Canadian delegation headed by General A. G. L. McNaughton, a former member and President of the Board, has worked tirelessly for agreement on a system of control which would give the nations of the world some measure of security against atomic attack. Because of the present bitterness between East and West, however, progress towards agreement has been disappointingly slow. Nevertheless, the achievement of an effective agreement will not only be a great contribution to peace but will also make it possible for the peoples of the world to share in the benefits to be derived from the peaceful uses of atomic energy.

Fisheries Education in Canada

William S. Hoar

SCHOOLS of Agriculture, Forestry, and Mining are well established in Canada, but there is only one Canadian institution — Laval University — which boasts a School of Fisheries. And there are few institutions which emphazise instructional work in Fisheries Biology.

This situation exists because of certain basic differences between ownership of land and water resources. The resources of the land are evident. Man can see what he owns, its extent and the manner in which his activities affect it. The resources of the ocean, on the other hand, are hidden in a medium which is foreign to man and covers a vast area of more than two-thirds of this planet. Further, man has developed certain legal rights with respect to land resources. He can acquire jurisdiction and control over definite areas. In contrast, the waters are national and international assets and their development is dependent upon political interest and international co-operation. Fish, moreover, move freely from one man-made area to another without respect for national interests.

Difficulties of Marine Research

The scientist, too, has [illegible] a more baffling problem than the land. Marine research, in particular, is expensive. Large vessels and rather complex gear are necessary for oceanographic work. For many years, botanists and zoologists were forced to confine their activities to the sea shores and sheltered bays. It was only when they had accumulated a sufficient body of knowledge in this way that interest could be aroused to obtain the public support necessary for large scale marine research.

It is perhaps not surprising that the first important contribution should be made by the great fishing nations of Northwest Europe. The initial step in the wider field of marine research was taken in 1872 when the British corvette *Challenger* sailed on her scientific cruise. The Challenger Expedition lasted for four years and made extensive physical and biological surveys over 68,900 nautical miles of Atlantic and Pacific oceans. The results, published in fifty volumes of reports, opened an entirely new field to the scientists and aroused a general interest in oceanographic investigation.

To these scientists of the mid-nineteenth century, the resources of the sea seemed inexhaustible. In fact, a Royal Commission, investigating fisheries in Great Britain, concluded that "there is not a particle of evidence that anything man does has an appreciable influence on the stock of herrings." However, this opinion did not prevail for long. It is difficult to say now whether a real depletion of certain fish occured or whether men simply became afraid of the fate of stocks they were attacking so

vigorously. The fact remains that at the close of the nineteenth century the feeling developed that populations of fish were not inexhaustible and that measures should be taken to conserve and increase their numbers. The Fishery Board of Scotland led the way in the early 'eighties, and in 1884 the Marine Biological Association was established at Plymouth. In 1899, King Oscar 11 of Sweden proposed an international conference which resulted in the eventua! establishment of an organization—the International Council for the Exploration of the Sea. Fot the past fifty years, this council has been influential in fostering international co-operation and promoting marine research.

Fisheries—A New Science

Most fisheries investigations have been of an exploratory nature. Until the extent and nature of the resources of the sea are known, until the kinds of fish, their life histories, foods, spawning habits and migrations have been elucidated, and until the movements of the ocean waters and the effects on these of winds, currents and river discharge are established, a scientific management of fisheries resources is impossible. There are still many blanks in our knowledge, but during the past twenty years sufficient facts have been learned to provide a basis for management programs.

We are now able to estimate the abundance of some of our important food fishes determine their ages, rates of growth and mortality; to follow their migrations, foresee the effects of various biological and environmental factors on the population and, finally, to predict with some precision the yield to the fisherman. When it is possible to determine the maximum continuous annual yield under definite conditions and thus reduce the element of gambling in fishing operations, then prediction is possible and it is reasonable to assume that we have a science of fisheries management. As yet, this ultimate goal has not been achieved for any fishery, but in the last twenty years the rather nebulous aims of the early fishery biologists have disappeared and the science has passed from the descriptive to the quantitative stage of a maturing sciencs.

The importance of biological investigations to the development of this science has been emphasized. There is another aspect which has been almost equally important in establishing the fishing industry on a sound scientific basis. The twentieth century developments in bacteriology, chemistry and physics have enabled man to prevent or delay the decomposition of fish when caught and to bring a desirable product to markets far distant in time and place. This science—usually known as Fisheries Technology—stems from the pickling of herring in the fourteenth century, but the nineteenth and twentieth century advances in physics and chemistry have given us modern refrigeration and canning of fish. The advances in the technological field, too, have led to a wider and eaiser exploitation of the sea. Each year sees the development of better fishing craft, more efficient gear and improved methods of locating fish. It seems that man now has the power to remove, at will, the great schools of important fish. Some manner of control and management becomes increasingly imperative with each improvement in fishing method and with each additional hazard to fish populations in our increasingly complex civilization.

Fisheries Science Defined

Some authorities claim that knowledge concerning fisheries is not yet sufficiently organized to constitute a definite science. Fisheries workers, in the past, have been trained in the fundamental sciences—zoology, botany chemistry, etc. Until fisheries science became something more than the natural history of fishes, the anatomy, embryology and physiology of fishes, the statistics of fishery yield and fish culture, then it could not be recognized as an independent discipline. These sub-

DBS

jects all form a part of the science of fisheries, but this science is something more in that it is an applied field of Biology with its own techniques and particular aims. It includes a body of organized knowledge regarding the supply of commercially important fish, the variations in supply and their causes and the methods of harvesting and marketing the resources. It is admittedly an infant science but other branches of applied Biology—for example, agriculture and medicine—were recognized and taught as distinct sciences long before knowledge was as advanced as it is now in the fisheries field.

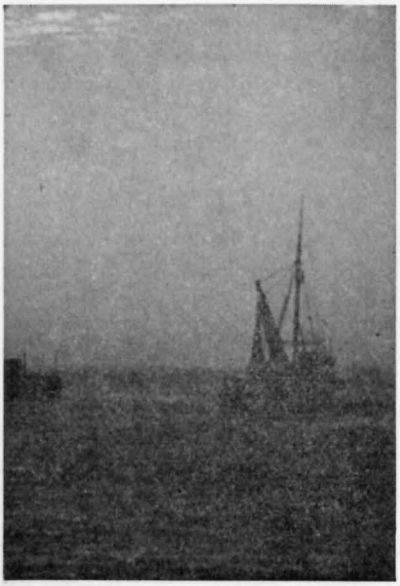
It is convenient to recognize two divisions of Fisheries.

1. *Fisheries Biology*, as defined by the Committee on Biology of the Food and Agriculture Organization's Fisheries Conference held at Baguio, 23-28 February, 1948, is "a specialization of biology (more especially ecology) applied to groups of aquatic organisms which are of actual or potential economic importance to man, and modified (from pure biology) by its employment of certain biological data. It is concerned with the identification of the natural units of stock of these organisms, with the elucidation of migratory, feeding and reproductive habits and of growth and mortality rates, and with the measurement of population levels including measurement and analysis of fluctuations of these levels and the effect upon them of fishing operations; it aims at the formulation of programs for the effective utilization of these resources."

2. *Fisheries Technology* was defined by the Technology Committee of the same Conference as "the study of fishing boats and gear, including fish ponds—their design, construction and use—(Fisheries Gear Technology), and of equipment for handling, processing, storage and transportation, the methods of using such equipment and examination of the product whilst undergoing process (Fisheries Food Technology)".

Canada—A Pioneer in Fisheries Work

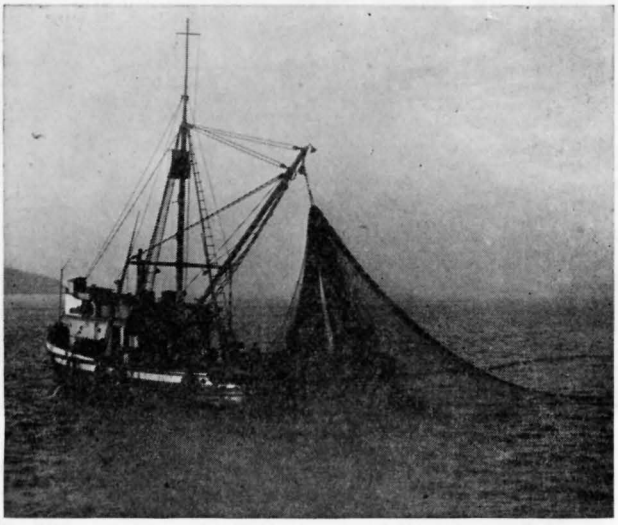
Canada has played an important role in the development of the fisheries field. Through her Fisheries Research Board, she has come to know someth ng



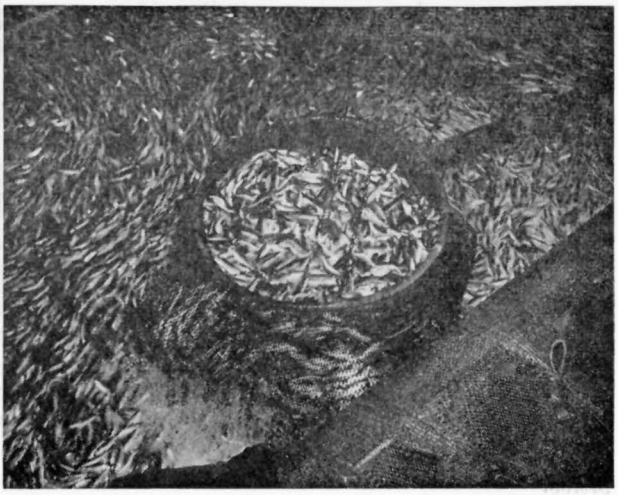
Seining at Twilight. The seiners reach their rendezvous at sunset, the period of slack tide.

The light skiff tows a $10,000 net in a giant circle; it goes 200 feet deep in the water and is nearly half a mile long.

The trapped fish are drawn to the vessel and scooped from the net.



An echo sounder traces a picture of the ocean floor by a sonic reflected beam. Any solid object between the hull and the ocean floor causes a shadow; thus shoals of fish are found.



DBS from CNR

A Skeena River fishing fleet at Prince Rupert, British Columbia. Canada's fishing grounds, both sea and inland, are unsurpassed in extent by those of any other country.

of the extent of these resources. In certain cases much of the information basic to sound management has been collected and programs have been initiated. Her scientists have done outstanding research on fish preservation and the use of the by-products. Today Canadian fish is as fine a product as is available anywhere.

To maintain her important place as a fishing nation and as a leader in fisheries further investigation and a sound educational program are essential. The knowledge of one generation must be made available to the next. In Canada a program of fisheries education is being extended under the aegis of the Dominion Department of Fisheries and the universities.

Educational Work of the Department of Fisheries

The educational work supported by the Federal Department of Fisheries is largely a program of adult education directed toward the fishermen. In general, there are two aims:

1. Improvement of the standard of living of the fishermen, and
2. Improvement of the quality of the fishery product.

To this end, the Department has been assisted by the Fisheries Research Board and the Universities—particularly St. Francis Xavier in Nova Scotia, Laval in Quebec, and the University of British Columbia. On numerous occasions the stations—both east and west—

have organized special courses for fishermen, either independently or in connection with university extension departments. Instruction has usually emphasized proper methods of handling and marketing fishery products although occasionally courses in fisheries biology, oceanography, navigation, motor mechanics, etc., have also been given. Both the experimental stations and the biological stations have co-operated in this work. Technological instruction to fishermen has been a feature of the program at the Halifax station for twenty years.

The more regular program of the Department of Fisheries operates through the Extension Departments of certain universities. This work stems from the co-operative movement developed by St. Francis Xavier University in the fishing communities of Nova Scotia. Recognizing the value of this to the fisherman, the Department, for the past thirteen years, has made an annual grant to St. Francis Xavier—and later to Laval and British Columbia—for instruction of the fishermen.

The program carried on in the Maritimes through St. Francis Xavier has been the most extensive. A number of field workers, travelling from community to community, have organized study clubs and associations. Instruction has been given in co-operative organizations and credit unions, as well as in business management, standard accounting systems, fish curing and sanitation. In Quebec a similar program has been carried on through the School of Fisheries at Ste. Anne de la Pocatière, and also on the Pacific Coast through the Extension Department of the University of British Columbia. At present, the Department grants about $10,000 annually for each province involved in the work. Although the general education of the fishermen is one of the main objectives of this program, fisheries education is an important feature and has done much to improve the standard of Canadian fish.

University Courses

Fisheries is the last of the four basic industries of Canada to be placed in a scientific footing. The slow development of a concrete fisheries educational program within the universities reflects the fact that fisheries is a new science not yet widely recognized. Only six—British Columbia, Dalhousie, Laval, McMaster, Montreal, and Toronto—out of twenty Canadian university calendars examined list courses in Ichthyology or Fisheries. One other—Saskatchewan—emphasizes fisheries in connection with Limno-biology and seminar work. Two others give courses in Aquatic Biology or Limnology which presumably include some work in fisheries. It is interesting to note, further, that in Canada's many universities, only three—British Columbis, Laval, and Toronto—list courses in Marine Biology, and only one—British Columbia—offers a course in Fisheries management. In contrast, Wildlife Management is offered in at least two institutions, and Forest Management forms a part of all Forestery school programs.

Such comparisions, however, may be misleading. Fisheries biologists are essentially biologists with broad training who are applying their knowledge in the field of fisheries. Likewise, fisheries technologists are chemists, physicists, and engineers working in fisheries problems. On these bases, Canada has trained her fisheries experts through sound scholarship in the basic sciences. During the past twenty years, however, Fisheries Biology and Fisheries Technology have become recognized as definite fields of applied research and, as such, should form a recognized part of the curricula of our universities.

Fisheries Biology in Canadian Universities

Three lines of interest have been apparent in the development of Fisheries Biology. Systematic studies including

classification, distribution and life histories of fish (Taxonomy), the aquatic environment and food organisms (Limnology and Marine Biology) formed the basis of the older established courses in fisheries. Several institutions offer sound courses in these fields—particularly in classification or taxonomy, and in fresh water biology or limnology. The work of the Toronto school has been outstanding and has produced most of the teachers and research workers who are active in this field in Canada.

The second field—scientific fisheries management—is in part an outgrowth of the first and, in part, a logical development from the important research of the past twenty-five years in the dynamics of fish populations. The fisheries investigations of northwest Europe, the work of the International Halibut Commission in America, and many very recent studies have demonstrated how fish populations may be expected to behave under different fishing intensities, what factors may modify predictions, and how a fishery may be scientifically managed. Several Canadian institutions are providing training for future workers in this field through courses in statistics and research training in fish biometrics. The work of Toronto may again be mentioned. More recently some Canadian teachers have attempted to organize the pertinent material into courses in Fisheries Management.

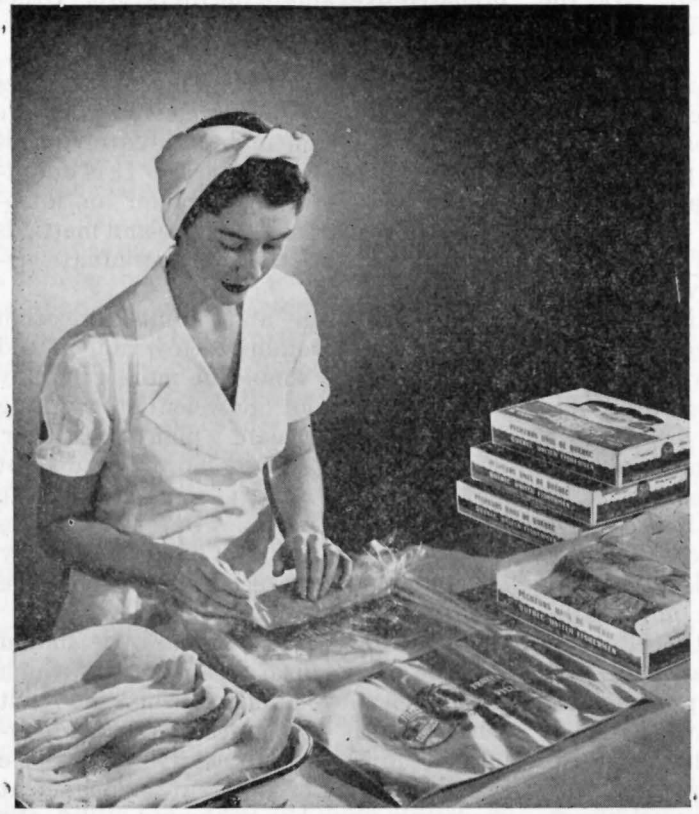
The third field is developing in connection with the research of a group of environmental physiologists. Several workers in Toronto have made important contributions to our knowledge of the behavior and environmental physiology of fish, and a considerable school of graduate students now exists. Recently British Columbia and Dalhousie have organized research groups.

These three aspects seem to cover quite adequately the problems set forth under the above definition of Fisheries of Fisheries Biology. The first field—systematics—will remain fundamental to work in fisheries biology; the third field—physiology—will probably become the most important sphere of university research in Fisheries. although formal courses are not likely to be introduced for undergraduates. This statement is based on the fact that the first field has now been quite well explored and the second will remain the sphere of governmental research bodies. However, this second field—fisheries management—should become an important part of the curricula of all university departments offering fisheries work. Whereas most Canadian institutions do not at present offer work in this field or do so only in seminar courses, the future should see the development of courses in Fisheries Management.

Fisheries Technology in Canadian Universities

Three universities now have programs for training fisheries technologists. The School of Fisheries at Ste. Anne de la Pocatière, Quebec, was established in 1938 under the supervision of Laval University. In co-operation with the Fisheries Research Board of Canada, Dalhousie, at Halifax, initiated course work in Fisheries Technology twenty years age and at present offers a Master's degree in this field. In 1946, the University of British Columbia organized a similar program.

The School of Fisheries at Ste. Anne de la Pocatière is a unique Canadian institution. It is the only specialized school of its kind in the country, and the only educational institution with independently organized courses and research in Fisheries technology. The emphasis here is on technology, but a broad program of course work has been laid down. The basic sciences—economics, mathematics, chemistry, physics, and biology—are stressed during the first two years. The courses of the junior and senior year include fish preservation, refrigeration, salting, and the utilization of by-products, as well as courses in navigation, statistic, and scientific fisheries management. In ad-



Wrapping fish fillets before freezing. The method of merchandising fish has changed considerably in recent years. Over 50 p.c. is now sold in the form of fresh or frozen fillets.

DBS

dition to the regular staff and certain professors from Laval, a number of experts are brought in each year to give special instruction in technology and related subjects. The number of students in this school is small—twelve to eighteen in all years. The graduates are finding ready employment in Quebec and elsewhere and the institution seems to be meeting a definite need. In addition to college grade courses, short term courses are available and considerable work is carried on in the field of adult education.

The organization of the fisheries technology work in British Columbia and Dalhousie Universities is entirely different. In both institutions, the training in this field is for graduate students only. Well-trained students, who have been graduated in chemistry, physics, bacteriology, or fields allied to any of the branches of fisheries technology, may do research in the Experimental Stations of the Fisheries Research Board and take certain additional university courses to fulfil the requirements for the Master's degree and, at British Columbia, for the Doctor's degree. The graduates are really chemists, physicists, bacteriologists, or engineers with an orientation in fisheries problems. British Columbia, in addition, offers two undergraduate courses in fisheries technology. These are orientation courses for Commerce students entering the fisheries business and for students taking a degree in Food Technology.

"On the Knees of the Gods"

There is now sufficient organized knowledge related to fisheries that special

instruction seems warranted. At the moment, however, it is difficult to see clearly what aspects should be stressed. In the research field, emphasis has changed periodically. The earliest attempts fishery management were based on the idea that reproduction was primarily at fault. Fish hatching and planting was looked upon as a panacea for the assumed or real scarcities of fish. This was the prevailing idea for fifty years. The intensive fishery investigations of the first half of the twentieth century were crystallized in a "theory of overfishing"—a thesis that there is a most profitable time to harvest a crop of fish, that a knowledge of the growth and mortality rates of a population will enable us to predict for exploitation. Recently, a third line of thought has been apparent, and workers in the field of fisheries have been more conscious of the importance of cyclical variations and the effect of the environment on abundance of fish. It is suggested in this approach that man's fishing activities have little or no effect in comparison with the effects of adverse temperature, salinity, and similar factors at certain critical times.

These changes in thought emphasize that this is a warning to the teacher who is attempting to organize material material to give students a basis on which to start. In spite of these uncertainties, however, the student entering the field of fisheries research should be provided with the established techniques and procedures used in his field and should be prepared to evaluate the literature. Other groups will desire less technical knowledge.

The university program for fisheries scientists should be primarily graduate training based on undergraduate courses in the fundamental sciences. It is doubtful whether anything beyond an introduction to fisheries literature and methods is indicated at the undergraduate level.

The extension and adult education courses of the Dominion Government and the universities should be more generally available to the non-scientist working with fish—fisherman, plant manager, business man. These, however, do not logically form a part of the academic work in universities. Special fisheries schools for this type of instruction may be indicated in certain parts of the country.

During the next few years, we should see the crystallization of ideas which have been developing during the past century. In the research field, long-term studies are necessary before the relative merits of different management programs can be evaluated. In the educational field, courses of instruction and standard text books must be made available.

Canada ranks high among the fishing nations of the world, with her fishery products now valued at almost $120 million annually. Canadians should be prepared to play a leading role in promoting fisheries education and research.