, the strength of the case is increased. They did not give the herrings food on the voyage to St. Andrew's, as such would have been inconvenient to their drinking-water. Moreover, they caught the herrings with peas on hooks. We fed them on earthworms. I am of opinion that this method would be far more successful than by attempting to keep the eggs at low temperatures, though it is true the latter are comparatively slow in development (much quicker, however, than the eggs of the salmon and trout). Of the five forms mentioned, however, the eggs of the herring are alone worthy of further experiment. I am not sanguine of success with them.

2. *Plaice.*—Two sizes of plaice (kept in separate tanks) should be experimented with—viz., (*a*) 7 in.–8 in. plaice, and (*b*) adult plaice of 14 in.–18 in., the former being of the small race. The former—(*a*)—should be fed on crustacea, &c., caught in tow-nets, and on small mussels in stock; the latter—(*b*)—on mussels, lobworms, &c.

3. *Turbot.*—Specimens of 11 in.–12 in. should be taken. Food: Mussels, young sand-eels, and shrimps. Both these and the plaice are extremely hardy, and would live for a long time without food.

4. *Haddock.*—I doubt whether this form could be successfully transported, though 8 in.–10 in. specimens in a "welled" ship might be tried, and the temperature carefully regulated. Acclimatised examples should be taken. Food: Mussels, shrimps, lobworms, and earthworms.

5. *Cod.*—Two sizes of cod should be tried—viz., (*a*) 10 in.–12 in. acclimatised in tanks, and (*b*) adults in a "welled" ship or similar arrangement. Food of (*a*): Mussels, shrimps, lobworms, and earthworms. Food of (*b*): Shore-crabs, Norway lobsters, whelks, mussels, limpets, and anemones. First experiment should be with (*a*).

Large concrete tanks should be ready at a suitable locality in New Zealand for the arrival of the specimens. An ample supply of pure and cool sea-water should be arranged in connection with the foregoing. It will be observed that I do not recommend experiments with the eggs of the plaice, turbot, haddock, or cod.

Lastly, failure at first should not discourage the Government. A careful and experienced scientific man should accompany the ship, and accurate records should be kept. From these deductions could be made for future improvements.

I am, &c.,

L. F. Ayson, Esq. W. N. MCINTOSH.

N.B.—When at my instigation the Scotch Fishery Board transported English soles to Scottish waters we used closed tanks, aerated by pipes and bellows. This was the most successful method.

SOME REMARKS ON THE POSSIBILITY OF INTRODUCING EUROPEAN SEA-FISHES INTO NEW ZEALAND WATERS. (By H. C. Dannevig, Cam. Philos., Sea-fish Culturist to the Fishery Board for Scotland.)

THE unquestionably great benefit to the colony in general which would attend a successful introduction of European food-fishes is of sufficient importance to justify attempts being made in that direction were the prospect of success ever so faint. But in the following I shall explain why, in my opinion, the prospects in reality are very encouraging, and that success is bound to follow judiciously planned and carefully attended experiments. The desired result is conditional to two points of equal importance, viz.: (1) Whether it is at all possible for European sea-fishes to live in New Zealand waters; and (2) whether it is possible to transport the species out there. As to the first question, it cannot, of course, be definitely answered until positive proofs are established; but, as a comparison of the physical conditions—temperature, &c.—show a considerable similarity between the New Zealand and European waters, no justifiable doubt can be entertained on this point. There is no apparent reason why our sea-fishes should not thrive out there equally well as the trout, although the success with the latter does not necessarily prove anything in relation to the former. The second condition, or the possibility of transporting the species out there, is next to be considered. As already suggested, this may be attained in two ways—(1) By taking out the eggs, or (2) by taking out the fishes. These modes have both advantages and disadvantages, and in the following is shortly referred to what I consider the most important features.

(1.) *The Transport of the Eggs.*

It is well known that the duration of the incubation of fish-eggs is influenced by the temperature of the water. The extent of this influence is very considerable, as will be seen from the following: Eggs of the cod will develop in about eight days and a half in water of 14° centigrade (57·2° Fahr.), in about fifteen days and a half in 6° centigrade

(42·8° Fahr.), and in about twenty-three days in water of 3° centigrade (37° Fahr.). The variation in time, as will be seen, is very great; but as yet little has been done with a view to ascertain accurately the limits of this variation.

The nearest approach to date is perhaps an experiment carried out by myself a few years ago, when I succeeded in keeping cod- and haddock-eggs at a temperature of 1° centigrade (30·2° Fahr.) for thirty-five days. The pulsation of the heart was then visible, and, upon being transferred to warmer water, the eggs soon hatched. I calculated the duration of incubation of cod- and haddock-eggs to be forty-two days in water of the above-mentioned temperature. This experiment, however, was carried out under difficulties, and I had some reason to believe that the low temperature was not always maintained accurately. If this is so, the time given will be below the mark. But any point of uncertainty in this respect can easily be determined with accuracy, and no doubt it will be found possible to retard the hatching of the cod- and haddock-eggs to between forty-five and fifty days—a time sufficiently long to allow of the transport being completed.

But the time of incubation of fish-eggs varies also according to their size, in this way: that under the same conditions the larger eggs take a longer time to develop than the smaller. The eggs of the cod and the haddock have nearly the same diameter, and the hatching-time is also the same. Plaice-eggs are larger, and take a longer time; while the eggs of the turbot again are smaller, and take a shorter time; in fact, I have some doubt whether it will ever be found possible to retard the development of the eggs of this valuable flat-fish sufficiently long to allow of the transport, and the herring-eggs would only be little more favourable in this respect.

From my present experience in sea-fish culture I feel justified in expressing as my opinion—(1) That the time of incubation of the plaice-eggs can be prolonged to more than forty-five days; (2) that the cod- and haddock-eggs probably can be retarded to forty-five days; and (3) that the eggs of the herring and the turbot probably cannot be retarded to forty-five days without seriously influencing the vitality of the embryos. This, I believe, is all that can be said on this point at the present time; but automatically arranged experiments, as already mentioned, would give certainty on these points, and at once decide the question. If the outcome of such experiments was, for instance, that cod- and haddock-eggs could be retarded sufficiently long, then it would be a relatively easy matter for a person thoroughly acquainted with the peculiarities of sea-fish eggs to carry them safely to their destination. But it must be kept in mind that the mortality amongst the larval sea-fishes in nature is very great, and, although the surviving percentage undoubtedly would be much increased by judiciously arranged rearing in confinement, it would be necessary to deal with a very large number of eggs in order to counterbalance the natural mortality and possible local influence so as to establish practical results.

(2.) *The Transport of the Fish.*

It is well known that some fishes are far easier kept in confinement than others, whether young or old, and of the species here in question I have no hesitation in stating that the plaice and the cod are the easier and the haddock and the herring the more difficult to deal with in this respect.

To attempt transport of the adult fishes would be no easy task, and, even if successful, would not be advisable. I should recommend immature fishes for such a purpose; they are far easier to deal with generally, and in the present exceptional case it would be well to make use of all available advantages. But, this being done, I firmly believe that a considerable number of young cod, haddock, plaice, turbot, and other fishes could be landed in New Zealand without much difficulty, and that success would also attend similar experiments with young herring if well studied and attended to. In connection herewith I have lately planned an arrangement of specially constructed tanks, &c., which, when properly fitted up in the ship, would maintain an abundant water-circulation automatically that would not be interrupted by the pitching of the vessel in rough weather, when it is not always easy for the attendant to perform his duties.

The next thing to be considered would be how to make the most of the landed materials, be it eggs or young fishes, in order best to attain to the ultimate desired result. To transport sea-fish eggs to New Zealand and hatch them there for the mere purpose of planting the fry on the coast would be an undertaking of questionable value, which I could not recommend; and, even if the young fry obtained were first reared through the post-larval stage before planting, the progress in practical result would necessarily be slow, as the number dealt with could only be very limited. The same should be said in regard to planting the young fishes that were transported out there, although the chances in this case would be somewhat better. The only proper course to follow would be to have established a permanent stock of breeding-fishes, which yearly would be able to produce great quantities of eggs; and the materials transported from Europe should therefore be utilised for such a purpose. With that in view, it is easily seen what method would be most preferable, because it is clear that if it is possible to transport the young fishes that already have passed the most critical stage in their life, then the risk, trouble, expense, and loss of time which would be connected with the transport of the eggs and subsequent rearing of the fry to the same stage would all be avoided, and the chances of success thereby much increased. It is logical, therefore, that attempts with eggs should only be resorted to in cases when the other means failed. The rearing of the new-imported fishes to maturity would not involve much difficulty when proper care was taken, while the mortality in this stage is always very low. From a sufficiently large stock of spawners great quantities of eggs would yearly be produced, and the best possible chance of having the species introduced on the coast would thus be available. There is this to be said of artificial sea-fish culture: that the working-expenses of a hatchery are not much different whether the number of fry produced is twenty millions or a hundred millions; but, as the practical result, of course, must be in proportion to the number of fry planted, it is always advisable that such hatching is carried out on a large scale.

I have the greatest confidence in the above-outlined scheme for the introduction of European sea-fishes into New Zealand waters; and, in regard to cod, haddocks, plaice, turbot, herring, and other species, I must express as my firm belief that carefully attended experiments with either of them have all prospects of success. But this opinion, which is based upon many years of practical experience in pisciculture, is given with the reserve that the practical part of the work is planned and carried out by a person well acquainted with the culture and habits of these fishes. I need hardly mention that in the various details there are a great many points to be observed which, though simple in themselves, would become obstacles to an inexperienced person, and a series of attempts would be likely to fail before the necessary practical knowledge was acquired. As the saying is, "What is worth doing is worth doing well," and for all interests and purposes it must strongly be recommended that risks of above-mentioned nature are avoided as much as possible. An expert on the subject would find difficulties enough to overcome as it is; but, while I feel sure of the latter bringing the matter to a satisfactory issue, I should hesitate in saying the same with regard to attempts made under any other conditions.

Dunbar Marine Hatchery, September, 1898.

Letters from G. M. Dannevig to Mr. Ayson.

Flodevigens Udklaekningsanstalt, G. M. Dannevig, Arendal, Norway,
24th September, 1898.

Dear Sir,—

The question of introducing the North Sea fishes to New Zealand is not new to me; it is many years since I first thought of it. Of course, it is possible—I will say it is a very easy job—as far as cod and plaice are concerned. Cool-chambers on board the steamer are absolutely necessary. I do not know enough about turbot to have an opinion.

Herring-spawn on gladd could be kept back in cold water; the very hardy might to a certain extent be reared in ponds till mature.

The haddock may be troublesome, but, suitably arranged, it may succeed after all. Of course, you will have to arrange suitable ponds in New Zealand and a hatchery for the propagation of the marine fishes.

When I said the job was easy I meant it to be planned in all its details by competent persons, and to be carried out by one who has a thorough knowledge of the subject. Theories are of no use whatever if not joined to practical experience.

But how will the fish thrive over there? I do not know much about the physical conditions over there. If you wish to have my opinion on this head, please send me the necessary materials, and I will look it over.

I remain, &c.,

Mr. L. F. Ayson, 13, Victoria Street, London. G. M. DANNEVIG.

DEAR SIR,— The Marine Hatchery, Dunbar, 14th September, 1898.

I am aware that the possibility of introducing the European lobster to New Zealand has been under consideration out there for some time. Although not referred to in your letter of the 31st August, I sincerely hope that the idea has not been abandoned now, when its realisation in connection with the project of introducing sea-fishes generally would only be an additional item of little trouble, but of immense importance.

The lobster-eggs, or berries, being far hardier than most sea-fish eggs, their transport in great numbers would not involve much difficulty, and, as their hatching extends over the greater part of the year, no retarding process would be required. If desirable, the adult animals may be taken out as well. That this is possible, and can be carried out on a fairly large scale without great cost, has been illustrated by an experiment that I carried out a few months ago, when lobster was kept under conditions that can be arranged on board ship for sixty days.

If you should like any experiments carried out in regard to packing lobster-eggs, &c., I shall be pleased to be at your disposal.

Faithfully yours,

L. F. Ayson, Esq. H. C. DANNEVIG.

SCIENTIFIC INVESTIGATIONS BY T. WEMYSS FULTON.

447, Great Western Road, Fishery Board for Scotland, Aberdeen,

DEAR SIR,— 29th September, 1898.

In reply to your inquiry as to the possibility of transporting certain of our food-fishes or their ova to New Zealand, I am of opinion that the difficulties of doing so are not such as to prevent the success of the attempt. It seems to me, from the experiments we have made here in transporting turbot and soles from England, that the chance of success in the case of flat-fishes is considerable, provided the fish are in good condition to begin with, and the arrangements carefully made. In obtaining adult soles and turbot for our hatching at Dunbar we found we could bring them long distances by rail in boxes so made that there was no jar in transit, and with the temperature kept moderately low.

A somewhat similar arrangement aboard one of the steamers could easily be made, and the small quantity of food that might be required *en route* could be kept in the refrigerator. If an experiment of this kind is attempted two points are important—(1) That the fish should be of a certain size; (2) that they should be carefully selected from a stock which has been living for some time in confinement, so that one may be certain they are in good health. Fish caught by the trawl, although they may present no obvious injury, frequently die in the tanks a few days, or it may be weeks, after they are caught. Others may be kept, and have been kept, for years in good condition. These remarks refer to flat-fish. With regard to haddock and cod, I think the difficulties would be greater—especially with the former—but not such as to preclude a trial. Herrings would probably be the most difficult to transport alive, as they more readily succumb to unfavourable conditions.

The difficulty of transporting fertilised eggs, and retarding their development on the way, appears to me to be more formidable than dealing with the fish themselves. In the first place, we do not know how long we can retard the development and hatching. We made certain experiments on the point, and, although we succeeded in keeping the fertilised eggs of cod and haddock for forty days before hatching occurred, I am not satisfied as to all the conditions of the experiment.

At the instance of Mr. G. M. Thomson, of Dunedin, who has taken a great interest in the subject, other experiments were commenced, but they could not be completed owing to the transfer of our marine station from Dunbar to Aberdeen. They will be resumed as soon as we can do so, and the temperature will be regulated automatically, and all precautions taken.

But, even if it is possible to delay the hatching of the eggs for a sufficiently long period, it is questionable if this method is the best. The eggs of all the species you mention, with the exception of the herring, are pelagic and buoyant, and this circumstance would present certain physical difficulties in transit. Then, again, they would require to be at once transferred to the place where the experiment is to be tried.

The best course, in my opinion, is to make an experiment in transporting nearly mature fishes, which would spawn shortly after their arrival. The fertilised spawn could then be collected and dealt with as we do here. You would also by this means, I think, get a much greater quantity of spawn than by transporting the eggs.

If it is decided to make the trial, I think there would be little difficulty in providing you with the fish required.

Believe me, &c.,

T. WEMYSS FULTON,

Scientific Superintendent of the Fisheries Board of Scotland.

LETTER FROM MR. J. C. EWART.

DEAR SIR,— University, Edinburgh, 28th September, 1898.

I made quite a number of experiments some years ago to find out, if possible, how best to introduce some of our fish to the New Zealand waters. I think it will be best to take young fish, feeding them on the way either with artificial food or with minute organisms caught from day to day by pumping water through a net. The fish could be kept for some time before starting, and they would require to have special enclosures provided against their arrival. It would be useless turning them out at once into the sea. Experiments might first be made on a small scale.

You will, however, doubtless learn more in America than I can tell.

If when you return you pass through Edinburgh I would like to talk matters over.

Yours, &c.,

J. C. EWART.

PART II.—FRESH-WATER FISHERIES.

SALMONIDÆ.

Every one throughout the colony must recognise the great value of the work already done by the different acclimatisation societies in establishing trout in our waters, and attempting to deal with the salmon problem. Some years ago the rivers and lakes in this colony contained only a few varieties of indigenous fish of no great value—such as eels, a variety allied to the grayling (Native name, *upokororo*), and some smaller fish of little value. Now these waters are swarming with trout.

Viewed in the light of recent developments, it is apparent that a serious mistake has been committed in liberating the same variety of trout in nearly all our waters. It would undoubtedly have been wiser to have devoted different rivers and lakes to different varieties of fish, such as the rainbow trout, American brook char, Loch Leven variety of trout, and the whitefish.

I believe, myself, that some of the early importations of trout-ova were crossed with the inferior bull-trout variety (*S. eriox*), and that this strain is one of the reasons why a considerable number of coarse large fish are found in our rivers. Those rivers which are still unstocked, such as some of the streams at the southern end of the West Coast, ought to be carefully conserved, and only stocked with suitable varieties, on the recommendation of experts. One of the principal questions to deal with is that of salmon.

Atlantic Salmon (Salmo salar). (Plate VI.)

Hitherto efforts made to establish this most valuable fish in New Zealand rivers have been unsuccessful. There are in this colony a considerable number of rivers where the natural conditions are unquestionably in every way favourable, and the reason why the fish do not return after their migration to the sea is a problem which every effort should be made to solve.

I consulted a number of the most practical scientific men in Great Britain who have studied the life-habits of salmon, and gave them, in detail, a history of the attempts made in this direction during the past twenty-five years. I also gave them a description of the New Zealand rivers, and the temperature and other conditions of the ocean around the coast (so far as is known), and they all agree that predacious fish taking the smolts as they migrate into the estuaries and bays is one of the most likely causes of the non-appearance of Atlantic salmon in the rivers; and they are all in favour of rearing the fish in a fishery, with fresh- and salt-water enclosures, to the breeding age before liberating.

In connection with this subject some correspondence will be found attached.

Pacific Salmon.

While undoubtedly that king of fish, the Atlantic salmon, is perhaps the finest sporting fish in the world, still due regard must be had to the other fine varieties of salmon inhabiting the Pacific Ocean, whose economic value is very great.

No true salmon feed in the rivers, but ascend them purely for breeding purposes, and I do not see how any harm could arise from attempting to acclimatise several different varieties, some of which may succeed although others may fail. Large quantities of the ova of the Pacific salmon can be obtained from the United States Fisheries Commission and from the Canadian Government for the cost of packing and transport, so that the total cost of landing, say, 1,000,000 ova from either Baird, Battle Creek, or Fraser River would probably not amount to more than £100. The fact that these salmon inhabit a wide range of the Pacific Ocean points to the probability that they might be established more readily on our coasts than the Atlantic variety.

From the year 1876 to 1878 ova of the quinnat variety were landed in New Zealand, but were, unfortunately, scattered about in small numbers, and in many cases were not put in the most suitable rivers. I think a further trial should be made with these varieties, more especially in view of the fact that apparently some fish caught in the Waitaki River have been identified as belonging to the Pacific salmon, or *Oncorhynchus*, family.

The four varieties which I would recommend the importation of are the quinnat salmon (*Oncorhynchus tschawytscha*), the sockeye or blue-back salmon (*O. nerka*), and two smaller varieties—the hump-back (*O. gorbuscha*) and the silver or Coho salmon (*O. kisutch*). The following is a short account of each of these varieties:—

Quinnat or Chinook Salmon (O. tschawytscha): Plate VII.—This is the most important variety, and no other salmon in the world compares with it in size. It has a wide geographical range, and great commercial value. It prefers large rivers, and it is supposed it does not wander far from the coast. It runs immense distances up the river to spawn, and would probably only suit our large rivers, such as the Waitaki, Clutha, or Buller. Though not a good sporting fish, except in tidal waters, where it will take bait, it is a magnificent fish for the table and for canning and preserving purposes.

Blue-back or Sockeye (O. nerka): Plate VIII.—This is a smaller variety of salmon, which frequents the Fraser River in immense numbers. It ranks next to the quinnat in commercial value, its flesh being a rich red, very suitable for canning, though the average weight is only about 5 lb. It has also a very wide geographical range in the Pacific Ocean.

Hump-back Salmon (O. gorbuscha).—The smallest variety of Pacific Salmon, and, as a rule, frequents smaller rivers, and does not run any great distance from the coast. The ova of this variety would probably be difficult to get, but it is a valuable fish.

Silver or Coho Salmon (O. kisutch): Plate IX.—This is a hardy variety, of graceful form and fairly good flesh. It has a wide geographical range, and does not ascend rivers any great distance from the ocean.

The last two smaller varieties are found on the Asiatic as well as on the American coast, and might probably be easily established in our waters.

The steel-head (*Salmo gairdneri*) (Plate X.) is a very fine variety of sea-trout, inhabiting a wide range of the Pacific Ocean. There is a controversy going on in America as to whether this fish is not a rainbow-trout with sea-going proclivities, and, as rainbow-trout have been successfully introduced into some of our rivers, I think we should try to solve this problem with the fish we already have in this country before attempting to import ova of the sea-run fish from America. If we can solve this problem here, where there are no steel-heads, it will be of great interest to the scientific world.

In connection with the foregoing remarks I have the honour to make the following suggestions: (1.) That a salt-water enclosure be established near the mouth of some river in the south of New Zealand, where experiments could be tried with Atlantic salmon in the direction indicated in the attached correspondence. (2.) That the offer made by the United States Fish Commission and the Canadian Government, of an extensive supply of Pacific salmon-ova, be accepted, and a large number imported. I would suggest that the ova of the Pacific salmon be hatched out and reared to the yearling stage before liberation; and that a considerable number be placed in rivers on the West Coast, where there are no trout, having due regard to the suitability of such rivers to the variety placed in them. Some of the Pacific varieties might also be dealt with in a separate salt-water enclosure from that in which the Atlantic salmon are experimented with.

By following out systematically for a few years a course such as I have sketched out, I think we should be able to establish one or more varieties of salmon on the coast of New Zealand, which would amply repay the colony for all the cost and labour hitherto expended.

Taking into consideration the fact that sea-run trout thrive excellently on our coasts, I feel confident that we can find some variety of salmon which will suit the surroundings of these Islands, and in time establish a fishery of great value. It is worth trying, and I do not think this colony should abandon the attempt until the question has been properly threshed out. It would also, I think, be wise to watch some of the best tributaries of the Waitaki and Aparima Rivers, in order to ascertain if any salmon are working up for spawning purposes. "Eyeing-out" stations up one of these rivers would give an opportunity of doing so, and millions of trout-ova could be collected there and held to the proper stages for distribution to the other hatcheries and outlying districts in New Zealand in the same way as the outlying stations are managed in America.

Attached to this report will be found two interesting plates: Plate XII. showing a reproduction of a snapshot photograph of a run of salmon up the Fraser River, and Plate XIII. showing a scow fish-wheel catching salmon for the canneries on the Columbia River.

Sea-trout.

Sea-trout (*S. trutta*) would be a valuable fish to import, and the ova of this variety could be obtained from Captain Omerod, Wyresdale Fishery, Lancashire, or elsewhere in Great Britain; and when importing ova from Great Britain this should not be lost sight of.

Whitefish (*Coregonus clupeiformis*). (Plate XI.)

The success attending the importation of the 2,000,000 of the ova of these fish I brought over from America with me, and liberated in Lake Kanieri, makes me hopeful that we may succeed in introducing this most valuable fish into our lakes.

The whitefish is one of the most important group of fresh-water fish in North America. There are several varieties, but the common whitefish is the best of the tribe, both as regards delicacy of flesh and size. Examples weighing over 20 lb. have been taken, but the average weight is about 4 lb.

In 1893 the catch for the market in the United States was over 8,000,000 lb., giving a market value of $330,000; and during the same year the catch in Canada amounted to 30,000,000 lb., valued at $1,535,000.

Whitefish are caught chiefly in gill-nets set at or near the bottom in deep water, although considerable numbers are also caught in pound-nets, traps, and seines. They are very plentiful in Lakes Erie, Huron, Michigan, and Superior. The opinion expressed by some authorities a few years ago that they could not be established in small lakes has now been proved to be quite erroneous. Two small lakes—Canadaque and Herman, in the State of New York—have been successfully stocked, and they are now sufficiently numerous in Lake Herman to permit of netting for the market.

While more is known of the habits of this species than of any other member of the group, many phases of its life-history are still obscure, and it remains in deep water most of its life. It is not a sport fish, and, owing to its small weak mouth, is seldom taken with a baited hook. It subsists on minute animal food, chiefly crustaceans, molluscs, and insect larvæ, the food of the fry and young fish being almost wholly small crustaceans.

The character of the water, temperature, and conditions surrounding many of our New Zealand lakes seems to point to their suitability for whitefish. The real question is whether the food in these lakes is suitable.

Whitefish have in the past been liberated in Lakes Rotoiti in Nelson and Coleridge in Canterbury, but I believe the attempt to liberate them in Lake Wakatipu was a failure. I should like very much to have an opportunity of testing Lakes Rotoiti and Coleridge with nets, to see if any can be caught; and, as reports of similar fish being seen in Rotoiti are circulated, I think this should be done.

I would respectfully recommend that a large number of the ova of whitefish be imported for several consecutive years, so as to endeavour to establish them firmly in some suitable lake, from whence others could be stocked.

Lake Char.

The alpine, Windermere, and Saibling variety of America would all be valuable species of char to import for our lakes as opportunity may occur.

Attached to this report will be found a short description, with plates, of some of the typical hatcheries in America. "The History of Howietoun," written by the late Sir J. G. Maitland—a book in circulation in this colony—gives such an accurate and interesting account of this typical hatchery that it seems hardly worth while repeating portions of it—for that is all it would amount to—in this report.

A Typical Trout and Atlantic Salmon Station, Craig Brook, Maine, U.S.A. (Superintendent, Charles E. Atkins.) (Plate XIV.)

The water-supply for this station is from Craig's Lake. The overflow from this lake flows down a rocky creek two miles before reaching the fishery, and as it is pure and well aerated it is just the right thing for hatching ova and rearing fish. It has plenty of fall, and is diverted as required, for the stock-fish ponds. The ponds for stock fish are extensive, very well arranged, and are constructed with a heavy flow of water through each.

While a varied stock of trout are kept, and a large number of their eggs hatched at Craig Brook, yet the main feature of this station is the collection and hatching-out of Atlantic salmon. Stock salmon are netted from the Penobscot River during the "summer run"—usually from the 15th May to the 1st June. These fish, as caught, are conveyed in floating cars to Dead Brook, where they are confined in large fresh-water enclosures till ready to spawn, in October. The superintendent states that these fish give their eggs as freely and in as good condition as fresh-river salmon in the spawning season.

The growth of live food in the ponds in which the fish are kept has been the subject of special study. Ponds that had been empty the preceding winter were in the spring fertilised with various animal and vegetable refuse. They were then stocked with different species of Crustacea native to the State, including shrimps (*Gammarus*) and entomostraca. These forms all multiplied there, some of them enormously, but no means was found of inducing continuous or frequent reproduction of them, and the young fish soon exhausted the supply.

A Typical Trout Station: Northville, Michigan. (Superintendent, Frank N. Clark.) (Plate XV.)

This is a large and well-equipped station. The splendid new hatchery is capable of accommodating about 15,000,000 ova, and the ponds are well constructed, and plentifully supplied with good water. The hatchery is fitted up with the Clark and Clark-Williamson's boxes. The last named is really a combination of the Clark and Williamson's tray-boxes, and acts very satisfactorily.

The stock of fish consists of American brook char, English brown, and Loch Leven trout, while large quantities of lake-trout (*Cristivomer naymacush*) eggs are collected from the fish in the great lakes. Brook char eggs are also collected from wild fish netted in the streams of Michigan.

There are several field-stations worked in connection with the Northville establishment. These stations are established on the part of some stream or lake where the fish to be dealt with are plentiful. A shed is built large enough to hold the necessary hatching-boxes, and a house is also built to accommodate the fishermen. The fish-eggs are collected and incubated, and when eyed are packed and sent to Northville to hatch out, or to any other place requiring a supply. It is found that by working these field or eyeing stations very large quantities of fish-eggs can be collected and distributed to other districts at a very small cost.

A Quinnat Salmon Station: Battle Creek Station, California. (Superintendent, John P. Babcock.)

This is the most remarkable salmon-propagating hatchery in the world; the total number of eggs secured for hatching in 1896 was over 25,000,000, and last season it had risen to 45,000,000. This station is situated near the mouth of Battle Creek, a tributary of the Sacramento River. Immediately above its confluence with the Sacramento Battle Creek is deep and lagoon-like for a distance of three miles, and salmon gather there in vast numbers before entering the shallow waters where their spawning-grounds commence. At the head of the lagoon is a retaining rack, which prevents the salmon ascending further up the river. In the rack placed across the river to stop the passage of fish it is customary to build large wooden traps, in which to capture the salmon. The trap is simply a square enclosure of vertically placed slabs with a V-shaped entrance, similar to that of an ordinary pound-net.

During the heavier run of fish immense numbers are caught. In the winter of 1896 the rack was kept up without a break from the 6th October to the 23rd November, and in that time 5,000 ripe female fish were taken, averaging 18 lb. in weight. The male salmon taken outnumbered the females by three to one.

The taking of spawn is performed by ten men, and the method of handling the fish and fertilising the eggs differs a little from that employed at other stations. At all the other salmon and trout hatcheries the dry system of impregnation is used, but at Battle Creek the superintendent first puts about a pint of water in the spawning-dish. Two spawn-takers operate at the one dish—one stripping the female and the other getting the milt from the male: thus practically the eggs and milt fall into the dish at the same time. The percentage of eggs fertilised is claimed to compare favourably with that obtained at other stations.

The hatchery at Battle Creek has 160 hatching-troughs, 16 ft. by 16 in. wide and 6½ in. deep. Twenty-four gallons of water per minute passes through each trough; and the average temperature is 52° Fahr. The eggs are incubated in deep wire trays or baskets, 24 in. long, all the width of the trough, and 6 in. deep. Each tray will hold 30,000 salmon-eggs. The eggs suffer no injury whatever from being packed together in this manner, the water being supplied in such a way that it forces itself up through the eggs, partially supporting them.

A Typical Whitefish Station: Put-in Bay, Lake Erie. (Superintendent, J. J. Stranahan.) (Plate XVI.)

This station is located in a sheltered bay on Put-in Bay Island. The site was chosen because of its central position for collecting ova and distributing the young fish hatched to different parts of the lake. The water for hatching is obtained from the lake through a pipe that extends 100 ft. into the lake. Pumps elevate the water to the loft of the hatchery, where it is received into supply-tanks, and from whence it is distributed through the hatchery by the usual methods of piping. The two supply-tanks have a capacity of 8,000 gallons, and are necessary to give an equal pressure in the pipes and to provide a reserve supply of water in the event of cessation of pumping.

Whitefish-eggs are hatched in the McDonald and the Chase jar. The former is in more genera use, although both give satisfactory results. For convenience and for economy of space and water the hatching-jars are arranged in tiers, constituting what is known as a "battery." The structure of a battery, with its complicated system of service-pipes, supply- and waste-troughs, with its jars and attachments is rather hard to describe clearly, but an idea can be got by reference to the plates in my possession.

A battery in full working-order, with all the jars filled with eggs, is a very interesting sight, and demonstrates the great advance made in fish-culture of late years, particularly in America, where semi-buoyant fish-eggs are manipulated in such vast numbers. The splendid results obtained is sufficient proof of the scientific and practical methods employed.

The supply of whitefish-ova is got by netting fish from the lakes. To obtain the large quantity required it has been found necessary to capture the fish in favourable weather, early in the season, and then to confine them in pens until ripe.

The penning is done in crates made of 3 in. battens, with a 2-in. space between each, to allow a free interchange of water. The crates are generally 8 ft. square and 6 ft. deep, placed in two rows, bound together with planks, and so anchored that there is a depth of not less than 4 ft. of water maintained through the rise and fall of the lake or river.

Whitefish are stripped and the eggs impregnated in the same way as is done with salmonoids. The dry process of impregnation is generally considered to be the best system, as a much larger percentage of fertile eggs is obtained when this system is adopted.

Correspondence *re* Salmon.

Circular Letter from Mr. Ayson to Fish Experts.

Dear Sir,—

As you are well aware, the Government and people of New Zealand are exceedingly anxious to establish the British salmon in the waters of that colony, but so far all attempts have been unsuccessful. Since the first consignment of ova was landed in Dunedin in 1878 thousands of pounds have been spent on the importation of ova and hatching out and liberating the young fish.

In that time several hundreds of thousands of healthy young fish have been turned into the best rivers, where they thrive well through the parr stage, and smolts have been caught on their way down to the estuaries. But no salmon has ever yet been caught that has returned from the sea. With regard to the disappearance, or, rather, non-appearance, of salmon from the sea, several theories are set forth as being the cause; the general one held is that, as smolts descend, they are devoured by voracious fishes that are known to frequent the estuaries and bays in great shoals. Difference in temperature of the water around the coast, want of suitable food, and strong ocean currents setting off the coast are all mentioned as the probable cause, but as yet all is theory, as nothing definite is known.

For a considerable time since I have held the opinion that the fish should be reared in confinement till they came to the breeding-age before being turned out. My plan is this: Take one of the most suitable rivers in the colony; on its estuary erect a fishery, consisting of hatching-shed, fresh-water rearing races and ponds, and a number of salt-water enclosures. Hatch out and rear the young fish in the fresh-water races till they come to the age when they want to go to the sea, then allow them to drop down into the salt-water enclosure. Give them plenty of room and feed, and so hold in as near natural conditions as possible till they are near spawning. When within a week or so of spawning open the gates, and let them out into the river—if possible, when there are signs of a fresh. So near spawning, the fish must go up stream and deposit their ova naturally. Let this work be carried on systematically for a number of years, importing every season a consignment of ova sufficient to keep up the necessary stock of fish at the fishery; though it is possible it might be of considerable advantage to strip some of the fish reared instead of turning them all out to spawn themselves.

This plan, I think, would, at any rate, help, if not altogether solve, the problem whether it is possible to establish British salmon in New Zealand waters. It has two special advantages over the old system of turning out artificially reared fry. The first is, the ova is deposited, the young fish hatched out and reared naturally in the river; and the opinion is still very strongly held that a great number of salmon return to the river they were originally reared in. The second advantage is that when liberated from the fishery the fish are of such a size as to be able to take care of themselves against enemies when going to the sea after spawning.

Knowing something of the great interest you take, and experience you have had, in dealing with fisheries, I should be glad of your opinion on "the New Zealand salmon problem"—whether you consider the plan I suggest practicable—and would be thankful for any suggestions of how you think it should be altered, added to, or improved.

I have, &c.,
L. F. Ayson,
Fishery Commissioner for the New Zealand Government.

Reply from Mr. J. J. Armstead.

Dear Sir,— Solway Fisheries, Dumfries, 13th September, 1898.

I have carefully read and considered the circular you have laid before me, and I am of opinion that your plan of making a number of salt-water enclosures is a very good one, and well worth a trial.

It is known that salmon take considerable journeys when in the sea, and that naturally they prefer a wide area to range over. They have, however, been retained in fresh water until they have matured their ova both in New Zealand and in Scotland, and these ova have been hatched and have produced fish.

In this country the salmon, after having once been to sea, are supposed to take very little food whilst in the fresh water, but in the salt water they feed voraciously.

I should be doubtful as to the entire success of your experiment if absolutely wild fish were being dealt with, but I am of opinion that by rearing the fry in ponds and feeding them until ready to go seaward they would become so far domesticated as to adapt themselves to surrounding circumstances, and that therefore there is before you a reasonable hope for success.

I think there is little doubt about the cause of the disappearance of your salmon—viz., the predacious fishes in the bays. After being protected on their first journey they will have grown large enough to take care of themselves, as the trout have done. The larger the salt-water enclosures the better, and ample provision should be made for the flow and ebb of the tide.

I should rather be inclined to allow the fish free access to the river whenever they wished to go, as they would only obey the dictates of nature in availing themselves of such an opportunity, and it might be hurtful to them to keep them back.

I am, &c.,
L. F. Ayson, Esq. J. J. Armstead.

Reply from Mr. R. B. Marston.

Dear Mr. Ayson,— St. Dunstan's House, Fetter Lane, London, E.C., 18th July, 1898.

I have carefully considered your letter of the 15th, with your proposed scheme for attempting to stock the New Zealand rivers with salmon, and I most certainly think that it is a scheme well worth trying—in fact, I think so well of it that I shall suggest it to the gentlemen who have determined to make another attempt to introduce salmon to the Thames, though I fear it is doomed to be a failure until we get the water purer; for ten miles it is from 20 to 35 per cent. too foul for even roach to live. We want 50 per cent. of oxygen for fish to live, and get only from 15 to 25 or 30 per cent. You have no such difficulties, and though I have had an idea that it is voracity and numbers of the fish of prey in your seas which stops samlets returning as grilse or salmon to your rivers, still I should much like to see your experiment tried.

Sir James Maitland's experiments showed that salmon can be reared in captivity until ready to spawn.

Yours, &c.,
R. B. Marston.

EXTRACT from a LETTER of REPLY dated 2nd September, 1898, from Mr. ALEXANDER LUMSDEN, Superintendent of the Tay Salmon-fisheries.

I think the experiment you propose a good one, and well worth a fair trial. I would not advise a very large scheme at first, and it could be extended after you have reared your first grilse.

EXTRACT from a LETTER of REPLY dated the 8th September, 1898, from Mr. JOHN THOMPSON, Manager of the Howietown Fishery.

The system previously followed for the introduction of the British salmon to New Zealand waters has not been successful, and you wish my opinion on the plan you have sketched out—viz., after hatching the ova and rearing the young salmon in fresh water near the estuary of one of your rivers, to retain them in salt- and fresh-water enclosures alternately, as they require, till near ready to spawn. It is a big scheme, but it seems to be quite practicable if gone into thoroughly; and it is certainly worth making a big effort to bring about so desirable a result, when there is such a reasonable chance of success.

So near spawning when released, the grilse must ascend the river and deposit their ova, and the young fish would thus be reared naturally, which is a big point.

After spawning, would be of such a size as to be able to hold their own amongst any enemies in the estuaries and bays.

REPLY FROM MR. WALTER E. ARCHER.

DEAR SIR,— Board of Trade, 29th September, 1898.

I have received your letter of the 24th instant, asking my opinion as to the New Zealand salmon problem, and particularly as to the chances of success of a scheme for hatching and rearing salmon-fry in fresh waters, and subsequently placing and retaining them in salt-water enclosures until nearly ready to spawn.

With regard to the previous attempts to stock the New Zealand waters with fry, I am not sufficiently conversant with the scale on which the experiment was made or the manner in which it was carried out to offer an opinion.

The experiment you now propose making—viz., of placing smolts in salt-water enclosures and retaining them there until ready to spawn—so far as I am aware, has nevr been tried before. The experiment most nearly analogous, perhaps, was that of placing some salmon-smolts in a salt-water tank at the Brighton Aquarium. One of these lived for seven years, but only reached 5 lb. in weight. The Howietown experiment (see Day's "British and Irish Salmonidæ," p. 103) differs from that which you propose making in that the smolts were confined in fresh-water ponds until nearly ready to spawn. But the result of this experiment would seem to justify the attempt which you propose making—to rear the fish under more natural conditions.

The success of the venture will, no doubt, depend largely—(1) on the food-supply, and (2) on the size of the enclosures. With regard to the first point, it may be useful to you to refer to the evidence contained in the Scottish Fishery Board's reports on salmon-fisheries as to—(1) the nature of the food actually found in salmon coming in from the sea ("Fourteenth Annual Report," Part II., p. 77); (2) the digestive power of the stomach and intestine of such salmon ("Investigation on the Life-history of Salmon," p. 171); and (3) the connection between the particular article of diet and the pigmentation of the muscle of salmon ("Life-history of Salmon," p. 162).

With regard to the second point, it would appear at first sight that the larger the enclosures the more likely is the experiment to prove successful, and within certain limits this, no doubt, is the case—*i.e.*, the fish are less likely to be stunted in growth in fair-sized ponds, such as those at Howietown, than in a tank the size of the Brighton Aquarium. The evidence, however, as to the migration of salmon given on pp. 60, *et seq.*, of the Scottish Fishery Board's eleventh annual report, Part II., shows that salmon, when in the sea, travel such immense distances in search of food that it would be quite impossible in such an experiment as that proposed to produce conditions even approaching those under which salmon live in their natural state. Under these circumstances, it would seem desirable that the enclosures should be of moderate size—narrow and long, rather than square or circular—so that the fish might be within reach of the food thrown them by the attendant. I am, &c.,

WALTER E. ARCHER,
Inspector of Fisheries.

L. F. Ayson, Esq.

RECOMMENDATIONS.

Considering the attempts to stock New Zealand waters with salmon-fry have been carried on for about twenty-five years with no satisfactory result, and that the Government and people of the colony are prepared to make further efforts to accomplish this important end, I would recommend the adoption of a carefully planned scheme, something on the lines sketched out in my circular-letter, and carry on the work systematically for a number of—say, six or ten—years. As past efforts have only been carried out at intervals, considerable difficulty has been experienced by the Home authorities in getting the ova from certain rivers where it is desirable to obtain a supply, and also it is not always easy to secure the requisite space in a suitable hatchery, where the necessary skilled supervision and proper appliances for packing are available. Under these circumstances, it follows that the experience of those who have had the charge of the operations one year are not available on another occasion. If, on the other hand, it were settled that there should be an annual shipment of ova for, say, six or ten consecutive years, it would be possible to make such complete arrangements as would obviate these drawbacks and secure the best results at the minimum cost.

Returns prove that there has been a considerable decrease in the quantity of salmon netted for market in all the Scotch rivers during the last two years, and also in the number of spawning fish that ascended the best rivers in the breeding season. On this account the Salmon Fishery Boards on most of the rivers are increasing and enlarging their hatcheries, and will not supply ova for export till their own boxes are fully supplied.

Orders for ova should be sent early in the season, reaching the Home Office not later than the 1st September each year. This would give sufficient time to make application to the different Fishery Boards and for arranging to get permission to collect the ova. While on the River Spey I interviewed the Duke of Richmond and Gordon's Commissioner (J. Muirhead, Esq.), who stated he considered there would be no difficulty in obtaining permission to get a supply of ova from their fisheries.

When visiting the German Government's large State hatchery at Hüningen I was informed by Professor Haacke that they can supply any quantity of Rhine salmon-ova packed and ready for transit at 5s. 6d. per thousand. As this fish is identical with the British salmon, this fact might prove of great utility in the event of our being unable at any time to secure ova from Scotland.

PART III.—ANIMALS AND BIRDS.

The country near Taupo and in the Urewera country, in the North Island, comprises a large area of poor land, covered for the most part with pumice, which, though not suitable for farming or grazing, would make a splendid reservation for deer, antelope, and game birds. Further south the great back-bone range of mountains in the North and South Islands, with its slopes, would answer a similar purpose, on which the timber ought to be preserved, for climatic reasons as well as to preserve our native fauna and flora.

In a great country like America it has been found necessary to set aside large reservations for a like object, and to pass extremely stringent laws; and there is no doubt that it would be wise in these, the earlier days of the history of this colony, to take a leaf out of their book, and add to the attractiveness of this land by preserving our remarkable indigenous birds, importing useful and interesting animals and birds, and conserving areas of forest.

While in America I ascertained, as far as I could, the cost of the following animals and birds: The wapiti deer or elk can be obtained from the Pacific Coast; they are fairly plentiful in North California and the States of Oregon, Washington, Idaho, and Montana; and the price quoted f.o.b. at San Francisco for full-grown animals was 125 dollars, and for yearlings 75 dollars. The wapiti is the largest and finest deer of North America, inhabiting mountainous wooded country, and would be a great acquisition to our game animals. The white-tailed deer of the eastern States would also be a desirable animal to acclimatise. The finest specimens of this deer are got in the States of Maine and Michigan, where they attain a maximum weight of 400 lb. They are also plentiful in the Adirondack Mountains, in the State of New York, but they are not so large as in the other States named. The price, f.o.b. at San Francisco, would be 75 dollars.

Rocky Mountain Sheep.

I made special inquiry about this animal, and find they are now becoming very scarce, and are seldom caught by trappers. Occasional specimens are brought in by the Indians, and the price charged is very high. Being a very wild animal, and inhabiting the coldest parts of the mountain regions, the risk of losing them on the voyage to New Zealand would be very great. The cost put on board the steamer at San Francisco would be about 400 dollars apiece. It would be useless to ship less than two or three pairs, and great difficulty would be experienced in getting this number together.

Considering the high price charged for the animals, the difficulty of obtaining, and the risk in transport, I would not recommend attempting to introduce them. Any of the species of deer mentioned in this report would be more useful and profitable game animals to import.

Birds.

North America has a great variety of game birds that should be suitable for this colony, and can be obtained and transported at a very reasonable price.

The Californian Valley quail have been successfully acclimatised, and there are several other varieties of this family that are really better birds, and can be easily procured. The following is a list of birds which would be a great acquisition to our game birds, besides being perfectly harmless to grain-crops, orchards, &c.:—

Virginian quail	About	50 dollars per hundred	f.o.b. at San Francisco.
Californian mountain quail ...	"	10 dollars per dozen	"
Ruffed grouse	"	10 "	"
Prairie chicken	"	12 "	"
Wood-duck	"	12 "	"
Pintail duck	"	12 "	"
Blue-and-green winged teal ...	"	12 "	"

The finest duck of North America is the canvas-back, but they are now very scarce, and bird-men whom I interviewed say they are seldom caught alive, and stand confinement badly.

Approximate Cost of Paper.—Preparation, not given; printing (2,000 copies), including plans, £48 10s.

By Authority: JOHN MACKAY, Government Printer, Wellington.—1899.

Price 1s. 6d.]

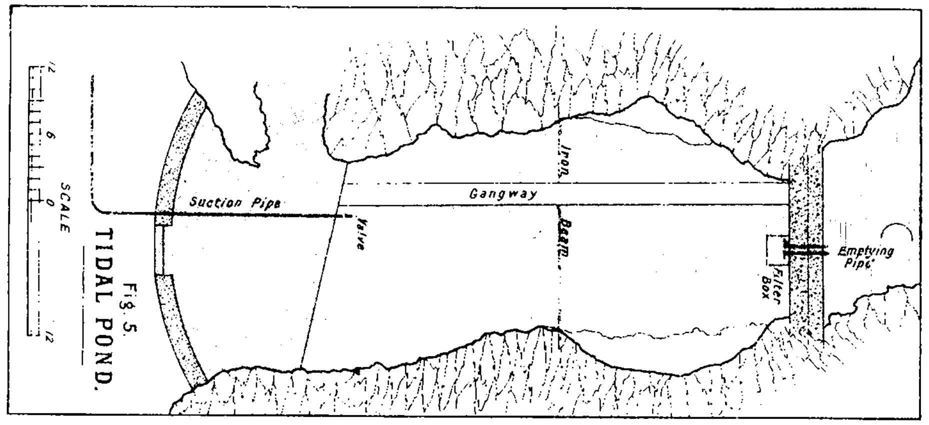
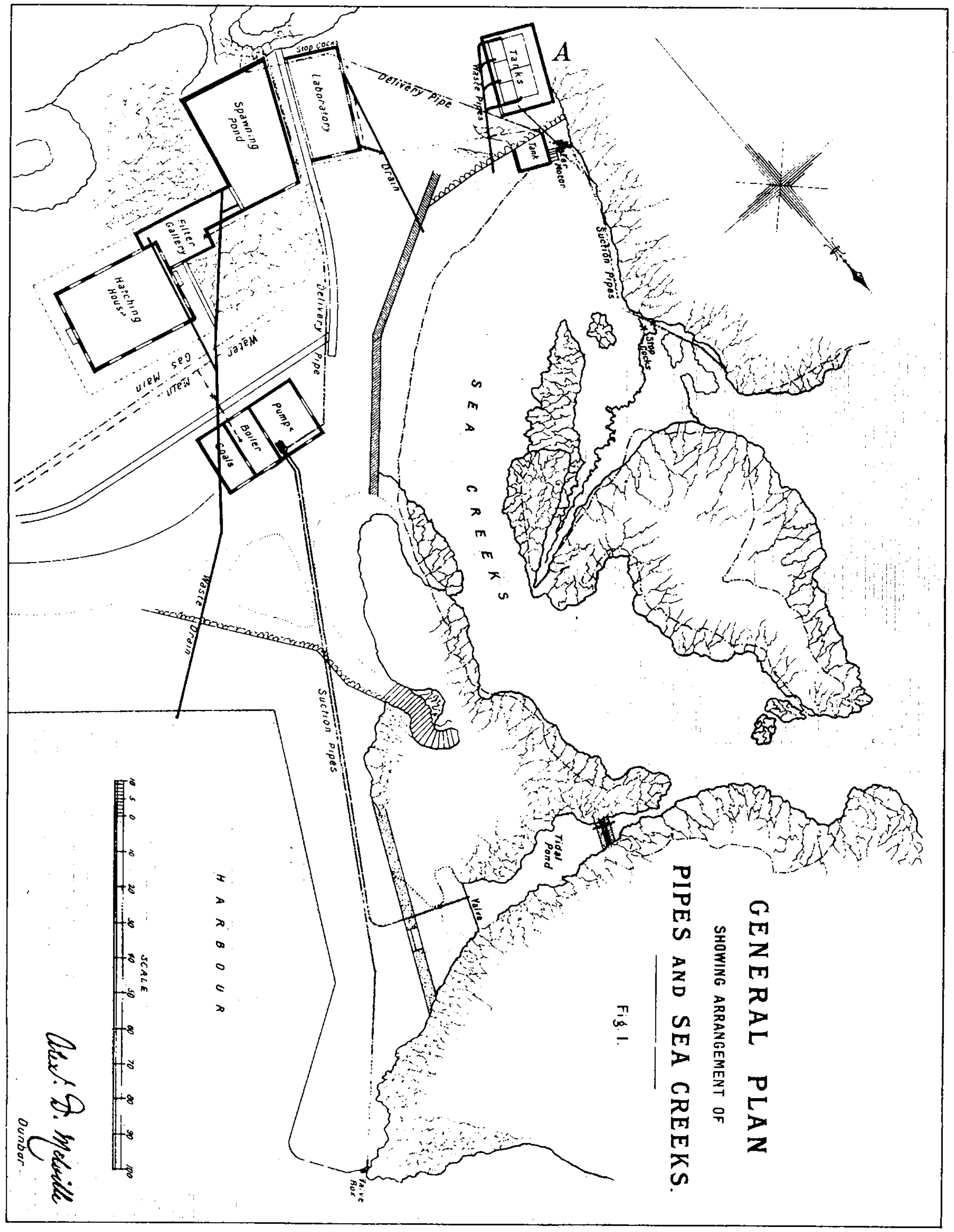


Fig. 5.
TIDAL POND.



GENERAL PLAN
SHOWING ARRANGEMENT OF
PIPES AND SEA CREEKS.

Fig. 1.

Alex. D. Melville
Dunbar

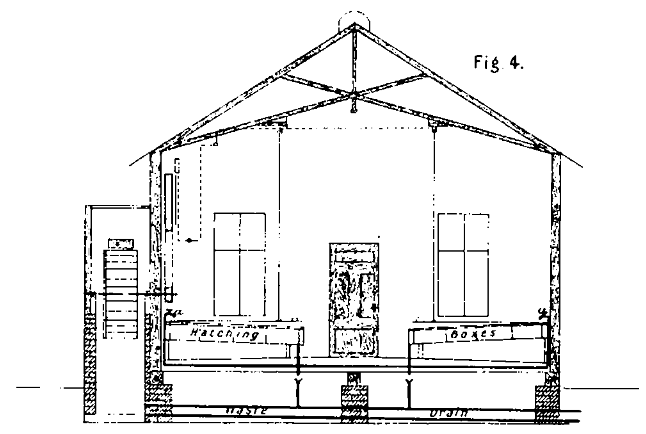


Fig 4.

Section through C.D.

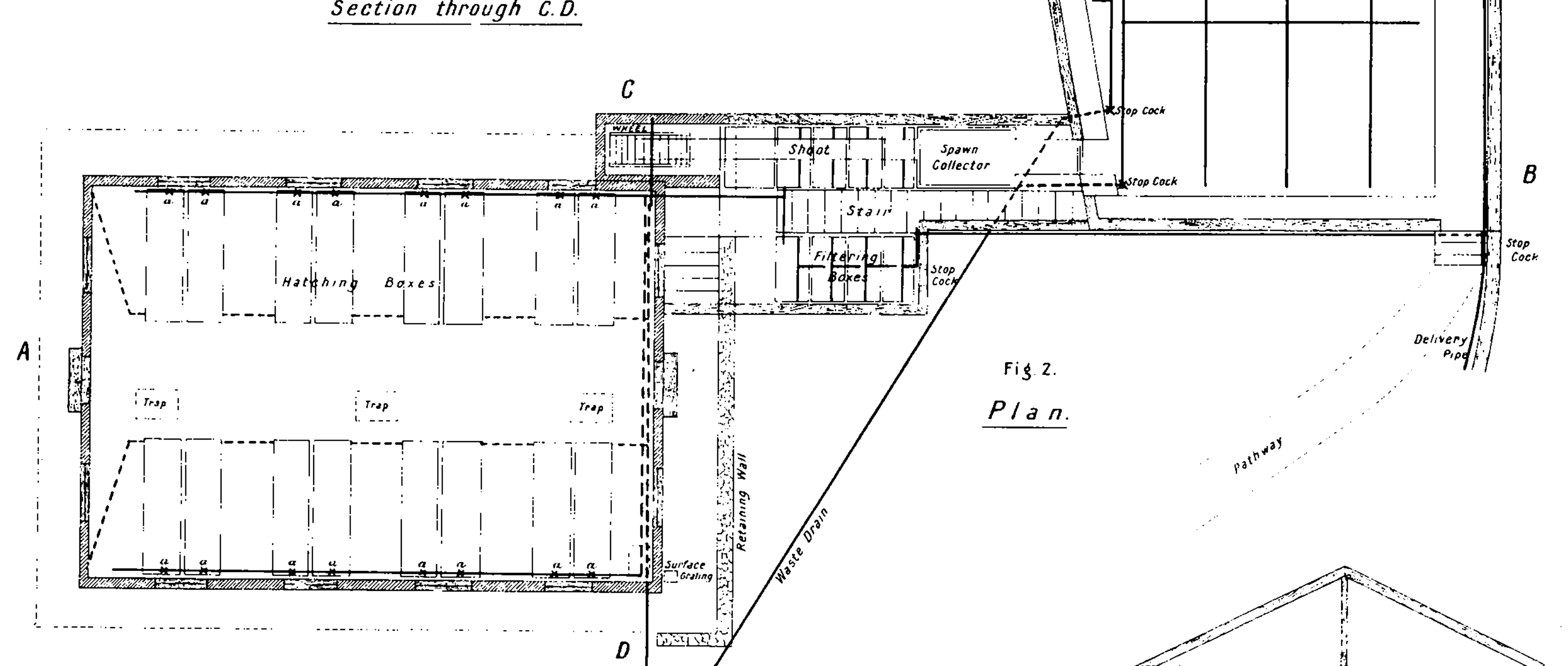


Fig 2.

Plan.

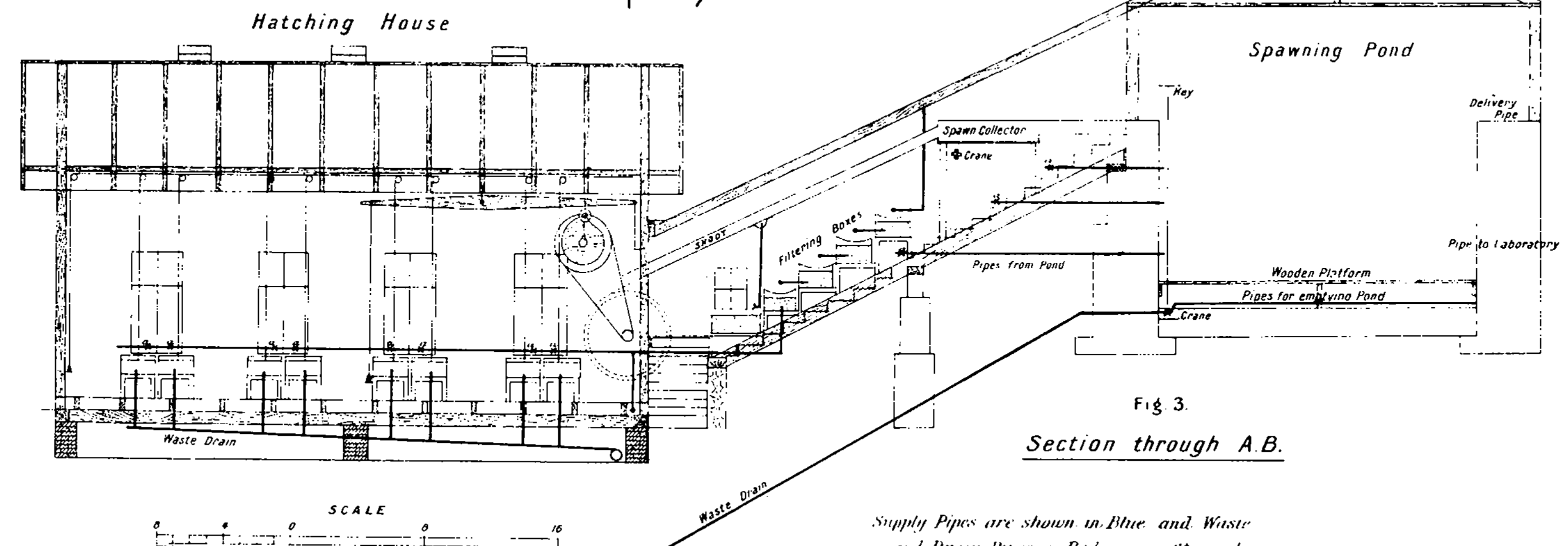


Fig 3.

Section through A.B.

Supply Pipes are shown in Blue and Waste and Drain Pipes in Red. a.a Stopcocks

Alex. D. Melville
Dunbar

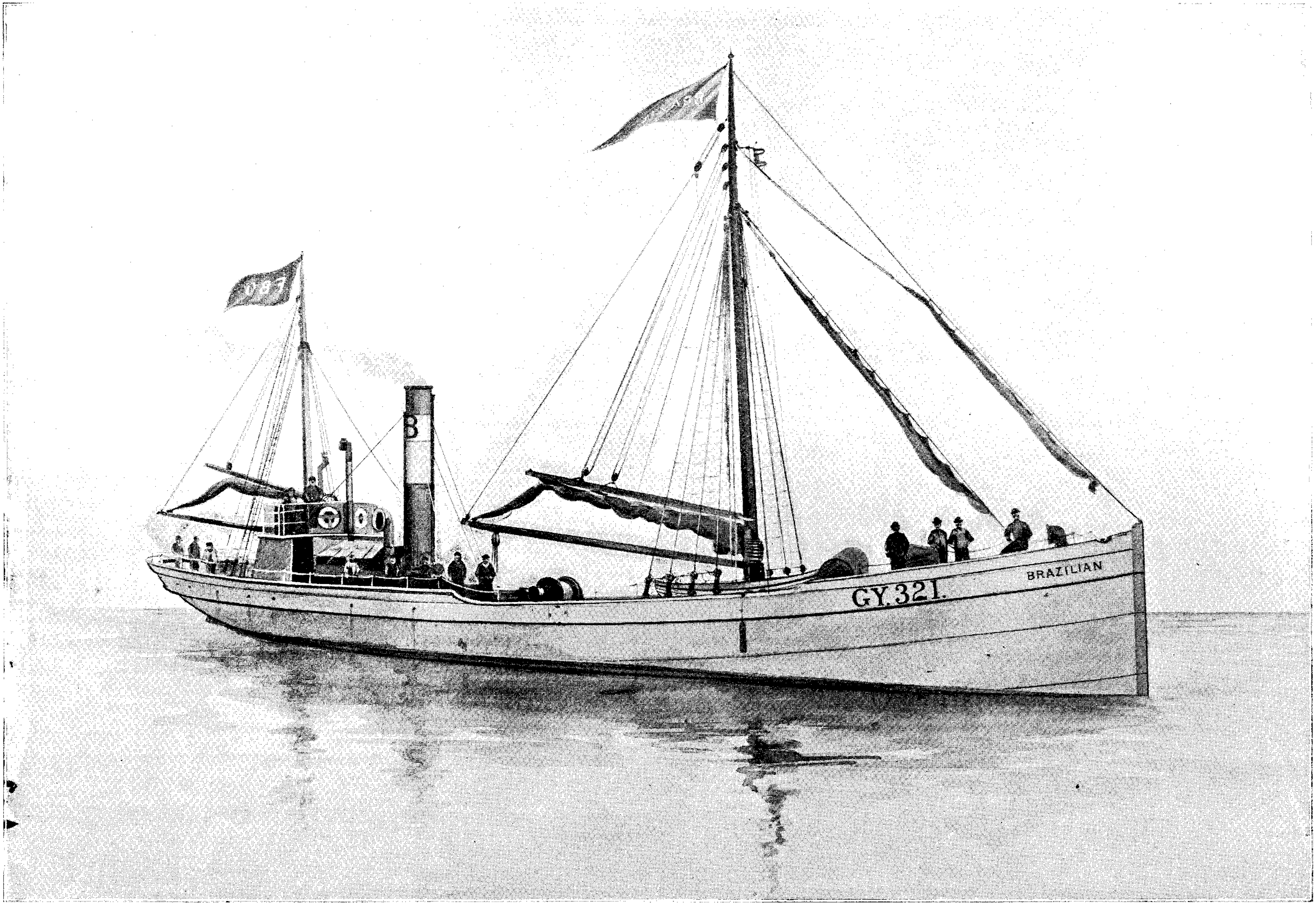


PLATE II.—Steam-trawler "Brazilian." Dimensions (over all): Length 117 ft.; beam, 20 ft. 6 in.; depth, 11 ft. 8 in.; gross tonnage, 183; speed, 10·6 knots.
Great Grimsby Co-operative Box and Fish Carrying Company (Limited).

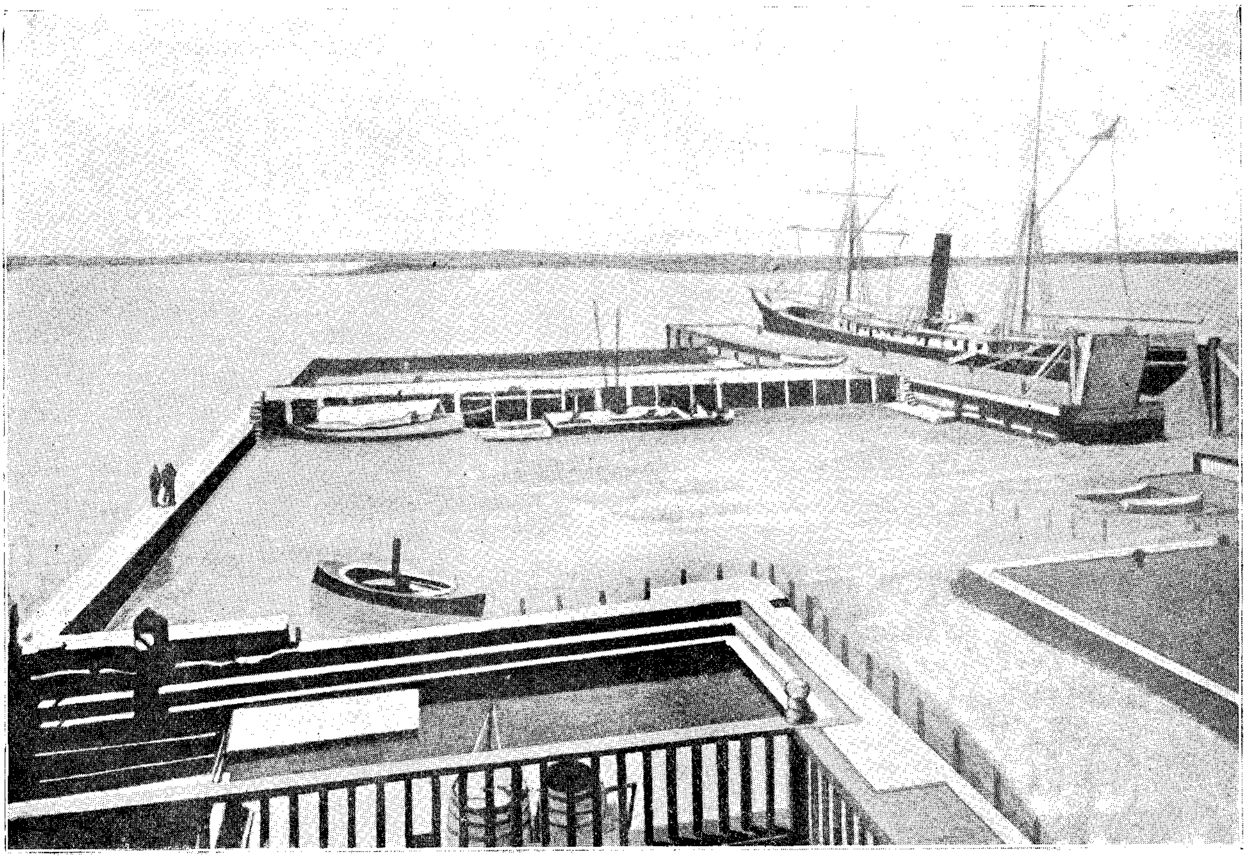


PLATE III.—Woods Hole Marine Station, Mass., U.S.A.

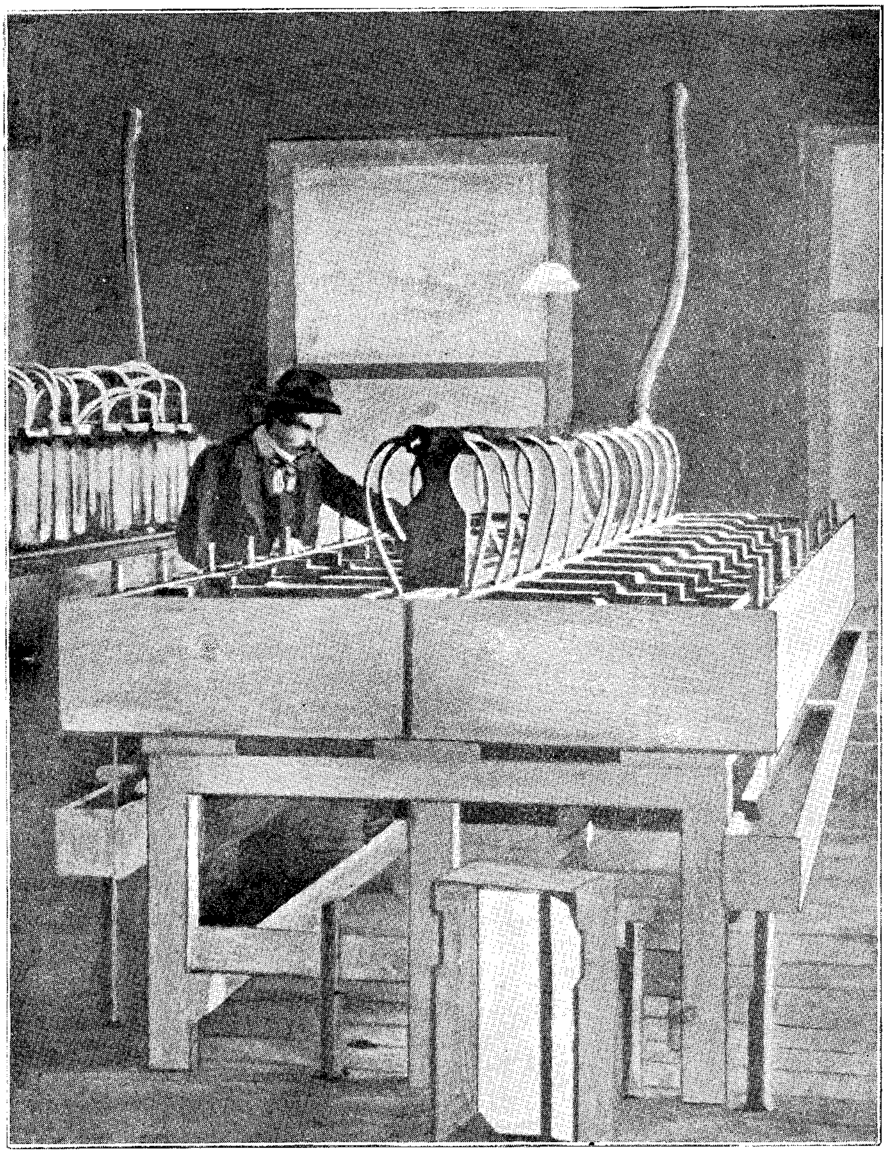


PLATE IV.—McDonald Tidal Boxes used for Hatching Cod and Flatfish, Woods Hole Marine Station, Mass., U.S.A.

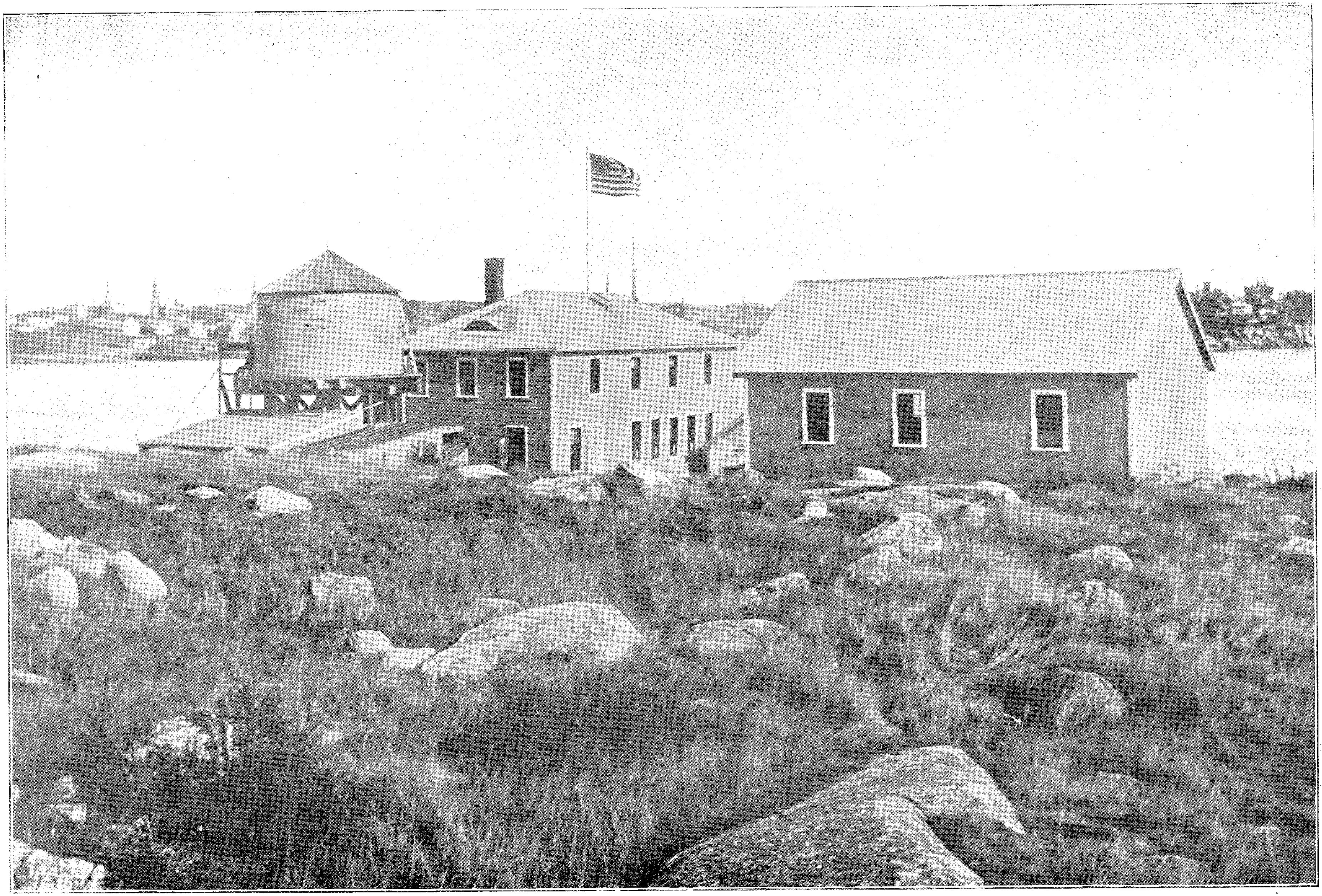


PLATE V.—Gloucester Marine Station, Mass., U.S.A.

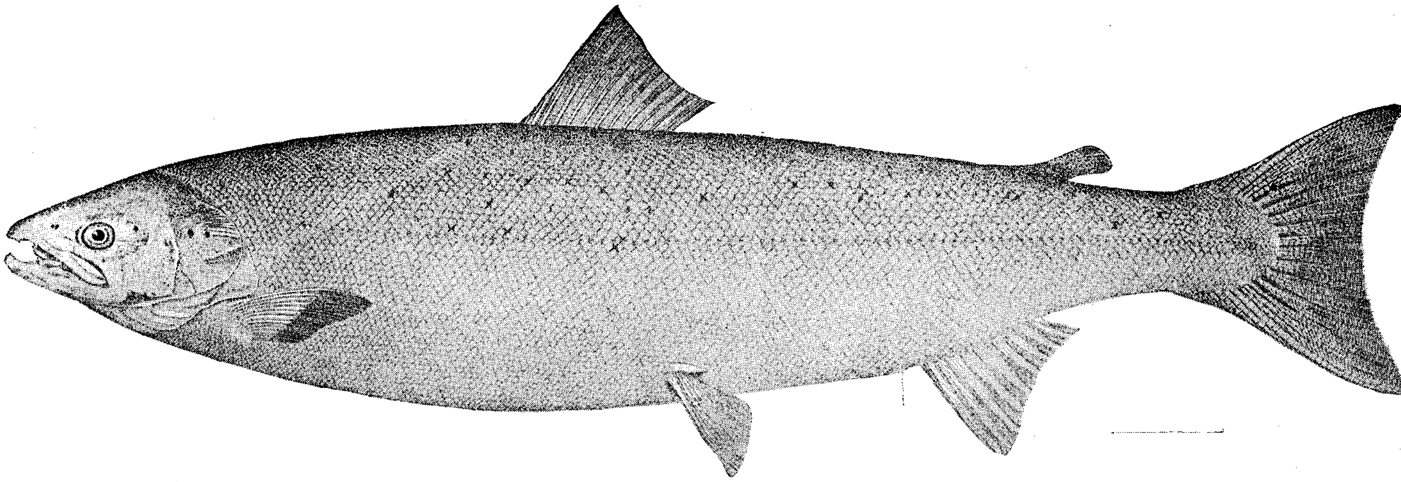


PLATE VI.—Salmo Salar *(Atlantic Salmon).*

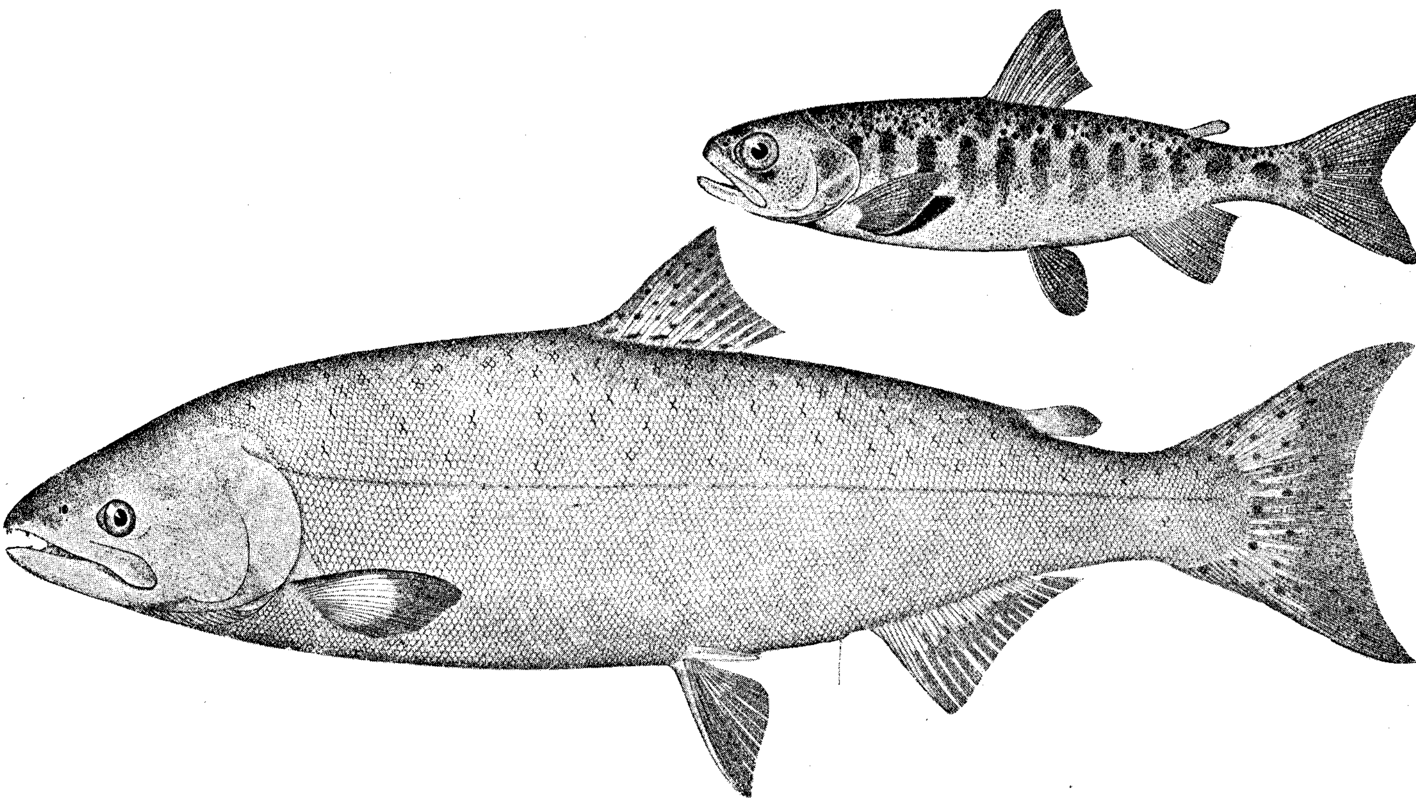


PLATE VII.—Oncorhynchus Tschawytscha. *(Quinnat Salmon; Chinook or King Salmon).*
The upper figure is the young of *Quinnat Salmon*, 4 inches long.

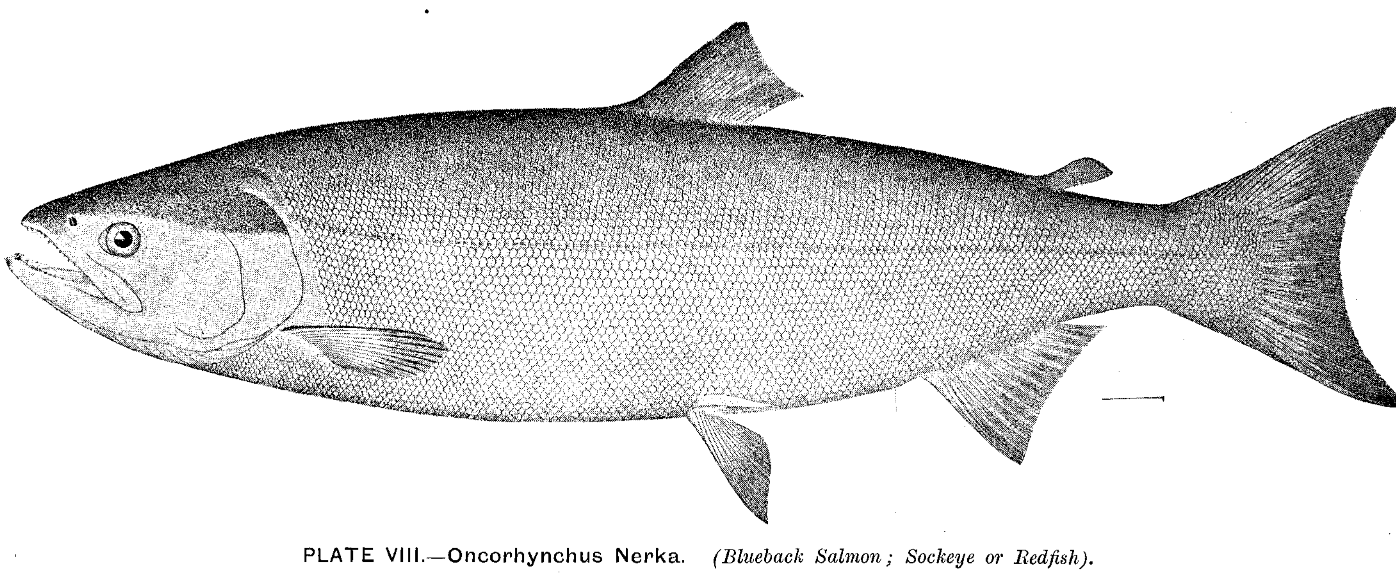


PLATE VIII.—Oncorhynchus Nerka. *(Blueback Salmon; Sockeye or Redfish).*

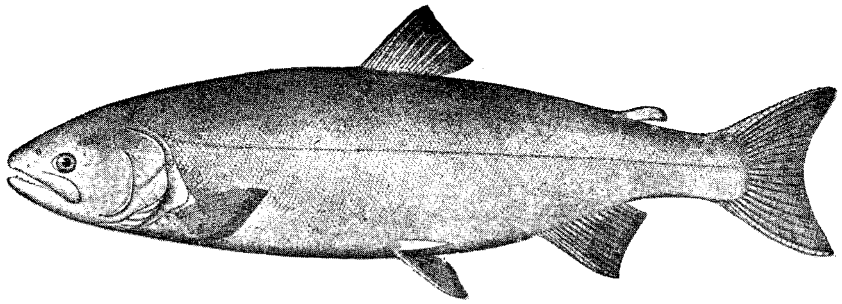


PLATE IX.—Oncorhynchus Kisutch. *(Silver Salmon or Coho).*

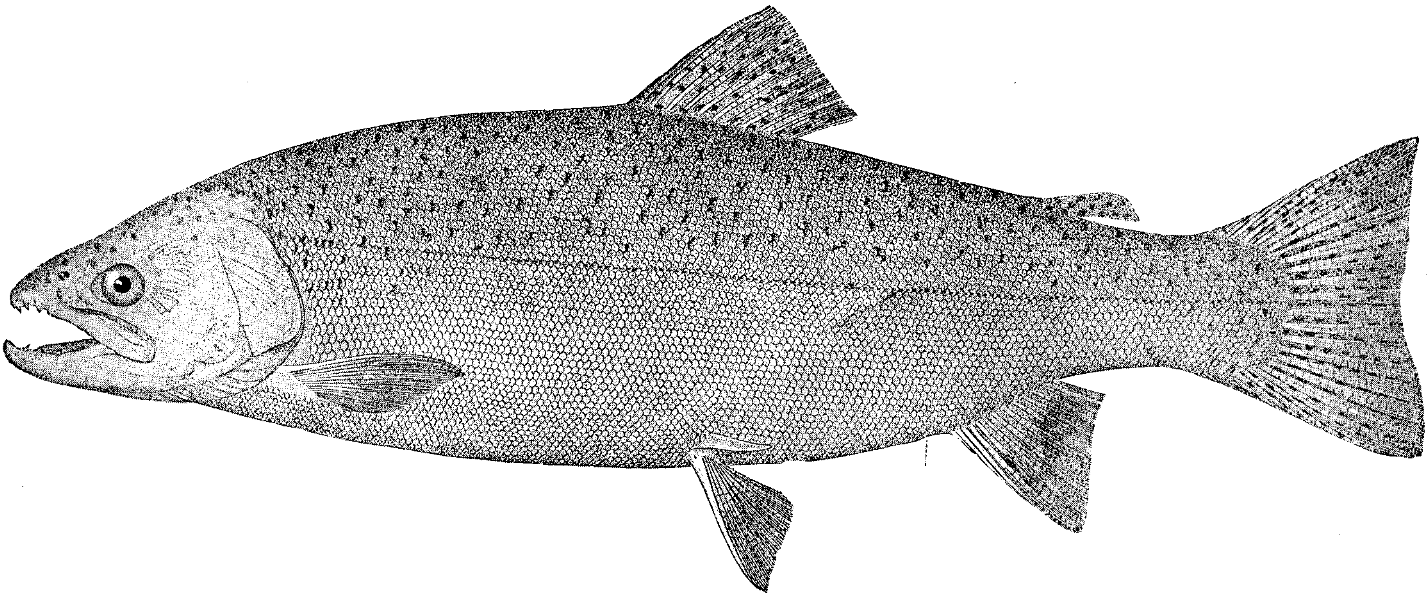


PLATE X.—Salmo Gairdneri. *(Steelhead).*

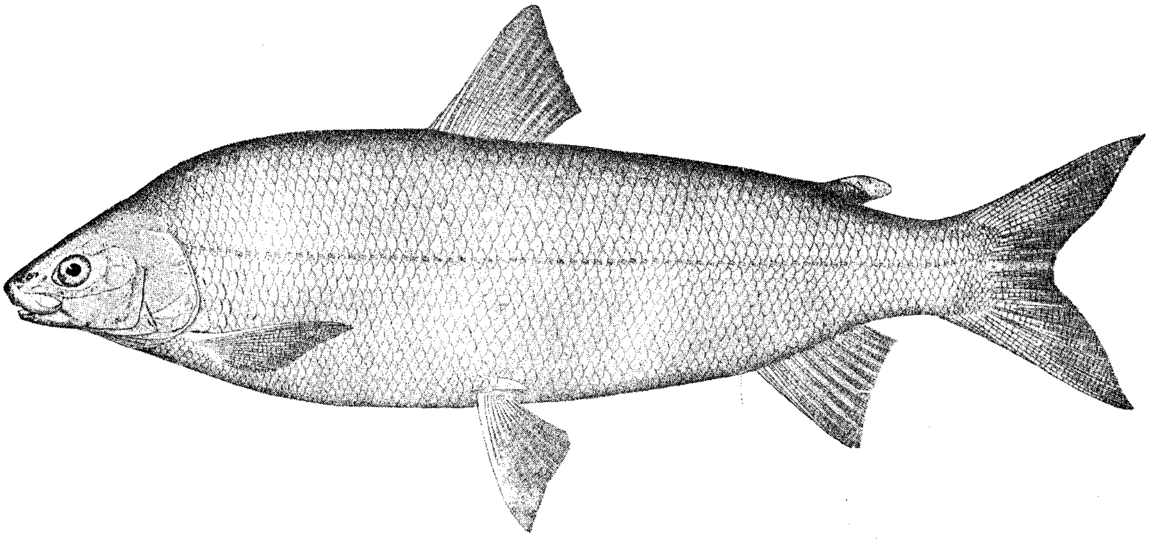


PLATE XI.—Coregonus Clupeiformis *(Common Whitefish).*
From a specimen 19 inches long.

PLATE XII.—Salmon running in Fraser River, British Columbia.

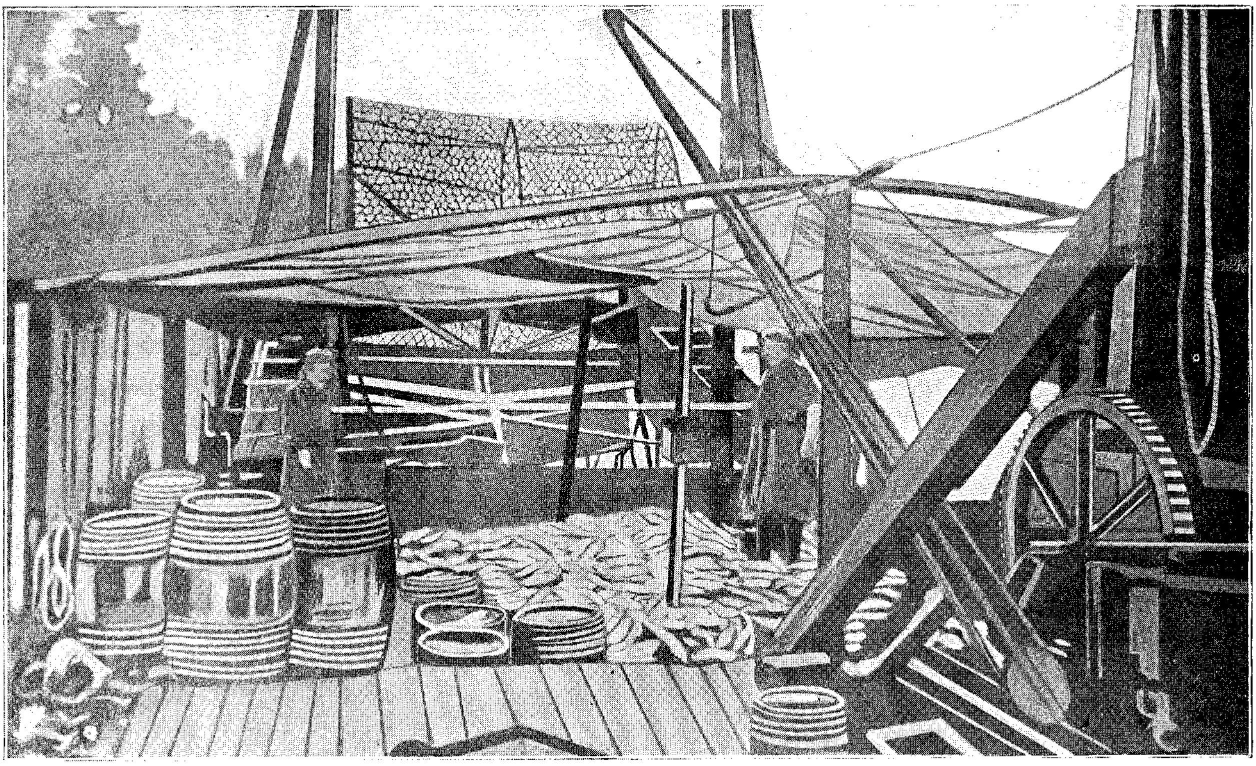


PLATE XIII. Scow Fish-wheel, Columbia River.

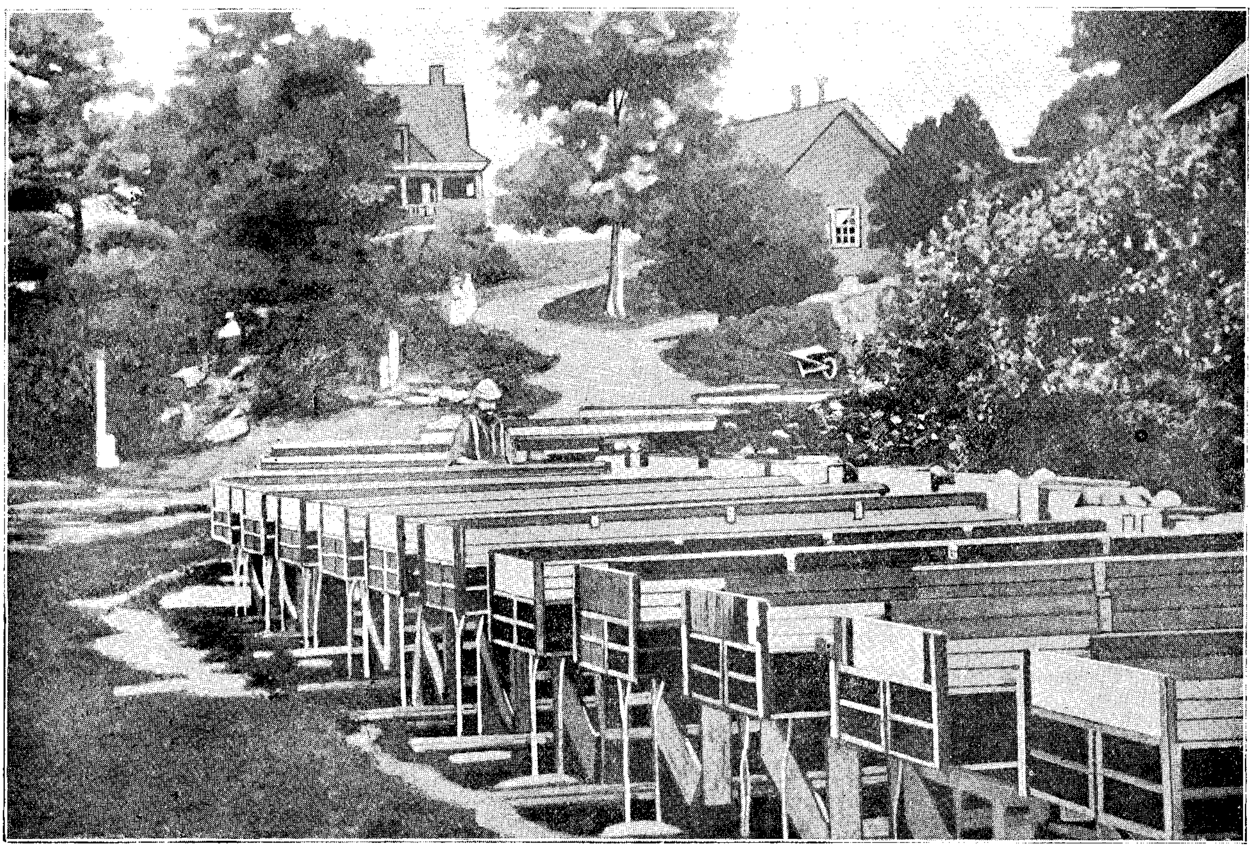


PLATE XIV.—Salmon-rearing Troughs, with Residence and Barracks in background, Craig Brook Station, Me., U.S.A.

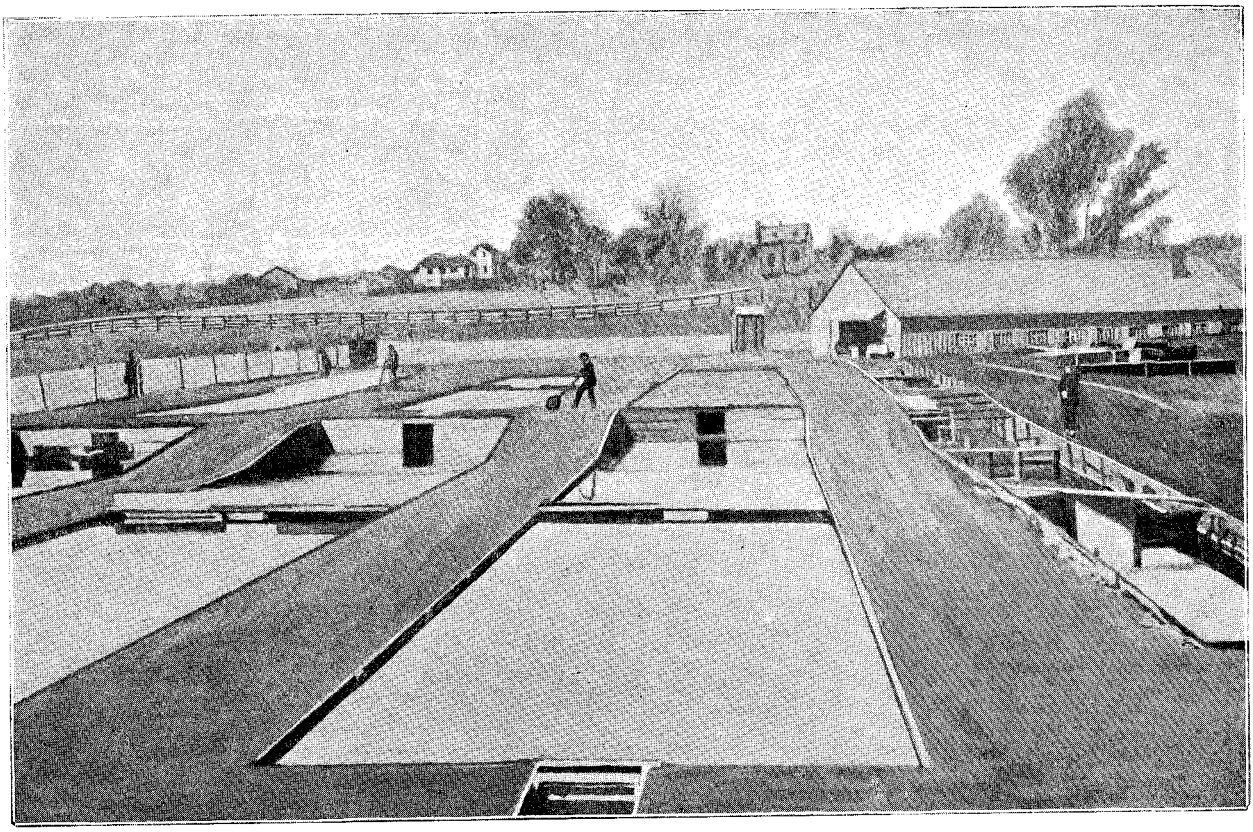


PLATE XV.—Trout Ponds, Northville, Mich., U.S.A.

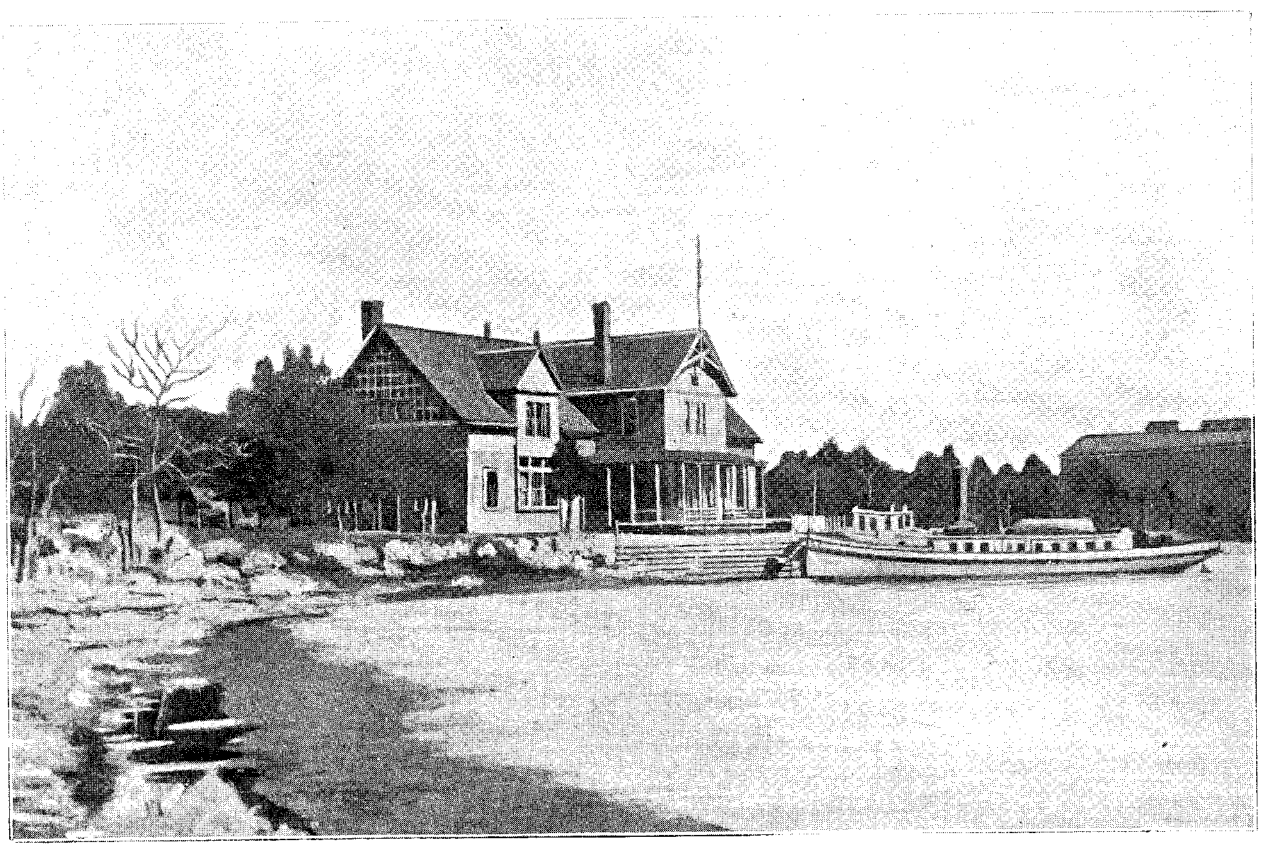


PLATE XVI.—Whitefish Hatchery, with steamer "Shearwater" at Dock, Put-in Bay Station, Ohio.

By Authority: JOHN MACKAY, Government Printer, Wellington.—1899.