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FISHERIES RESEARCH IN CANADA

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IN fisheries research as in many other things Canada through her intermediate position is powerfully influenced by both Great Britain and the United States, but their differences have permitted her to "call her soul her own" and to follow a somewhat independent course. Her organization for fisheries research did not spring like Minerva "full-armored from the head of Jove," the creation of some master or collective mind, as have many research organizations, but has developed like an organism, in relation to its environment and by learning from experience.

After the forced union of Upper and Lower Canada (Ontario and Quebec) in 1841, the new Province of Canada felt the stimulus of opportunity for self-government. With demands for protection of its fishing population along the shores of the Gulf of St. Lawrence from inroads of fishermen from the colonies of New Brunswick and Nova Scotia and from the New England states, it considered the services of a British cruiser inadequate and in 1852 appointed Pierre Fortin, a graduate in medicine of McGill University and in later life a Member of Parliament, as magistrate in command of the expedition for the protection of the fisheries in the Gulf of St. Lawrence, building the armed schooner *La Canadienne* for his use. He was not only magistrate, but also counselor and physician to the scattered communities along the coast, and in addition initiated fisheries research. He described the fishes (naming a new species) as well as the fisheries, and developed a system of detailed fishery statistics that was adopted for the rest of Canada and that has given this country these basic data for fishery research, collected in more detail and continuously for a longer period than holds for any other country. On confederation of the province with New Brunswick and Nova Scotia to form the Dominion of Canada in

1867, a Department of Marine and Fisheries was formed and recently there has been a Department and a Minister of Fisheries to represent this relatively important field in the counsels of the Cabinet.

In spite of keen desire by those in authority for more knowledge, fisheries research did not develop in the uncongenial atmosphere of administration, where, under pressing need for immediate action, the best thinking ability that is available is preempted for making wise decision with the knowledge at hand. However, the department assisted the sponge specialist, J. F. Whiteaves, to dredge in the Gulf of St. Lawrence in the seventies, which resulted in his "Marine Invertebrates of Eastern Canada." Also it employed the naturalist and geologist, H. Y. Hind, to prepare its case before the Halifax Commission of 1877 in Canada's controversy with the United States over fishing rights, and he produced a noteworthy but little known presentation of available oceanographic knowledge of Canadian Atlantic waters on the causation of the fisheries.

Other forces were at work. Rapid increase in the population of the continent produced the illusion of diminishing natural resources, there being an actual decrease in the amount per person. This illusion was fortified (1) by the undoubted disappearance of certain animals, as in fisheries the early extermination of walrus in the Gulf of St. Lawrence, and (2) by emphasizing each drop in abundance of valuable species in long-term fluctuations of still unknown origin. This brought about the establishment of a federal fishery service in the United States with the appointment of Spencer Baird of the Smithsonian Institution as Commissioner of Fish and Fisheries in 1871. The largely illusory decrease of fishes was already being seen as having a remedy, which has proved equally illusory. Artificial hatching and planting of fry originated in Europe and developed simultaneously and rapidly in both Canada and the United States, giving extensive governmental fish cultural services and bringing into existence in 1870 what is now the American Fisheries Society.

It was, therefore, natural that Canada, in appointing a scientist as Commissioner of Fisheries in 1893, selected a specialist in fish embryology, E. E. Prince, a native of Leeds, England, who had a background of experience at the Gatty Marine Laboratory in Scotland under the zoologist, W. C. McIntosh, of St. Andrews University. The new appointee immediately advocated an idea already prevalent in Canadian academic circles that there should be a marine biological station for fishery research. The idea took definite shape at a meeting of the British Association for the Advancement of Science at Toronto in 1897, and with a grant from the Government the Marine Biological Station of Canada came into being in 1899 at St. Andrews, New Brunswick. Its board of management consisted of university representatives who wished summer facilities for themselves, their colleagues and their students to make contributions to knowledge that would be of value for the fisheries.

The station, with a movable laboratory, transported on a scow, tried in successive two-year periods five different sites along the coast, ending at Seven Islands on the north shore of the St. Lawrence but without the laboratory, which had suffered shipwreck. It was then permanently established in 1908 at St. Andrews as the Atlantic Biological Station. By this time there was on the Great Lakes the Georgian Bay Biological Station, established in 1901 under the curatorship of B. A. Bensley, of the University of Toronto, and, in British Columbia, the Pacific Biological Station, established near Nanaimo in 1907 under the curatorship of the Reverend G. W. Taylor, a retired Anglican clergyman, who had followed an English tradition of using leisure time to advance knowledge of systematic zoology.

The managing body was now a board of directors, of which one, the secretary, D. P. Penhallow, botanist of McGill University, directed the development of the new station at St. Andrews forcefully. But need for direction of work towards definite objectives conflicts with the freedom so necessary for the most fundamental research. After an enthusiastic start, the work quickly declined but was redeveloped with steady progress under curatorship. Under control of the board's finances by the department, a clerk's veto of a request for purchase of scientific literature because the latter was in foreign languages caused an explosion and resulted in the creation in 1912 by Act of Parliament of the Biological Board of Canada, an independent body under the minister to have charge of all biological stations.

Under the stimulus of the Great War, the secretary of the board, the biochemist, A. B. Macallum, of Toronto, fostered work at the St. Andrews Station, starting in 1915, on the biochemistry, bacteriology and handling of fresh and cured fish. As the first chairman of the Canadian Research Council, established in 1916, he favored the development of such work in a central institute under the council, the course taken in Great Britain. Then the Department of Fisheries, arguing that the board as a volunteer organization could not be expected to undertake all the necessary fisheries research, attempted in 1920 through parliamentary action to develop a scientific division for the purpose, which would have put fisheries research of all kinds under administration as it is in the United States. Macallum blocked this, but it cost him his membership on the board.

There have been full-time curators at both Atlantic and Pacific Stations from 1916 on and, on being made directors in 1919, they were to an increasing extent active in developing the work. Attack on practical problems was encouraged by A. P. Knight, biologist of Queen's University, made chairman in 1920 and a member from the beginning, who had taken the first formal step toward creation of the board by a letter to the Royal Society of Canada in 1895. He had himself been studying pollution, bait, effectiveness of lobster culture and conditions in lobster factories in cooperation with the department. Inquiry in 1922 revealed that the fishing industry was for the most part untouched by what the board had done or even frankly sceptical of its having any value. In 1923, in order to bring the work definitely into relation with practice, non-scientists were brought into the board to represent administration and industry. Much more money was made available and new stations for the study of industrial problems in handling fish were shortly established on both east and west coasts. On careful consideration the first of these was established not at the center of government as in the United States nor at a foremost university research center as in Great Britain, but at Halifax, the most important center for the industry and with a university at hand. The second was established for political reasons at Prince Rupert, a remote fishing center, but has recently been transferred to Vancouver, which is comparable with Halifax.

The boom period of the twenties was gathering headway, with young men flocking into research as a profession and the public keyed up with great expectations. The chairmanship of the board went in 1925 to J. P. McMurrich, the anatomist, of Toronto, who as a young man trained under R. Ramsay Wright and enthused with the possibilities and need for biological research had publicly urged in 1884 such a development as was now in train. He had had a long experience in investigation at biological stations and universities in the United States, and he encouraged the directors of the four stations to develop the work. With departmental urging, the new experimental stations were quickly staffed with full-time investigators, and on the recommendation of a Royal Commission on Maritime Fisheries in 1928, this policy was extended to the biological stations. Annual expenditure, which had started at $2,000 in 1900 and had risen to over $46,000 by 1923, climbed rapidly to a peak of nearly $400,000 in 1930.

Then came the "depression," and in three years' time expenditures were cut by more than 50 per cent. With the board no longer dominated by men who wished to contribute personally to fisheries investigation and with increasing demands from the employed staff, financial support but not facilities available otherwise was withdrawn from volunteer workers from the universities.

The stations had grown in response to more or less local conditions rather than with central planning, but under the forceful chairmanship of the biochemist, A. T. Cameron, of Winnipeg, the organization was remodeled to achieve balance and smooth working, and so came to approximate the character of other research organizations. With centralization of direction and initiative, scientific output as judged by number and volume of publications dropped steadily in the face of increasing expenditure. In 1937, the Biological Board of Canada became the Fisheries Research Board of Canada, signalizing the change in forty years from a group of university investigators eager for facilities for personal investigation into a body of administrators, nine representing the most pertinent sciences in the universities, two the Department of Fisheries and four the fishing industry. This tripartite organization has permitted fusion of the varied points of view requisite for a successful policy of research toward fishery objectives.

In Ontario, the Great Lakes have offered a continuing challenge to biologists. R. Ramsay Wright on going from Glasgow to Toronto in 1874 responded to the challenge not only by training his budding investigators (including Macallum and McMurrich) on fresh-water material as in their combined work in monographing the catfish *Amiurus,* but by a lengthy report in 1892 upon the provincial fish and fisheries. He advocated a lake station which materialized on Georgian Bay under the board, but which languished and was abandoned in 1914. The board continued support of investigation of the Great Lakes until 1920, but, with Ontario then in control of its own fisheries, Bensley developed in 1924 the Ontario Fisheries Research Laboratory at the provincial University of Toronto, taking the smaller lakes for study as being more manageable and starting with Lake Nipigon.

First in 1920 did the board investigate lakes in the Prairie Provinces, namely, the interesting alkaline Quill lakes of Saskatchewan in which the stock of desirable fish comes and goes with long-period fluctuations in salinity. Steady investigation of the varied Prairie lakes began in 1925 with staff drawn from the University of Manitoba, and later augmented from the University of Saskatchewan; but, with these provinces assuming control of their natural resources, the work was discontinued after 1930.

An appeal for federal assistance to the Ontario Fisheries Research Laboratory led to the formation in 1936, under the auspices of the National Research Council and the Fisheries Research Board, of a National Committee on Fish Culture, which administers a grant to the council, by which aid has been given for work by university investigators on waters of the interior provinces. The aim of the committee is to survey and coordinate the whole field of fish culture research. Of somewhat similar character and similarly sponsored are the Canadian Committee on Storage and Transport of Food, formed in 1938, and the Canadian Committee on Oceanography, formed in 1939.

The vast northern or Arctic part of Canada has been given but sporadic attention in keeping with its virtually uninhabitable character. Stefansson may maintain it to be a friendly country, but neither he nor any one else has pioneered its successful settlement with people of European stock. The prevalent idea, doubtless a European product, that northern waters teem with life has maintained great hopes for development of fisheries, particularly among the people of the Prairie Provinces in regard to the inland sea of Hudson Bay, 500 miles in diameter. The board sent investigators to the bay and strait in the twenties, and one went with a modern steam trawler, sent by the department in 1930 to make a thorough search for fish other than those in the tributary streams and close to shore. Not a single commercial fish was obtained. This agreed with the experience of the Hudson's Bay Company in the eighteenth century, which with experienced Spitzbergen fishermen obtained only three fish for an expenditure of £20,000. That all the water of the bay except a shallow surface layer in the summer was found to have a temperature below $-1.8°$ C. explains not only its lack of commercial fish but also the high arctic character of its fauna. And yet it lies south of the latitude of Iceland, which has such notable fisheries.

To have more of the famous Malpeque oysters, particularly the "Curtain Island Cups," took the first station to that bay in Prince Edward Island in 1903 and 1904, with their life history to be elucidated. The mature English investigator (a member of the board), to whom had been assigned this phase of the work, lost caste by mistaking scale insects on planted brush for oyster spat and he complained later in *Nature* of the poor facilities for research. It was the "chore boy" of the station, Jos. Stafford, of Toronto and McGill Universities, who published ten years later a volume on "The Canadian Oyster, its Development, Environment and Culture." But the Malpeque oysters were almost exterminated in 1915 and 1916 by a disease, presumably introduced with seed oysters from Long Island Sound. When this was made a federal scientific and administrative problem, the board established in 1929 the Prince Edward Island Biological Station on the bay in charge of A. W. H. Needler. With scarcely any oysters left, it was possible to replace public fishing by private culture and with new methods the resistant stock that had developed in the inlets was extended to ever new areas. The industry grew so rapidly that in 1941 it was justifiable to issue a bulletin on "Oyster Farming in Eastern Canada."

Although producing more lobsters than any other country Canada had to have hatcheries, the first in 1891, but these failed to improve conditions. When shown by Knight to be worse than useless, they were abandoned in 1919. He tried out the rearing method of A. D. Mead, of Rhode Island, in 1914 and 1915 in the cold water of the Bay of Fundy with absolute failure and in 1916 in the warm water of Northumberland Strait with so little success that no further efforts have been made. Then the value of governmental hatching and planting of salmonids, which had been developed extensively in both the United States and Canada, but not in Great Britain, was brought into serious question by H. C. White's results in studying from 1923 to 1930 the fate of speckled trout fry planted in streams of Ontario and Prince Edward Island. A thorough test of the effectiveness of sockeye salmon culture was made by R. E. Foerster in a part of the Fraser River system, B. C., from 1925 to 1935, and it revealed results so incommensurate with cost that the artificial culture of sockeye salmon was abandoned by Canada in 1937.

These negative results leave open the question of what we should do to get more fish. Control of fish predators on sockeye salmon in British Columbia and of bird predators on Atlantic salmon in Nova Scotia has been not without promise, but the predation problem is a knotty one. Fish culture has been definitely successful for introductions into suitable barren waters. Starting from that solid fact, attempts are being made to develop effective regular use of the product of Atlantic salmon hatcheries for waters in which natural hatching is demonstrably unsuccessful or inadequate.

The United States, but not Canada, took membership for a time in the North European International Council for the Exploration of the Sea. In 1920, on the initiative of Canada, the North American Council on Fishery Investigations was formed in cooperation with the United States and Newfoundland. This has permitted Canadian fisheries research on the Atlantic to be closely stimulated by and coordinated with the investigations of the U. S. Bureau of Fisheries and the work of the Woods Hole Oceanographic Institution. Contacts were established with the European council, particularly through the fact that France, which belonged to that council, took membership in 1922 in the North American Council because of her fisheries on the Grand Banks.

The Passamaquoddy tidal power project at the boundary between the United States and Canada provided the council with a most difficult problem in fishery research. The St. Andrews Station, which had been studying the waters involved, believed that Canadian fear of serious injury to the local very concentrated "sardine" (small herring) fishery, largely Canadian, had some real basis, while the power project made a great appeal to the imagination of New England, particularly with the domestic market for the sardines having been ruined by liquor prohibition, since they had been used to stimulate thirst. The council could not state what effect the project would have and the investigation, which it recommended, lasting over two years and carried out by scientists from four countries, failed to provide the basis for sure forecast of the effect. A revised plan, considered as not apt to cause serious damage to the fisheries, was started by the U. S. Government, but abandoned after $6,000,000 had been spent "before ascertaining if the plans were technically sound" as stated in SCIENCE (Vol. 83, p. 508) by President Compton, of the Massachusetts Institute of Technology, who supported the statement that this project "breaks all records in getting the least electricity for the money."

International cooperation in fisheries research has gone farthest on the Pacific coast. As a background, there has been the treaty of 1911 between the two countries for the preservation and utilization of the fur seals of the Pribilof Islands, which has worked so satisfactorily. In 1924, the North Pacific Halibut Treaty between the United States and Canada became effective, and the commission that was appointed under its provisions has had continuous scientific investigation of the halibut problem. Outstanding has been its thorough attempt to test the theory of overfishing by following carefully the result of definite restriction in the catch. A more economic condition has resulted, namely, an increased yield per unit of effort, whatever may be the effect on the stock, which is not yet clear. There has, however, been some failure to control the catch. A similar commission for the sockeye salmon of the Fraser River came into being in 1937, taking over the scientific investigations carried on by the Fisheries Research Board of Canada. It is a question, however, whether the principal matter, the bringing back of the large runs eliminated by a rock slide at Hell's Gate in 1913 blocking the ascent of the fish, is not already being remedied by nature.

Difficulty in handling "fish" is due largely to its very perishable nature. For example, smut or blackening in canned lobster was found by Andrew MacPhail of McGill in 1898 to be iron sulfide associated with bacterial decomposition and he advocated more thorough sterilization of the cans. Then F. C. Harrison, of MacDonald College, reinvestigated it (1923) and recommended chemical control by use of acid pickle in the cans, but G. B. Reed, of Queen's, was able to show (1924) that the important thing was to avoid decomposition before canning, which might be serious in four hours' time.

Smoked fish (finnan haddies and smoked fillets) presented the first problem for the Halifax Station, but the trouble was found to be merely failure in muggy weather to dry the outer part quickly enough into a shiny pellicle before it was acted upon by the smoke which prevents the sheen from developing, and the housewife wanted the sheen. The good effects of the smoke proved to be due largely to the contained formaldehyde, which, curiously enough, the "pure food" laws prohibit from use for preservation of food. Frozen fish has had a poor reputation, and Canadian frozen hake was the subject of strong official complaint from the troops in France in the Great War. Rapid freezing and steady cold storage were found to give a prime product and, as a demonstration, many tons of really fresh haddock fillets were sold in Toronto in the frozen state in 1929 as a high quality product at a price 50 per cent. above that of the "fresh" fish. The trade has, however, as yet been unable to ensure proper handling at all stages from the water to the consumer. The Halifax Station has shown that the fishy odor of "fresh" fish, which is absent from fish that are really fresh, is the result of the setting free in sea fish of trimethylamine from trimethylamine oxide by incipient decomposition. Really fresh fish, which are without the fishy odor both during cooking and eating, which leave no aftertaste, and which could be greatly relished by many people, particularly invalids, who now dislike fish, is as yet practically unobtainable, through failure of the trade to use sufficient care and speed in handling. Tests showed that the "fresh" fish sold in winter when preservation is easier actually contained more trimethylamine than it did in summer.

In contrast with fish handling, the crying need in connection with the actual fishing is not for the application of the knowledge we have but for more knowledge. Fishery regulation like fish culture is still based for the most part upon hope, not upon assurance of effectiveness. Real advance requires freedom of thought, which will come only by removing the incubus of the past—time-honored beliefs without proved basis. "Homing of salmon" is a belief that satisfies and removes incentive to discover how that fish moves in the sea and why. "Races" of fish have an extensive literature without any facts of breeding and have so often been shown to be environmental effects that there are serious proposals to remove from "race" any implication of heredity. "Depletion," except as an uneconomic condition which may exist when fishing starts, is little more than a bogie to frighten the credulous. That it is so seems to me to be evident from E. S. Russell's recent (1942) book "The Overfishing Problem" (based upon his lectures at the Johns Hopkins University, which were sponsored by the late Raymond Pearl), since it is stated that "there is more than a risk—there is a threat—of destruction of stocks." Those who raise this bogie to get definite action conveniently ignore incompatible facts such as these: More herring (102,194,000 lbs.) were caught in the Canadian Passamaquoddy region (Bay of Fundy) in 1941 than ever before, although this region is fished more intensively than any other, with the chief incidence on the yearling fish less than half-way on the road to sexual maturity and with no protection for the spawners. Although Lake Erie is more intensively fished than any other of the Great Lakes, it yielded more whitefish in 1939 than is recorded for any earlier year and the Canadian catch (U. S. figures not available) was 45 per cent. higher in 1941 than in 1939. We have still much to learn.

INTERNATIONALISM IN SCIENCE[1]

By Dr. KARL K. DARROW

BELL TELEPHONE LABORATORIES

I HAVE been asked to speak on internationalism in science, or rather in the particular field of science which happens to be mine, the field of physics. The quickest way to handle this subject would be to reverse it, and speak of *nationalism* in science. This would be a conveniently narrow subject, for in science there is hardly any nationalism. The laws of nature are everywhere the same, and the ways of describing them do not differ from land to land. You may indeed remark that in different lands they are described in different languages. In so far as this is true it is not important, except as an inconvenience; and it is not even entirely true. The laws of nature are described by mathematics, and mathematics is a universal language. You can look at a book of physics in some language of which the very letters may be unfamiliar, and still you can tell what the author is treating by following the train of his equations. If you can read his words or get some one to translate them, you find that there is no imprint of nationality on his ideas, any more than on the laws which he happens to be describing.

So, the journals and the books of science are a cosmopolitan literature, and indeed the most cosmopolitan thing which now remains to us. In the happy days before the other war there were other cosmopolitan things: the gold standard, and the free circulation of art and of artists from country to country, and the worldwide diffusion of travel and trade with limitations so light that they now seem like freedom. These did not survive the other war, or survived it only in a crippled fashion; but the literature of science continued still to pass all boundaries even when its creators could not, a sort of intellectual gold standard by which the worth of every contribution and the standing of every contributor were appraised. Englishmen were not judged by Englishmen exclusively, nor Germans by Germans nor Americans by Americans; the common opinion of the scientific world was the court of first and last resort. No experiment was disregarded, no idea neglected because it came from the opposite side of a frontier. Few if any scientists strove to keep their ideas confined within their own countries. The notion of keeping a discovery undisclosed is repugnant, I can without exaggeration say it is revolting, to nearly every man of science. So few are the exceptions to this rule that we still look with wonder on Newton and on Cavendish, who were exceptions to it, and try to divine what peculiar quirk of personality made them such deviations from the norm. Nearly every one in science spoke to all who would listen, and nearly every one in the entire world of science was ready to listen to a new experiment or a new idea, from whatever part it came.

But even so, were there not some nations which were always the discoverers and the teachers, and others which were always the copyists and the learners? Nothing would seem more natural, and nothing could be further from the truth.

Take the four men whose consecutive labors enabled us to understand the motions of the heavenly bodies: Copernicus the Pole, Galileo the Italian, Kepler the German and Newton the Englishman. They were astronomers, but they were physicists also, for the laws of motion of the heavenly bodies are those of earthly bodies also, exemplified on a grander scale. Take the story of radioactivity. Radioactivity was discovered because x-rays had been discovered. The discoverer of x-rays was a German, but the man whom his work inspired was a Frenchman. Another Frenchman and his Polish wife carried on the study, and for a time it might have been thought that Paris was destined to be the center of all wisdom about radioactivity for ages to come. Not for a very long time, however! Not a decade had elapsed before every one who cared at all about this field was looking eagerly to England, and not because of an Englishman either, but because of a New Zealander whom a fellowship endowed in Britain had brought to Cambridge. The focal point of research in radioactivity traveled with this man to Montreal and then back again to England. It is Rutherford of whom I speak, the very man who later became the first of all men to achieve the transmutation of the elements. So long as he lived, the great Cavendish laboratory at Cambridge was the greatest scene of transmutation

[1] Broadcast, under the auspices of the American Philosophical Society, over Station WRUL on June 24.