

all be cleared up before the experiment is tried: first, the physical and biological condition of the area where it is proposed to place the fish or their eggs, so far as it may affect the experiment; and, secondly, the means and methods of transport that may be available. The introduction of a new form in this way may be done by means of a considerable number of adults before the spawning-time, or by eggs or fry, but in any case the success of the experiment will depend upon the survival of the first generation to the reproductive period in numbers sufficient to carry on the species. The two points in regard to the physical conditions which should be investigated are the temperature and the currents, both of which might be simply ascertained. I need say nothing about the influence of the temperature, except that it has been too much exaggerated; but from experiments we have now in progress it appears that the action of the currents might have an important bearing upon the case by transporting the pelagic ova or fry a considerable distance from the place where they, or the adults producing them, were placed in the sea. In regard to the biological conditions, it would be important to ascertain the spawning-time of the native species, and when their eggs and larvæ are found in greatest abundance in the sea, for it can scarcely be doubted that that would be the preferable time to introduce the new forms, as the minute life upon which larval fishes prey is then most abundant, and the other conditions most suitable."

It would seem at first sight, from the enormous fecundity especially of the cod and turbot, that, even if one or two adult fish could be introduced into these seas, and their ova were once liberated and fertilised, the experiment would be bound to succeed. But a remark of Dr. Fulton's on this matter is worth quoting here. He says, "A single female turbot may produce in one season 9,000,000 or 10,000,000, a cod 6,000,000 or 7,000,000, a ling 20,000,000 or 30,000,000, a haddock 500,000 to about 1,000,000, and so on. The import of this enormous fecundity has frequently been altogether misunderstood; arguments have been based upon it to show the inutilty of interference in fisheries. In reality, fecundity is a measure of the natural destruction that occurs in the life-history of any species, since, on the reasonable assumption that the total number of a species remains fairly constant over a period, it is only necessary that a few individuals of the new generation should, on the average, survive to the reproductive stage in order to keep up the relative abundance of that species. Hence the proportion of the eggs produced by sea-fishes which give rise to reproductive individuals is infinitesimal. Of the 10,000,000 produced by the turbot, 9,999,998, or thereabout, take no part in the production of another generation, but are destroyed at one period or another when left to natural conditions. So with other species." (Tenth Annual Report, page 190.) The enemies which the young fish would have to encounter here are just as numerous as in their native seas; so that, unless the young fish after escaping from the egg were protected for a time, the chances against their survival would be very great.

In order to arrive at any sure ground on which to base conclusions, I propose to consider, first, what is known about the life-history of these fish bearing on this subject; and, second, what we require to know about local conditions as affecting the possibilities of carrying out any experiment to a successful issue. My facts under the first head are chiefly drawn from the annual reports of the Scotch Fishery Board, supplemented by papers in the Journal of the Marine Biological Association of Great Britain.

The cod (*Gadus morrhua*) spawns in Scottish waters from about the end of January to the end of May, but chiefly in March. As is the case with the majority of food-fishes, the eggs float at the surface of the water, and remain floating up to the time of hatching. The ova hatch out in about fourteen days, when the temperature of the water is 6·52 deg. C. This seems to be about an average temperature for the surface-waters of the east of Scotland towards the end of April. With a lower temperature the process of hatching is retarded. I have no data with regard to the cod, but, taking the figures given in the twelfth annual report for the plaice, I find that with a temperature averaging 5·24 deg. C. the eggs took twenty-one days to hatch out, while at 8·86 deg. C. they only took fourteen days. By lowering the temperature of the water in the hatching-boxes it would then be quite easy to retard the hatching for some weeks. In January, February, and March, when cod begin to spawn, the temperature may range from 3 deg. to 5 deg. C., but it would seem that very few fish hatch out till April, when the temperature begins to rise steadily. It would therefore be a very simple matter to obtain eggs during these months, and transmit them to New Zealand by direct steamer in suitable boxes, supplied with a steady stream of sea-water cooled probably to 0 deg. C., as recommended by those competent to do so. Such eggs would arrive in the colony in the month of May, and would have to be dealt with at once. Perhaps adult cod could be brought out in suitable tanks. Dr. Fulton, however, seems to think that the carriage of round fish will always be a matter of greater difficulty than that of flat-fish, and there really seems no reason why fertilised ova could not be easily carried and kept during the voyage at such a temperature that their hatching could be retarded for several weeks. The hatching of cod and the protection of the fry for a very brief period is now carried on on a vast scale in many countries. When it is remembered that the greatest destruction of fish takes place while they are still in the egg, the ova being cast forth by millions into the open sea, and devoured in the great majority of cases before they can hatch, it will be seen that the protection and hatching of the eggs is the all-important step towards reducing the death-rate among them.

In 1892 the Dildo hatchery, in Newfoundland, liberated 39,650,000 cod fry; the Wood's Holl station, in New England, hatched out 7,820,000 (in 1891, £36,000,000); while the great Flødevig hatchery at Arandel, Norway, hatched and planted 207,000,000. The Dunbar hatchery, in Scotland, was only opened in 1893, and operations were chiefly confined to the hatching of plaice, of which over 26,000,000 fry were liberated. Of cod, only 500,000 eggs were hatched, but the hatching-house is capable of accommodating 80,000,000 ova at one time, and two lots can be dealt with in a season. Of the 500,000 eggs placed in the hatchery, and which were obtained, not from the fish kept in the breeding-ponds, but from specimens caught and stripped at sea, it is interesting to know that not above 4 per cent. died. It is clear there would be no difficulty whatever in obtaining ova, nor in getting the services of men thoroughly qualified to carry on the work of a hatchery.

The herring spawns chiefly in spring (March to May) and in autumn (September and October), but the process goes on to some extent in nearly every month of the year. The ova, contrary to the usual rule in food fishes, are naturally deposited in gravel-covered areas, and form a layer on the surface nearly $\frac{1}{2}$ in. thick, and at depths from seven to thirteen fathoms. Professor Cossart Ewart has described at length the whole process of hatching and rearing the fry in the Second Report of the Scotch Fishery Board for 1884. He obtained ripe herring and artificially fertilised the ova, and these hatched in from eighteen to twenty-two days.

An attempt was made by the Stout-Vogel Government to introduce herring-ova to this colony in 1886, and the experiment failed from a very simple cause indeed. Professor Ewart, who undertook the conduct of the experiment up to the shipping of the ova, secured at very considerable trouble a number of trays of ova from the famous Ballantrae beds in the west of Scotland. The steamer "Jackall" was placed at his disposal for the purpose, the boxes were prepared, and, when all was ready, the steamer went in among the fishing-boats and obtained from them a number of ripe fish just taken in the nets. The ova were collected into the boxes, and at great trouble were conveyed to the steamship "Ruapehu," which was ready to sail for New Zealand. Arrangements had been made for keeping the ova constantly supplied with cold sea-water during transit. The eggs were in excellent order when put on board the steamer, and an expert was sent out to look after them during the voyage. But on arrival of the steamer at Madeira, a telegram was despatched to London to say that all the ova were dead. The pipes to supply sea-water to the boxes, instead of being sent through coolers filled with ice, which would have lowered the temperature to 0 deg. C. were sent through the steamer's refrigerator, with the result that at the very outset the water in them was frozen. It is quite clear from this experiment that there is no great difficulty either in getting or in transmitting herring-ova. On arrival in the colony it was intended to transfer the ova to a floating box, the bottom of which was made of a fine-meshed cloth, so that the eggs would hatch out in a sort of floating cage, in which, while supplied with abundant change of water, they would be protected till it was considered safe to liberate them.

The turbot spawns from the beginning of April to the end of July, but chiefly in the month of June. At this time the average temperature of the North Sea ranges from 9 deg. to 12 deg. C. The eggs are slightly smaller than those of the cod, and when deposited they float singly on the surface of the sea, but they seem always to sink some days before hatching takes place. I have no results to record as to the artificial hatching of these fish, for the experiments at Dunbar were not far enough advanced to be included in the annual report for 1893, and I have not seen that for 1894; but tow-net surface gatherings in the North Sea in July and August usually contain young turbot from 5 mm. to 15 mm. (1·5 in. to 3·5 in.) in length. They appear to remain near the surface till the adult form has been assumed, and then descend to the bottom to spend the first winter of their life, probably in comparatively shallow