

PLATE XXVII.—*The Natural History of Otago Harbour and the Adjacent Sea, together with a Record of the Researches carried on at the Portobello Marine Fish-hatchery: Part I.*

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Plate X.

AN examination of the coast-line in and near Otago Harbour shows that at a comparatively recent period there has been a considerable upward movement of the land-surface. It is quite evident that then Otago Peninsula was an island, separated from the mainland by a somewhat deep channel, and itself indented by three or four inlets, of which Tomahawk Lagoon, Hooper's Inlet, and Papanui Inlet are the relics. The last two are still subject to tidal influence, though nearly dry at low water; Tomahawk Lagoon is now cut off from the sea except at very high tides. Partly by elevation of the coast-line, partly by denudation of the adjacent land, and partly by blown sand, these various sheets of water gradually filled up. The main channel ultimately became completely blocked at its south-western end, forming the long narrow inlet now known as Otago Harbour. This is a shallow sheet of water about fifteen miles long, less than four miles broad at the widest point, and full of broad sand-banks which are partly exposed at low tide, and are separated by somewhat narrow channels. It is cut into two distinct basins by the projecting peninsulas of Port Chalmers and Portobello, and the two rocky islands, Quarantine Island and Goat Island. These two basins are united by three rock-bound passages, through which a strong tide pours backwards and forwards, keeping deep and well-scoured channels. I am informed by Mr. J. Blair Mason, Engineer to the Harbour Board, that the area of the whole harbour is 12,058 acres, and that during spring tides (with a rise of 6 ft.) 2,626,232,400 cubic feet of water flow in and out of the harbour each tide, while during neap tides (with a rise of 5 ft.) the volume is 2,100,985,920 cubic feet.

The amount of extraneous nitrogenous matter which finds its way into the harbour is now comparatively small, and is scarcely noticeable. Formerly, when all the drainage of Dunedin went into it, the amount was considerable, though it could barely be detected on the outflowing tide at the site of the Portobello Hatchery; but since this source of contamination was cut off it is a negligible quantity. A series of analyses were made for the Otago Institute some eleven or twelve years ago, but, unfortunately, I cannot lay my hands on them.

It is difficult to say how far the operations of the Harbour Board and the movements of steamers have affected the marine life of the harbour—probably much less than is popularly imagined. The results of tow-nettings at various periods of the year and at various times both of day and night, of hand-dredging in the channels, and of shore-collecting between tide-marks, seem to me to show that minute life is as abundant to-day as it was thirty years ago. Wherever this is the case the larger animals are sure to be found to a considerable extent, for food-supply appears to be the most potent factor in the distribution of organisms.

It was from a consideration of the large volume of constantly renewed sea-water passing and repassing between Quarantine Island and Porto-

bello Peninsula, and of the strong flow passing round the peninsula into Big Bay or Lower Portobello Bay (as it is variously called), together with the accessibility of the spot and the possibility of acquiring a small and suitable area of land on easy terms, that the Otago Institute was induced some years ago to select the site for the present fish-hatchery and biological station. In some respects there are drawbacks to the position, but these are more than counterbalanced by the advantages referred to.

Outside the harbour the ocean-bottom slopes with an easy grade into deep water. Round the rocky portions of the peninsula the grade is steeper. Thus the 30-fathom line comes nearly within two miles of Cape Saunders, a slope of about 1 in 58; while off Taiaroa Head it is between six and seven miles distant, a slope of about 1 in 180. The 50-fathom line comes within about eight miles of the coast opposite the mouth of Papanui Inlet, and there would appear to be at that point a depression or slight valley on the ocean-floor running out seawards. The contour-lines on the map accompanying this paper* (kindly prepared by the Survey Department, Dunedin) can only be taken as approximately accurate, as no detailed survey of the sea-bottom has been made. According to the fishermen who work outside, and who go in for line fishing, there is quite a deep trough or valley about ten miles south-east of Cape Saunders, where the depth very quickly passes from 80 or 90 to 150 fathoms, and from there slopes out to very deep water. A similar sharp depression occurs between thirty and forty miles farther north. Though the exact location of these submarine valleys is not laid down on any map, they are well known to the fishermen, who in suitable conditions of wind and tide find these deeps very excellent fishing-grounds.

According to the Admiralty charts of this coast still in use, based on the surveys made by Captain J. L. Stokes in the "Acheron" (1849-51), a current sets up the coast in a north-easterly direction at the rate of from one to one and a quarter knots per hour. The "New Zealand Pilot" (8th edition) says, "On the east coast of the South Island the current usually sets northward with a rate of about one mile an hour." According to the fishermen, this current, especially at a distance of five to ten miles off the coast at Cape Saunders, frequently runs at the rate of four miles an hour. It is especially strong just before a south-west wind sets in, and when fishing under such conditions in from 90 to 150 fathoms it is sometimes almost impossible to let the lines down, even with heavy sinkers. On the other hand, just before north-east weather sets in, the current ceases entirely, and the lines go down nearly plumb from the boats. One effect of this nearly constant northerly current is the formation of an eddy into Blueskin Bay and round to the north of Taiaroa Head. This frequently causes the accumulation of large quantities of plankton and various pelagic organisms in that sheltered area, and, as a consequence, also the frequent accumulation of large quantities of fish. The general set up the coast of a north-easterly current is one argument in favour of the establishment of a marine hatchery in this part of Otago. Any swimming organisms liberated outside of Taiaroa Head, or even within the harbour on an ebb tide, tend to be carried along the coast northwards.

One physical phenomenon, which has been observed only since the station was started, is of considerable interest and importance. From the very first daily observations have been made of certain meteorological

* Map showing the coast-line between Taiari Mouth and Moeraki, with contour-lines showing the depth of the adjacent sea.

facts—viz., the direction of the wind, the rainfall, and especially the temperature of the air, of the water of the bay, and of the hatching-ponds. These have been regularly recorded at 9 a.m. each day for more than seven years. At the same hour, through the courtesy of the engineers of Mr. F. J. Sullivan's trawling-steamers, the ocean temperature has been frequently (but only from time to time) recorded. None of these observations can be treated as strictly accurate, because the station is not provided with suitable instruments; therefore they can only be looked on as approximately correct. But, making this allowance, it may be affirmed generally that the temperature of the ocean-water at a distance of about two miles outside Taiaroa Head does not fall below 8.8° C. (48° Fahr.) in winter, nor does it rise above 12.2° C. (54° Fahr.) in summer. On the other hand, inside the harbour the variation, both seasonal and diurnal, is much greater, while in the hatchery-ponds it is greater still. In very cold winter weather the temperature of the water in the bay just outside the hatchery-ponds has fallen as low as 4.5° C. (40.1° Fahr.), while in the ponds on one occasion it went as low as 0° C. (32° Fahr.).

The effect of changes of temperature in the water on the animal-life which it contains has not yet been much studied, but it probably accounts for a good deal of the migration of organisms which seems to be such a conspicuous phenomenon in studying the natural history of the sea. It is probable that at the approach of winter many species of fish and other organisms leave shallow bays and estuaries, and move out into deeper water, where the temperature conditions are more uniform. Blue-cod, trumpeter, and some other species which are not uncommon in Otago Harbour in the summer months are conspicuous by their absence during winter.

NOTES ON FISHES.

In the "Transactions of the New Zealand Institute," vol. 38, p. 549, I gave a list of the principal fishes which have been recorded from Otago Harbour and the adjacent sea. Since the establishment of the Portobello Hatchery a good deal of valuable information on the subject has been accumulated by Mr. T. Anderton, the Curator, and this is now summarized up to date. In the following notes the numbers refer to the above list.

1. *Polyprion prognathus* Forster.

The hapuka, or groper, is caught in Otago throughout the whole year.

It appears to spawn about August, for the roes are sold in abundance in the Dunedin shops in July, while all big fish taken in September are "spent." But perfectly ripe fish have never been taken, for they cease to take bait some time before they spawn, and those which are taken in August are usually small and immature fish. The roe is estimated by Mr. Anderton to contain about 1,250,000 eggs. The most mature eggs which have been taken show no signs of oil-globules, and at once sink when placed in sea-water.

The hapuka is a gross feeder, and is most destructive to fish smaller than itself. Over 150 stomachs have been examined, and among the contents were red-cod, mackerel, warehou, soles, pig-fish, octopus, squid, whale-feed (*Munida*), swimming-crabs (*Nectocarcinus*), *Nyctiphanes*, and tests of *Salpidae*. Evidently all the food they take swimming, and they do not feed on the bottom on any stationary food.

38. *Munida gregaria* Fabricius. (Chilton, *l.c.*, p. 301.)

This interesting crustacean is abundant in both its forms in Otago waters. In the bottom (or creeping) form it occasionally comes up the harbour in immense numbers. In September, 1898, the Upper Harbour seemed full of them, and they were seen creeping over the stones and piles of the jetties and among the rocks on the foreshore in countless thousands.

But it is in the swimming stage (formerly known as *Grimotheca gregaria*) that they are so enormously abundant. They are found all the year round, but are particularly numerous in the summer months, when they move about in great bright-red shoals. They furnish one of the commonest articles of food, especially to fishes which swim near the surface, and they have been taken from the stomachs of the following: Red-cod, hapuka, kelp-fish, terakihi, blue-cod, spotty, parrot-fish, ling, leather-jacket, smooth hound, and spiny dog-fish.

At the hatchery Anderton has obtained the swimming stage carrying ova in the month of September; while during the same month numbers of those in the ponds in the *Grimotheca* (swimming) stage gradually sank to the bottom and became quite indistinguishable from the *Munida* (ground or creeping form).

*Macrura.*39. *Jasus edwardsii* Hutton.

The common crayfish is extremely abundant in Otago Harbour near the hatchery, and along the whole east coast of Otago.

The ova hatch out in November and December, and immense numbers of the fry have been liberated from the hatchery-ponds. A note on their development was published in *Trans. N.Z. Inst.*, vol. 39, p. 484, pl. 20.

40. *Pontophilus australis* G. M. Thomson.

A very common shrimp in the harbour and on the coast.

41. *Betaeus aequimanus* Dana.

The jumping shrimp is found commonly under stones between tide-marks all along the east coast.

42. *Alope palpalis* White.

This is a fine large prawn, frequently met with in rock-pools along the coast.

43. *Hippolyte bifidirostris* Miers.

Common along the east coast, where it is frequently picked up by the trawlers.

44. *Palaemon affinis* Milne-Edwards.

Very common, and the only shrimp used as food by man to any extent.

45. *Brachycarpus audouini* Bate.

A slender little shrimp, quite common along the coast, and frequently picked up with trawled material.