

of this portrait, for all Mr. Billings's early associations were connected with Ottawa, the fossils contained in its rocks were the first objects of his scientific study, and, although much of his work was afterwards done in Montreal, the collections to which his time was devoted have come back to be preserved here.

Billings was one of a remarkable triumvirate connected with its initiation and early work of the Canadian Geological Survey, all well in the van of scientific progress at the time, but each working along his own lines. Logan and Hunt were his associates, but his scientific eminence was less recognised in Canada because his work was less obviously connected with the economic problems that the Survey had set itself to solve. His audience was not so much in the little Canada of that day as in the studies and laboratories of Europe and the United States.

The accuracy of his observations is evidenced by the permanence of his reputation among those palæontologists of a later generation that has arisen since his day. It is not often that, nearly twenty-five years after the death of a man whose time was devoted to purely scientific pursuits, interest in his life and work have been maintained in such a way as to render a memorial like this possible, and I may therefore close by again congratulating both those who initiated and those who have aided by subscribing towards the production of this portrait.

POWERS OF ADAPTATION IN FISHES.

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Fishes are frequently classed as fresh-water species and marine species, but there are many which occupy a kind of neutral position, and have the habit of spending part of their time in fresh water and part in the sea. The salmon, sea-trout, smelt, striped bass, sturgeon, shad, &c., are familiar examples, many of them being anadromous, and ascending into fresh water for spawning purposes, while a few are catadromous, like the eel, and deposit their spawn in the sea. The power of adaptation

implied in this change of environment is most remarkable, and appears, in many instances at least, to be acquired during the life of the individual. Thus, a newly-hatched salmon soon dies if placed in sea-water, and the eggs of that species are also fatally affected by the same treatment ; yet later in life the salmon lives indifferently in salt water and in river water. Further, many species, which normally migrate, have lost the habit and, like the land-locked salmon, smelt, flounder, or herring, may pass their days without ever tasting salt water. Some curious instances of extreme changes of habitat in certain mollusks are on record, as, for instance, the bed of cockles (*Cardium edule*) which was described before the Wernerian Society in Edinburgh in 1825 as existing in a Yorkshire peat moss 40 miles from the sea. These shell-fish lived in a sandy channel, communicating with the river Tees, and were precisely like those distributed over the vast beds, eight or ten square miles in extent, at the estuary of that river. To the taste, however, they were distinctly less salt in flavour. A Mr. Brand, more than a hundred years earlier, had described, in an account of the Orkney Isles, a bed of cockles in the fields a mile from the sea. They were in a deep furrow to which salt water might have had access during an exceptional storm. Specimens of the sea-whelk (*Buccinum undatum*) have been found in a fresh-water lake on the island of Yell, a mile and a half from the sea, and as the apex or tip was fractured it was thought that sea-birds or crows had carried them to their new location. Yet, the shell being somewhat thinner in texture, and more distinctly banded, it seems more probable that they had lived for a long period in their fresh-water environment, and thus differed from the marine forms.

Oysters, as is well known, flourish in brackish water, and can endure transference to water almost destitute of salinity ; but they do not appear to breed or maintain a healthy state, they merely fatten and increase in size.

Many fishes in the same way are unfavourably affected if prevented from performing their usual migrations from or to salt water. Dr. Barfurth discovered that the ovaries become diseased, and the eggs degenerate in fishes which are prevented from normally migrating. The same observer has recorded the fact

that the ill-effects reappear in the following season, the eggs and brood of the fish, permitted after confinement to ascend to the spawning grounds, being very inferior and clearly affected detrimentally. The eminent Scottish authority, Professor W. C. McIntosh, some years ago described flounders that became egg-bound and swollen while confined in salt-water tanks ; and ultimately they sickened and died.

The results, in all cases, are not so unfavourable. Sir J. G. Maitland kept some sea-salmon fry from March, 1881, when they were hatched, until 1884, and took the eggs and milt, so that he secured young salmon fry of small parent fish (smolts) which had never been to sea. Dr. Francis Day has told us that some of the young brood had attained a length of $5\frac{1}{2}$ inches in 1886. The retention of sea-salmon in fresh water is found usually to retard their growth, and in one of the earliest experiments (at Lier, in Norway) the weight reached in five years was under two pounds, less than one-tenth of that normally reached by migratory salmon. Sea-salmon planted in Lake Huron prior to 1883 were reported by the late Mr. Wilmot to be smaller than those found along the coast. The ouananiche of Lake St. John, P.Q., like their land-locked congeners in Lake Onawa and other waters in Maine, and the Chamcook Lakes in New Brunswick, are smaller than sea-salmon. In many cases access to the sea is possible ; but if from some geological or other natural cause the fish were originally prevented from descending to the sea, the catadromous habit appears not to have been resumed, partly no doubt owing to the abundance of food in their fresh-water habitat. Land-locked smelt are very often abundant in waters containing land-locked salmon, and they afford an ample supply of food. Pacific salmon exhibit the same phenomenon, of which Kennerley's salmon is an example ; but the spring salmon artificially land-locked in California in 1875 or earlier, bred, and their progeny reached a weight of eight or ten pounds, though on account of scarcity of food, another series were found in nine years to barely reach a weight of two pounds. The spring salmon or quinnat is a large species ranging from 15 to 50 or 60 pounds or even more. The salmon retained at Tadousac, and in certain small lakes adjacent to the Restigouche proved to be

stunted, and weighed less than a quarter the weight normally reached at the age of the specimens referred to. The adaptability of smelt (*Osmerus mordax*) has long been known. Nearly seventy years ago Col. Meynell acclimatised smelt and bred them in a small sheet of water in England, and quite a number of lakes in New Brunswick, Lake Utopia and others contain land-locked smelt.

Only one or two members of the cod family (*Gadidae*) are indigenous to fresh water. All the rest are marine, the fresh-water species being the cusk or burbot, often called ling or lawyer. The tom-cod (*Microgadus*), while it prefers saline or brackish, water can survive in a fresh-water environment, and occurs in abundance in Lake St. Peter, below Montreal. An allied form, the silver hake (*Merluccius bilinearis*) is recorded as abundant in Darling's Lake, near Rothesay, N.B., attracted from the sea by the ascending schools of gaspereaux, which are their favourite food. In the Baltic Sea, the true cod, as well as the haddock, pollock, and other gadoids, occur, but reach only one-quarter of the size which these fishes attain in the sea. In the Bras d'Or Lakes cod are stated to be large (sometimes 56 or 58 pounds), but the head is of disproportionate size, as though they were not well fed. They are caught through the ice at Whycocomagh, far inland and in water of low salinity.

Of the herring tribe at least five species come up into fresh water annually, and some have become land-locked like the gaspereaux or alewives (*Pomolobus pseudharengus*) of Lake Ontario and Lakes Cayuga and Seneca (N. Y. State) and other inland waters. They are often erroneously called shad or menhaden, and they die in immense numbers in early summer owing to some unfavourable circumstance connected, doubtless, with their non-sea-going habit. True sea-herring are not known to be land-locked in Canada; but in Iceland and in the Baltic a fresh-water variety occurs. Some of the Baltic herring were kept for a long period in tanks by Professor McIntosh in Scotland, the water supplied to them being perfectly fresh. They were somewhat stunted.

Many fish when permanently shut off from the sea improve in size and table qualities. Dr. J. C. Mitchell, an authority on the

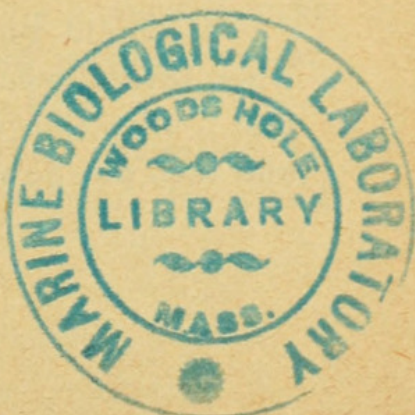
fishes of Egypt, affirms that three species of mullet reached a large size and were of finer flavour after retention in fresh water than those in salt or brackish water. In Florida red fish (*Pagrus*) confined in a fresh-water lake were found 38 pounds in weight, and improved in delicacy of flavour, while numerous other marine species survived the change, but some sharks and sting-rays succumbed, owing, it was surmised, to the winter cold of 1885. The shark tribe are essentially marine, and ill-able to adapt themselves to non-marine surroundings. I know of one record only of a marine species found far from the ocean, viz., a questionable instance of a dogfish, which was stated to have followed the salmon schools for a distance of 1,500 miles from the Pacific shore. The fish was recorded to have been killed up the Bruno River, Nevada, by the wheel of a waggon crossing a ford. There are, it is true, some fresh-water sharks, like *Carcharias gangetica* in the Ganges, and the Senegal saw-fish, also Indian and South American rays (*Narcine*, *Torpedo*, &c.). Certain whales also are non-marine, such as the small *Platanista gangetica* in the Ganges, and *Inia* and *Pontoporia*, belonging to the Grampus and Porpoise family, and found in the Amazon and other South American rivers. The white beluga ascends the St. Lawrence for 150 miles, and goes up the Saguenay River for some distance.

The carps, of which our suckers and mullets are examples, are credited with much plasticity. The German carp can not only endure but survive changes of a remarkable character, living in mud and existing far from lakes or streams for a long period. Certain suckers can endure alkaline and other chemical impurities, and an extraordinarily high temperature. In that wonderful volcanic geyser area, the Yellowstone Park, Professor Jordan found suckers and chubs in water of 85° F. and 88° F. and young trout in a temperature of about 75° F.

The catfish and bull-heads are notoriously tenacious of life. Thoreau, indeed, said that *Ameiurus nebulosus* opens and shuts its mouth for half an hour after its head has been cut off; but there are only one or two questionable instances of their surviving removal from favourable surroundings. More experiments are, however, desirable. If, as Bloch stated, the delicate grayling (*Thymallus*) can flourish in brackish water, contrary to Sir

Humphrey Davy's dictum that salmon and trout will do so, but the fastidious grayling cannot do so, it is possible that the variety of fishes capable of acclimatisation in saline, alkaline or other waters may be considerable. The sticklebacks, while normally frequenting fresh water, except *G. spinachia*, flourish in brackish water, and in shore pools reached by high tides. The marine flat-fishes, the flounder, &c., are found up rivers far from the sea, while the striped bass has been successfully retained for years in fresh water, but the climax is reached in that paradoxical fish, the blenny of Ceylon and the Celebes, which habitually lives on damp rocks, leaping from one to the other, and shunning the water to avoid being drowned! *Periophthalmus*, as it is called on account of its projecting eyes, leaps, when pursued, like a frog. and, as Dr. Günther says, seems to "prefer escaping in that way to swimming beneath the surface."

The plasticity and adaptability of various fishes to new surroundings is not only a matter of peculiar biological interest, it is of eminent practical importance. Hence the brief sketch which I have prepared has been amplified and in a somewhat detailed form will appear as a special report in the forthcoming Blue Book of the Fisheries Department to be laid before Parliament at the approaching session. The subject is one needing fuller investigation. If barren waters remote from the sea, and unfavourable, from conditions of temperature, alkalinity, and the like, for indigenous inland species, can be stocked with fine species of fish, marine or brackish in their habitat, the possibility of conferring immense benefit upon the public becomes plainly apparent. From our present fragmentary knowledge it may be surmised that no small number of species have such powers of endurance as to facilitate the work of acclimatization.





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