28.—DESCRIPTION OF THE MARINE HATCHERY AT DUNBAR, SCOTLAND.

BY DR. T. WEMYSS FULTON, F. R. S. E.,
Superintendent of Scientific Investigations, Fishery Board for Scotland.

In a paper by Prof. W. C. McIntosh, included in the present Bulletin (pp. 241–256), reference is made to an establishment for hatching marine food-fishes at Dunbar, which has been erected by the Fishery Board for Scotland, and of which I have been asked to furnish a description. It may be briefly premised that in Scotland, as in so many other countries, the comparative scarcity of certain important sea fishes has been manifested in recent years. This has been especially evident with the more valuable *Pleuronectidæ*, such as turbot, brill, and plaice. Notwithstanding the extension of beam-trawling—the method of fishing by which the pleuronectids are principally obtained—the number captured off the Scottish coasts has diminished year by year; as indeed they have diminished throughout the North Sea generally.

Certain regulative measures have been tried, which, if it can not be said they have quite failed, have at least not had the results they were expected to have. In 1886 and subsequent years beam-trawling was prohibited within certain firths and areas; and in 1889 practically the whole of the territorial waters of Scotland, and also some bays and firths which extended beyond the territorial limit, were closed by statute to this mode of fishing. But the quantity of flatfishes landed continues to decrease. That this is not due to restriction in the extent of fishing ground in consequence of the prohibition referred to, is shown by the scientific observations and experiments conducted by the *Garland* since 1886. These are given in full detail in the various annual reports of the Fishery Board; but it may be mentioned here that while in the period 1886–1888 the average number of flatfishes captured in each haul of the net in the protected waters of the Firth of Forth and St. Andrews Bay was 188·6, it was only 136·4 in the period 1890–1892. The diminution indicated is probably largely explained by increased trawling in the waters outside the territorial zone where the fishes congregate at the spawning season and where fishing operations can not be interfered with under any powers at present existing. At all events it shows that the regulative measures referred to have not succeeded in increasing the abundance of fish in the protected waters, and points to a hopeful field for the application of fish-hatching.

When it was decided to proceed with the erection of a hatchery for sea fish, the writer visited and inspected the well-known Norwegian establishment at Flöderig, which is under the direction of Capt. G. M. Dannevig; and later this gentleman came to Scotland and made an examination of the site proposed at Dunbar. He having reported favorably, work was thereafter commenced, and a hatchery on the model of

Capt. Dannevig's has now been completed. The establishment may be described under the following heads: (1) the hatchery house; (2) the spawning pond; (3) the filtering gallery; (4) the tidal pond; (5) the pumping apparatus.

The hatching house consists of a substantial and ornamental wooden building 35 feet in length, 24 feet broad, and 18 feet in height. The walls, which are double, stand upon a foundation of brick and concrete, a space of 2 feet being left between the flooring and the ground for the circulation of air and the convenience of piping. As abundance of light is desirable, there are 12 large windows in the sides and gables and a door is placed at either end. At present 16 of Dannevig's hatching apparatus are fitted up, each capable of containing about 5,000,000 of cod eggs, or a total of about 80,000,000.

The apparatus consists of an oblong wooden box, 8 feet in length, 2 feet 3 inches in breadth, and 1 foot deep. It is divided into two series of 7 water-tight compartments by one central longitudinal and 6 transverse partitions, making altogether 14 compartments. The first and last compartments in each series—those at the ends—are narrow and communicate with one another, the pair at one end receiving the water from the inflow pipe, and the pair at the other end communicating with the outflow pipe. The intervening ten compartments are wider, and it is into these that the hatching boxes which contain the eggs are placed.

Each hatching box is 12 inches long, 10 inches broad and 10 inches deep; the sides are made of wood, ⅝ inch thick, and the bottom of haircloth, fine enough to prevent any eggs from passing out while admitting a free circulation of water. The boxes are attached by leather hinges to the transverse partitions; and into the top of each partition, between the hinges, a broad, flattened metallic spout is inserted, which fits into a corresponding spout attached below it to the edge of the hatching box. The apparatus, with its ten boxes, is placed with one end against the end of the room, and rests on wooden supports so arranged that this end is 3 inches higher than the end which projects towards the center of the room, this difference in level giving what experience has shown to be the most suitable flow of water.

The supply pipes, made of galvanized iron, are led along the walls, a brass cock being inserted above each apparatus. The water falls from the cock into one of the narrow end compartments, which communicate with one another, and when these are full it flows over by the spouts into the first pair of hatching boxes. It passes through the haircloth bottom into the compartments in which the boxes are placed, and when these are full it overflows in turn into the second pair of boxes, and so on until it reaches the narrow end compartments, whence it escapes by a pipe passing through the floor of the room.

As has been said, the hatching boxes are hinged at one side, and as the compartment becomes full the fore edge of the box is floated up and ultimately projects about 3 inches or so above the surface. This gives occasion for the application of one of the special features of Dannevig's method, namely, an up-and-down movement of the box, by means of which the eggs are kept equally distributed throughout the mass of water, as may be shown by testing any part of the box with a dip-tube. The movement is accomplished in the following way: An iron rod, 8 feet long, is hinged at the upper end of the apparatus, next the wall, and passes down the middle between the two series of hatching boxes. It possesses five short, transverse pieces, one opposite each pair of boxes, and resting upon the free edges of the latter; and it is so weighted as just to be sufficiently heavy to depress them. When the rod is raised the buoyancy of the boxes causes them to rise and to regain their former position.

The movement of the rods is brought about automatically by a system of wires and pulleys, the wires being connected on the one hand with the free end of the rods, and on the other hand with the end of a wooden beam which rests upon an eccentric wheel kept in motion by a waterwheel driven by the overflow water from the spawning pond. As the end of the beam rises and falls on the eccentric the iron rods also rise and fall, and the hatching boxes are raised and depressed. The rise is gradual and the depression rapid, the water in the latter part of the movement being forced upwards through the hair netting and the eggs whirled gently about and kept in constant motion. The speed of the eccentric wheel can easily be regulated; about two revolutions in three minutes is generally sufficient.

The spawning pond or tank, in which the spawning fishes are placed during hatching operations, is constructed of solid concrete sunk in the ground, the thickness of the walls at the top varying from 2 to 4 feet. It is 40 feet in length by 11½ feet deep, the breadth at one end being 26 feet and at the other end 18 feet, the variation in breadth being due to the nature of the ground. It is capable of containing a little over 60,000 gallons of water. This pond is situated 27 feet from the hatching house, and on higher ground, so that the level of the water in it is about 18 feet above the level of the hatching boxes, and it is inclosed by wooden walls which rest upon the outer edge of the concrete, and is covered by a roofing of galvanized iron with movable skylight windows, which can be darkened when necessary. The upper flat surface of the concrete forms a convenient pathway all round the pond.

The feed pipe from the pumps is carried along the top and enters at one corner (that furthest from the overflow into the spawn-collector), and it is so arranged that the water can be put in at any height. In order to empty the pond, or lower the level of the water, two 4-inch iron pipes pass through the bottom, each controlled by a cock worked from above by a fixed rod, and communicating outside with the waste and drain pipes, and inside with a series of movable perforated pipes lying on the concrete floor, and by means of which the bottom layer of water can be rapidly removed. About 18 inches above the bottom is a flooring of smooth boarding, with spaces between, the width of which may be increased or diminished according to circumstances. The object of this arrangement is to allow excrementitious waters, remains of food, etc., to pass beneath the flooring, whence they may be quickly taken away by the perforated pipes. Three 2½-inch galvanized iron pipes are also carried through the wall at different levels and pass into the filtering gallery; they are provided with cocks, and their use will be presently explained.

It is into this pond that the spawning fishes, males and females, are placed, and the spawning process, the ejection and impregnation of the eggs, goes on naturally as it would in the sea. As the buoyant eggs rise to the surface they are carried by the overflow into the "spawn-collector." The eggs are retained, and the water passes on into the chute to supply the waterwheel for the movement of the boxes, as above described. The spawn-collector consists essentially of a large wooden frame, the bottom, sides, and one end of which are covered with haircloth. It is placed in a large horizontal wooden box, which may be described as a dilatation of the water-chute to the wheel with which it communicates. This box is deeper and wider than the haircloth frame, so that a space may exist all around the latter; and it is continuous with a short chute passing between the spawning pond and the open end of the spawn-collector. All the overflow water must pass through the haircloth, and by means of wooden slides the height and flow of the water may be regulated so that the retained eggs may not be subjected to injurious pressure. The eggs are transferred from the collector to the hatching boxes.

The filtering gallery passes down the sloping bank between the spawning pond and the hatching house. The floor is made of concrete, and a stair passes up the center to the spawning house. On either side are arranged the filtering boxes, eight in number, forming a duplicate series of four each, and through these four filters all the water that goes to the hatching boxes must pass. Each filtering-box is 4 feet long, 2 feet wide, and 1½ feet deep. The top is covered by a movable frame of filtering material, made in two pieces for convenience of removal; and as the boxes are arranged at different levels, in step-and-stair fashion, the water passes in succession from the first to the second, and so on to the fourth, and thence to the pipe leading to the hatching boxes. The filtering material on the first box is made of coarse material (cheese cloth); that on the second, coarse flannel; finer flannel on the third, and still finer on the fourth; but, as a rule, no sediment is to be found on this one, and the water passing to the hatching house is absolutely limpid and pure. One object in having a duplicate series, which can be used alternately or together, is for convenience in cleaning. There is also a wooden sink, supplied with water from the waterwheel shoot, in which the filtering frames may be scrubbed.

The spawn-collector, above described, is contained in the upper part of the gallery, and the shoot to the waterwheel passes down one side, near the roof. The waterwheel is placed at the side of the hatching house, at the lower part of the gallery. It is 5 feet in diameter, of the overshot variety, and the axle passes through the wall of the hatching house, the movement being transferred to the eccentric wheel by a stop. From 700 to 900 gallons of water an hour is sufficient to supply the wheel, the waste water being carried off by a drain pipe.

The *tidal pond* is situated about 50 yards from the hatchery, on the rocky shore. It was originally a cavern,* the walls and roof being of solid rock, and the eastern part closed by the castle walls. The seaward entrance has been closed up by a concrete wall varying in thickness from 9 feet to 2 feet. Through this wall two 6-inch pipes are carried, one at the bottom which is controlled by a slide valve worked by a rod from above; the other at a height of 5 feet. The valve in connection with the latter is such that it can work automatically, admitting water when the level outside is higher than that within, and preventing water from escaping when it is lower. The bottom pipe is for emptying, or partly emptying the pond when the tide is low. Thus

* It may be of interest to state that the hatchery lies within the precincts of one of the most historic spots in Scotland—the old castle of Dunbar—associated with Scottish history for 800 years, and dismantled subsequent to the flight of Queen Mary and Bothwell, who took refuge in it. A human skull and a large quantity of the bones of horses were disinterred in digging the foundations for the spawning pond. A portion of the cavern, now converted into a peaceful fish-pond, formed the dungeon in which the poet Gavin Douglas, Bishop of Dunkeld, and many other illustrious prisoners were confined. A dark and tortuous passage still exists, leading upward between massive walls towards the citadel. The westward opening, now closed, is conjectured to have been the portal through which the brave Sir Alexander Ramsay, of Dalhousie brought succor to Black Agnes during the siege of the castle by the English under the Earls of Salisbury and Arundel in 1338, and it was probably by this postern that King Edward II escaped in a fishing boat after his disastrous defeat at Bannockburn in 1314.

at every tide a fresh supply of water may be admitted if desired. Both pipes open on the inner side into a long, vertical water-tight wooden box, which fits against the concrete wall, and is open above so that the valve may be controlled. Large filtering frames are fitted into apertures in this box by india-rubber joints, so that practically every drop of water entering the pond may be passed through them—a very useful provision in stormy weather.

At the end opposite to the concrete wall is a stone-work platform continuous with the harbor quay, and a door is let into the wall, at this part of which entrance to the pond is obtained. The length of the pond is 42 feet, the average breadth about 20 feet, and the depth of water at high tide about 9 feet; it can therefore contain nearly 50,000 gallons of water—all of which, as has been explained, filters itself as it passes in. The bottom is laid with concrete, and when fish are present this is covered with a layer of clean sand. The purpose of the tidal pond is twofold: (1) it serves as a storage place for the spawners, in which they may be collected before the spawning season, and (2) as a reservoir of pure filtered water which may be pumped up to the hatching house during the prevalence of storms, when the water outside may become somewhat turbid in certain winds. As the tide rises the water pours in by the upper pipe and passes through the filtering apparatus into the pond; when the tide falls, the valve closes automatically and prevents the escape of the water.

The pumping apparatus consists of two Worthington brass-lined, direct-acting steam pumps, each capable of throwing over 3,000 gallons per hour. The boiler is of the best locomotive type, made of steel, by Robey & Co., Lincoln, and of 8-horse power. The pump house is placed between the hatchery and spawning pond on the one hand, and the harbor and tidal pond on the other hand. It is 24 feet long by 18 feet in breadth. The floor is of concrete, and a partition separates the boiler from the pumps. Built against the boiler compartment is the coal house, which can accommodate about 12 tons of coal. The pumps are so fitted up that one may pump from the entrance to the harbor, and the other from the tidal pond, or one or both may pump from the harbor and the pond at the same time. The suction pipes are 2½ inches in diameter, and made of the best galvanized iron; they are supplied with foot-valves and roses. The supply pipe to the spawning pond and hatchery is of the same diameter and material. At the side of the spawning pond a branch is given off to the filtering-gallery, and this branch on entering the gallery bifurcates to supply each of the two series of filtering-boxes. Cocks are placed so that the volume of water entering the spawning-pond or the filtering gallery can be easily regulated. The Worthington pumps have worked very smoothly, without any noise, and have given satisfaction.

There is a special feature in connection with the working of this hatchery to which attention may be drawn. At the Norwegian establishment and, I understand, at others, the pumps are kept working during the night as well as in the day, so that a constant supply of water may be obtained for the spawning pond and the hatching boxes; this, of course, necessitates extra staff and expense. At the Dunbar hatchery, however, the night work is dispensed with, water from the spawning ponds being used for the hatching boxes and the waterwheel, by means of the three pipes, previously referred to, which pass through the wall of the pond. These pipes are fitted on the inner end, which projects into the pond, with large haircloth roses or filters, which prevent any eggs passing out with the water. One of these is connected in the gallery house with the pipes supplying the filtering boxes, and another is led into the lower part of the shoot for the waterwheel. By means of the cocks, the supply of water for both these purposes can be easily regulated.

Since each of the sixteen hatching boxes requires between 90 and 100 gallons of water per hour, and the waterwheel about 800 gallons; and since each inch of depth in the pond is equivalent to about 480 gallons, the utilization of the water in this manner from 11 o'clock at night to about 6 in the morning will reduce the level of the water in the pond to the extent of only about 2½ to 3 feet. This can soon be made up when the pumps are put on. The fish at present used—plaice—do not require a constant circulation to be maintained; indeed, in some preliminary operations in the tidal pond it was found that eighty large flatfish (including a few common soles) could be kept for two days and three nights in about 7,000 gallons of water, in perfect health, without the water being renewed or any circulation maintained. It would be probably different with more actively-breathing fish, such as cod.

Another advantage of retaining the water in the spawning pond during night is that the impregnation of all the eggs is made more certain and with a relatively smaller number of males than would be the case were a constant overflow kept up. Spawning takes place at night and the eggs are confined floating in the pond for many hours. In the morning the pumps are started, and a very gentle circulation maintained during the day; in the afternoon a large volume of water is poured in, and in the course of a few hours practically all the eggs in the pond are collected in the spawn-collector.

The number of plaice at present in the spawning pond is 220, ranging in length from 14 to 27 inches; but they are being added to, it being estimated that the pond can accommodate more than double the number named. There are two males to three females, this being the proportion of the sexes which obtains in the sea;* but it is probable that the proportion of females may be considerably increased (and therefore the functional capacity of the pond), owing to the special facilities for impregnation adverted to above.

The hatchery has been in operation only for a few weeks, and, so far, with the greatest success. The death rate among the eggs has been exceedingly small, far below what is usual with cod eggs. Mr. Harold Dannevig has charge of the hatching operations, and to his systematic attention much of the success is due. It is hoped, later in the season, to proceed with the hatching of the common sole, lemon sole, and possibly the turbot; and it should be stated that the present plant—boiler, pumps, ponds, waterwheel, etc.—is sufficient for a hatchery double the size of the one existing, *i. e.*, for between 30 and 40 of Dannevig's apparatus.

---

* *Vide* a paper by the writer on The Reproduction, Maturity, and Sexual Relations of the Food Fishes: Tenth Annual Report Fishery Board for Scotland, part III, p. 239. 1892.